



॥ सत्यमेव जयते ॥

**Uttar Pradesh Rajarshi Tandon
Open University**

**Master of Business
Administration**

**M.B.A.-2.2
Production Management**

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MANAGEMENT 03-104**

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BLOCK

1

BASIC ISSUES PRODUCTION MANAGEMENT

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परिभाषक

अनुवाद की स्थिति में

मूल लेखक

अनुवाद

मूल सम्पादक

भाषा सम्पादक

मूल परिभाषक

सहयोगी टीम

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ग्रुफ रीडर

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MBA 2.2 PRODUCTION MANAGEMENT

- 1. Production and Operations Management: An Overview**
- 2. Production System: Issues and Environment**
- 3. Total Quality Management**
- 4. Latest Techniques in Production Management**

This block consists of four units. The first unit gives an overview of Production and Operations Management, production process involved in converting raw materials into final product, optimal decisions related to management of production. The second unit of this block deals with issues related to production system and environment, productivity, various techniques of productivity and recent advances in production systems. The third unit discusses various aspects of Total Quality Management. Contents of this unit include the different principles and approaches towards TQM and ISO certifications. The fourth unit highlights the latest techniques in production management, including flexible manufacturing systems, CAD, CAM, Kaizen and work study.

UNIT-1

PRODUCTION AND OPERATIONS MANAGEMENT: AN OVERVIEW

OBJECTIVES

After reading this unit you should be able to know about:

- Systemic view of operations management process
- Production process involved in conversion of raw materials into a final product
- Operational decisions related to management of production
- Factors related to optimal use of resources in hand

STRUCTURE

- 1.1 Introduction
- 1.2 Systemic view of production/operations management process
- 1.3 Schematic view of production/operations management process
- 1.4 Scope of production and operations management
- 1.5 Factors of production
- 1.6 Productive use of resources
- 1.7 Environmental concerns of operations
- 1.8 Social concerns of operations
- 1.9 Strategic role of operations
- 1.10 Multidisciplinary nature of operations
- 1.11 Whither operations management in India
- 1.12 Summary
- 1.13 Self assessment test
- 1.14 Case study
- 1.15 Suggested readings

1.1 INTRODUCTION

You must be aware of the terms production, manufacturing, input and output. The products you see around in your daily life, say a mobile, a TV, a laptop, a car, etc., all are the outputs of some production process or

the other. Stated in simple terms, Production/Operations Management is the process that combines and transforms various resources used in the production/operations subsystem of an organization into value added products/services in a controlled manner, as per the policies of the organization. Therefore, it is that part of an organization, which is concerned with the transformation of a range of inputs into the required (products/services), having the requisite quality level. Let us first understand the definition, scope and significance of production/operations management.

Joseph G. Monks defines Operations Management as the process whereby resources, flowing within a defined system, are combined and transformed by a controlled manner to add value in accordance with policies communicated by the management. Operations managers are those who are concerned with planning, organizing, and controlling the activities which affect human behavior through models. According to **Albert Porter**, Operations Management is about how organizations produce or deliver the goods and services that provide the reason for their existence. Operations can be seen as one of many functions (e.g., marketing, finance, personnel) within the organization; it is that part of the organization which is devoted to the production or delivery of goods and services. **Greasley** opines that Operations Management is about the management of the processes that produce or deliver goods and services. Not every organization will have a functional department called 'operations', but they will all undertake operations activities because every organization produces goods and/or delivers services. According to **Elwood S. Buffa**, production management deals with decision-making related to production process, so that the resulting goods or services are produced according to specification in amounts and by the schedule demanded and at minimum cost.

Production Management as a functional area of management becomes an acceptable term from the 1930s to 1950s. You must be able to recall the name of F. W. Taylor, hailed as the Father of Scientific Management. As Taylor's philosophy of applying scientific principles to production techniques become more and more popular, managers developed techniques that focused on economic efficiency in manufacturing. Workers were studied in great detail to eliminate wasteful efforts and achieve greater efficiency. At the same time, psychologists, socialists and other social scientists began to study people and human behavior in the working environment. In addition, economists, mathematicians, and computer specialists contributed newer, more sophisticated analytical approaches to production.

With the 1970s emerged two distinct changes in views. The most obvious of these, reflected in the new name **Operations Management**, was a shift from manufacturing to the service sector. As the latter became more prominent, the change from 'production' to 'operations' emphasized the broadening of the field of production management to include service organizations. The second and perhaps more suitable change was the

beginning of an emphasis on synthesis, rather than just analysis, in management practices.

Manufacturing and Service Operations

Albert Porter classifies organizations in two broad categories, as either manufacturing or service. Manufacturing organizations produce physical, tangible items which can be stored as inventory before delivery to the customer. Service organizations, on the other hand, produce intangible items that cannot be produced ahead of time. One of the key developments in operations is the increasing importance of service operations as service industry accounts for an increasing proportion of the output of industrialized economies. We have already discussed the shift from manufacturing to service sector in the previous section. Let us now discuss the main implications of this shift in context of operations management. Because a service cannot be stored, its production and consumption occur at the same time. This implies that the producer of the service will come into contact with the customer. In fact, the customer will be involved to a greater or lesser extent in the actual delivery of the operation. For instance, a supermarket requires a customer to choose and transport the goods around the store and queue at an appropriate checkout point. However it should not be assumed that all employees in a service operation have to deal directly with a customer. For the supermarket example, the checkout point is an example of high customer contact, but store personnel may not have to deal directly with the customer at all. This distinction in services is denoted by 'back office' tasks which add value to the inputs of the service operation (e.g., stocktaking) and 'front office' tasks which deal with the customer both as an input and output of the operation.

Services are intangible; hence they cannot have a store of finished goods. Manufacturing operations often compensate for fluctuations in demand by fulfilling demand from finished goods inventory produced during a slack period. However, this option is not open to service operations and they must focus on trying to alter the demand pattern to meet capacity by such strategies as discounting the price of the service during periods of low demand. Because the output of a service is intangible, it is more difficult to assess performance by such measures as productivity or output. For example a manufacturer can simply count the volume of output of its product range, but an administration service for example will have more difficulty in measuring the productivity of their employees.

Activity

According to experts, service and manufacturing systems should be in tune with the process of the organization. Discuss the relevance of this statement in context of a courier company that assures delivery of a local letter within 24 hours.

1.2 SYSTEMIC VIEW OF PRODUCTION/OPERATIONS MANAGEMENT PROCESS

Let us discuss the systems view of operations management as explained by Albert Porter. A system is a group of interrelated items in which no item studied in isolation will act in the same way as it would in the system. A system is divided into a series of parts or subsystems, and any system is a part of a larger system. The system's boundary defines what is inside the system and what is outside. A system's environment is everything outside the system boundary that may have an impact on the behavior of the system. Its inputs are the physical objects of information that enter it from the environment and its outputs are the same which leave it for the environment.

The activities in an operations system can be classified as input, transformation process and output. The input activity involves two categories of resources. Transforming resources are the elements that act on, or carry out, the transformation process on other elements. These include such elements as labor, equipment/plant and energy. The nature and mix of these resources will differ between operations. The transformed resources are the elements which give the operations system its purpose or goal. The operations system is concerned with converting the transformed resources from inputs into outputs in the form of goods and services. There are three main types of transformed resource of materials which can be transformed either physically (e.g., manufacturing), by location (e.g., transportation), by ownership (e.g., retail) or by storage (e.g., warehousing), information which can be transformed by property (e.g., accountants), by possession (e.g., market research), by storage (e.g., libraries), or by location (e.g., telecommunications) and customers they can be transformed either physically (hairstylist), by storage (e.g., hotels), by location (e.g., airlines), by physiological state (e.g., hospitals), or by psychological state (e.g., entertainment). Two types of transforming resources are facilities (e.g., building and equipment) and staff (all the people involved in the operations process).

The sub-systems of a firm related to specific business disciplines are termed as the functional areas of a business. The three main functional areas in a business are operations, marketing and finance functions. The marketing function works to find and create demand for the company's goods and services by understanding customer needs and developing new markets. The need for marketing and operations to work closely together is particularly important as the marketing function will provide the forecast of demand from which operations can plan sufficient capacity in order to deliver goods and services on time. The finance function is responsible for the obtaining and controlling of funds and covering decisions such as investment in equipment and price-volume decisions. Other functions which play a supporting role in the organization include the personnel function which will play a role on the recruitment and labor relations, the research and development function which generates and

investigates the potential of new ideas and the information technology department which supplies and co-ordinates the computer-based information needs of the organization.

The relationship between functions can be seen as a number of sub-systems within the system called the 'organization'. Thus each function (e.g., marketing) can be treated using the same input/process/output transformation model as the operations function. In other words, each function within the organization can be treated as performing an operations activity, as they are transforming inputs into outputs. This implies every part of the organization is involved in the operations activity (to an external or internal customer). When we look upon operations as a function in itself, we generally refer to the part of the organization which provides goods and services for external customers.

The operations function itself is involved in all parts of the firm and thus has a major impact on the competitive position of the organization. The traditional view of the operations sub-system is that it is one function within a linear sequence of processes and is thus 'buffered' from the actions of the marketplace. Thus both physical stocks and allocation of responsibility within functions outside of operations are used to protect the operations system from the external environment. For example, the R&D function will carry responsibility for the development of new product ideas which are then 'passed on' to the operations function and the purchasing function will take responsibility for the sourcing of materials and bought-in services. Physical buffers include stocks of materials before and after the operations function to ensure stability of supply and ability to meet fluctuating demand respectively.

As proposed by Porter, the idea behind the systems approach is that the operations function can concentrate solely on transforming inputs of raw materials into goods and services, without the need to consider the external environment outside of the organizational system. The disadvantage of this model includes the slowness of response to changes in the environment as they are transmitted through various connected functions and the inability of operations to develop in response to the needs of customers. In fact, the operations function is critical in meeting customer needs and is deeply involved in the performance of the organization. For example, the parameters under which a product/service can be marketed are directly consequent on inputs from the operations functions such as flexibility affecting the product range available.

Thus instead of being seen as simply a 'black box' which takes raw materials and transforms them into a product/service, the operations function should be seen as critical to the marketing position and competitive advantage of the organization. The need for operations to improve performance across a number of attributes (e.g., quality, delivery and cost) means that competitive improvements will require long-term commitment and thus a strategic view of operations. The approach requires a commitment to quality improvement and then an improvement in other competitive factors that together will lead to a reduction in cost. This contrasts with the direct approach to cost reduction of cutting the

labor force or 'downsizing'. Apart from failing to tackle the underlying problems and increase performance across the competitive factors, this approach is limited by the fact that direct labor costs typically account for a small proportion of overall costs.

1.3 SCHEMATIC VIEW OF PRODUCTION/OPERATIONS MANAGEMENT PROCESS

Kumar and Suresh propose a schematic view of the production/operations management process with three basic stages: *planning, controlling and organizing*, explained in Figure 1.

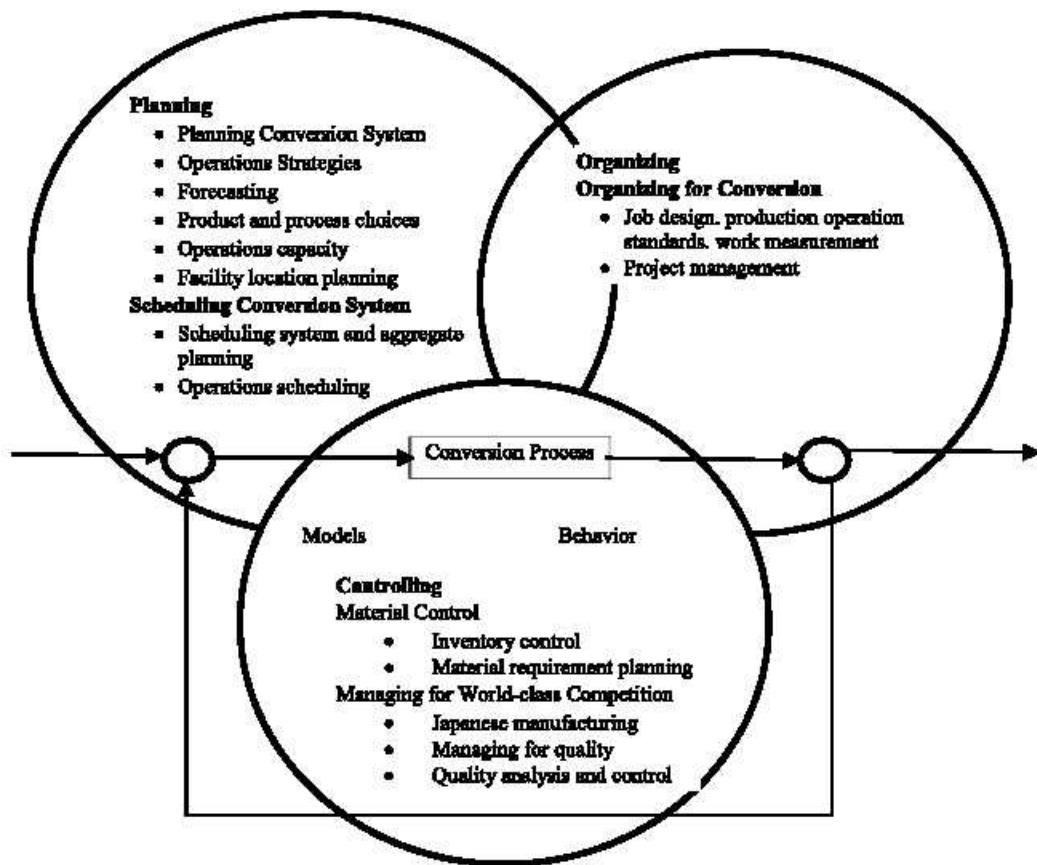


Figure 1: Schematic View of Production/Operations Management Process
Source: Kumar and Suresh (2008)

Planning

Planning encompasses activities that establish a course of action and guide future decision making. The operations manager defines the objectives for the operations sub-system of an organization, and lays down the policies and procedures for achieving these objectives. This stage includes clarifying the role and focus of operations in the organization's overall strategy. It also involves product planning, facility designing and using the conversion process.

Organizing

Organizing comprises activities that establish a structure of tasks and authority. Operations managers design a structure of roles and the flow of information within the operations sub-system. They determine the activities required to achieve the goals and assign authorities and responsibilities for carrying them out.

Controlling

Controlling includes activities that assure that actual performance is in accordance with planned performance. To ensure that the plans for the operations sub-systems are accomplished, the operations manager must exercise control by measuring actual outputs and comparing them to planned operations management. Controlling costs, quality and schedules are the important functions in this context.

Behavior

Operation managers are concerned with how their efforts to plan, organize, and control affect human behavior. They also want to know how the behavior of subordinates can affect management's planning, organizing, and controlling actions. Their interest lies in decision-making behavior.

Models

As operation managers plan, organize and control the conversion process, they encounter many problems and must make many decisions. They can simplify their difficulties using models like aggregate planning models for examining how best to use the existing capacity in short-term, break even analysis to identify break even volumes, linear programming and computer simulation for capacity utilization, decision tree analysis for long-term capacity problem of facility expansion, simple median model for determining best locations of facilities, etc.

1.4 SCOPE OF PRODUCTION AND OPERATIONS MANAGEMENT

As proposed by **Kumar and Suresh**, production and operations management is concerned with the conversion of inputs into outputs, using physical resources, so as to provide the desired utilities to the customer, while meeting the other organizational objectives of effectiveness, efficiency and adoptability. It distinguishes itself from other functions such as HR, Marketing, and Finance by its primary concern for 'conversion by using physical resources'. **Kumar and Suresh** propose the activities which are listed under production and operations management function as: location of facilities, plant layout and material handling, product design, process design, production planning and control, quality control, materials management and maintenance management. Let us discuss each of these activities as explained by **Kumar and Suresh**.

- **Location of Facilities**

Location of facilities for operations is a long term capacity decision which involves a long term commitment about the geographically static factors that affect a business organization. It is an important strategic level decision-making for an organization. It deals with the questions such as 'where our main operations should be based?'

The selection of location is a key-decision as large investment is made in building plant and machinery. An improper location of plant may lead to waste of all the investments made in plant and machinery equipments. Hence, location of plant should be based on the company's expansion plan and policy, diversification plan for the products, changing sources of raw materials and many other factors. The purpose of location study is to find the optimal location that will results in the greatest advantage to the organization.

- **Plant Layout and Material Handling**

Plant layout refers to the physical arrangement of facilities. It is the configuration of departments, work centers and equipment in the conversion process. The overall objective of plant layout is to design a physical arrangement that meets the required output quality and quantity most economically.

According to James Moore, "Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipments and all other supporting services along with the design of best structure to contain all these facilities".

Material handling refers to the moving of materials from the store room to the machine and from one machine to the next during the process of manufacture. It is also defined as the art and science of moving, packing and storing of products in any form. Material handling is a specialized activity for a modern manufacturing concern, with 50 to 75 per cent of the cost of production. This cost can be reduced by proper section, operation and maintenance of material handling devices.

Material handling devices increase the output, improve quality, speed up deliveries and decrease the cost of production. Hence, material handling is a prime consideration in the designing new plant and several existing plants.

- **Product Design**

Every business organization has to design, develop and introduce new products as a survival and growth strategy. Developing new products and launching them in the market is the biggest challenge faced by any organization. Product design deals with conversion of ideas into reality.

The entire process of need identification to physical manufactures of product involves three functions: marketing, product development, and manufacturing. Product development translates the needs of customers given by marketing into technical specifications and designing the various features into the product to these specifications. Manufacturing has the responsibility of selecting the processes by which the product can be manufactured. Product design and development provides link between marketing, customer needs and expectations and the activities required to manufacture the product.

- **Process Design**

Process design is a macroscopic decision-making of an overall process route for converting raw materials into finished goods. Decisions related to process design encompass the selection of a process, choice of technology, process flow analysis and layout of the facilities. Hence important decisions in process design include analysis of workflow for converting raw materials into finished product and selection of workstation for each included in the workflow.

- **Production Planning and Control**

Production planning and control can be defined as the process of planning the production in advance, setting the exact route of each item, fixing the starting and finishing dates for each item, giving production orders to shops, and following up the progress of products according to orders.

The principle of production planning and control lies in the statement 'First Plan Your Work and then Work on Your Plan'. Main functions of production planning and control include planning, routing, scheduling, dispatching and follow-up.

Planning is deciding in advance what to do, how to do it, when to do it and who is to do it. Planning bridges the gap from where we are, to where we want to go. It makes it possible for things to occur which would not otherwise happen. **Routing** may be defined as the selection of the path which each part of the product will follow, while being transformed from raw material to finished product. Routing determines the most advantageous path to be followed from department to department and machine to machine till raw material gets its final shape. **Scheduling** determines the program for operations. Scheduling may be defined as 'the fixation of time and date for each operation' as well as it determines the sequence of operations to be followed. **Dispatching** is concerned with starting of the processes. It gives necessary authority so as to start a particular work, which has already been planned under routing and scheduling. Therefore, dispatching is release of orders and instruction for the starting of production for any item in acceptance with the route sheet and schedule charts.

Finally, the function of **follow-up** is to report daily the progress of work in each shop in a prescribed proforma and to investigate the causes of deviations from the planned performance.

- **Quality Control**

Kumar and Suresh define Quality Control (QC) as a system that is used to maintain a desired level of quality in a product or service. It is a systematic control of various factors that affect the quality of the product. Quality control can also be defined as 'that industrial management technique by means of which product of uniform acceptable quality is manufactured'. It is the entire collection of activities which ensures that the operation will produce the optimum quality products at minimum cost. Quality control aims at prevention of defects at the source, relies on effective feedback system and corrective action procedure. The main objectives of quality control are:

To improve the income of the organization by making production more acceptable to the customers i.e., by providing longer life, greater usefulness, maintainability, etc.

- ❖ To reduce the cost of the organization through reduction of losses due to defects.
- ❖ To achieve interchangeability of manufacture in large scale production.
- ❖ To produce optimal quality at reduced price.
- ❖ To ensure satisfaction of customers with products or services of high quality, to build customer goodwill, confidence and reputation of manufacturer.
- ❖ To make inspection prompt to ensure quality control.
- ❖ To check any variation during manufacturing.

- **Materials Management**

Materials management is that aspect of management which is primarily concerned with the acquisition, control and use of materials needed, and flow of goods and services connected with the production process having some predetermined objectives in view. The main objectives of materials management are:

- ❖ To minimize material cost.
- ❖ To purchase, receive, transport and store materials efficiently and to reduce the related costs.
- ❖ To cut down costs through simplification, standardization, value analysis, import substitution, etc.

- ❖ To trace new sources of supply and to develop cordial relations with them in order to ensure continuous supply at reasonable rates.
- ❖ To reduce investment tied in the inventories for use in other productive purposes and to develop high inventory turnover ratios.
- **Maintenance Management**

In modern industries, equipment and machinery are a very important part of the total productive effort. Therefore, their idleness or downtime becomes very expensive. Hence, it is very important that the plant machinery should be properly maintained. The main objectives of maintenance management are:

 - ❖ To achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.
 - ❖ To keep the machines and other facilities in such a condition that permits them to be used at their optimal capacity without interruption.
 - ❖ To ensure the availability of machines, buildings and services required by other sections of the factory for the performance of their functions at optimal return on investment.

1.5 FACTORS OF PRODUCTION

Factors of production refer to the resources used to produce goods and services, i.e., land, labor, capital and entrepreneurship. Factors of production are also known as “productive resources.” Let us briefly discuss these factors of production now.

Land

This means the land itself and the productive natural resources occurring in nature. So soil, water, natural gas, plants and minerals like bauxite are all included in this factor of production. Every business uses some physical space, though some use more space than the others. For example, the branch of a nationalized bank in your neighborhood uses much less land than a factory manufacturing steel. In terms of economics, river, marine resources and water bodies also count as land. Land and natural resources are in limited supply. Economists use the term “rent” to describe the return (or earnings) from land as a factor of production.

Labor

Labor refers to human effort in any form, skilled or unskilled, manual or intellectual. Thus talents, training and skills of people that contribute to the production of goods and services all come under labor. Such labor can be physical or mental. Physical labor earns wages and mental labor (or

intellectual service) earns salary in return for contribution in the organization.

Capital

Capital refers to the productive resources made by past human efforts, including resources such as buildings, equipment, machinery and vehicles.

Enterprise

Geetika, Ghosh and Choudhury propose that the ability and action to collect, coordinate, and utilize all the factors of production for the purpose of economic gains is known as enterprise. The special feature of this factor of production is that the returns herein are expected, but not certain. All the other factors contribute to production process for definite returns, without any risk and uncertainty. Therefore entrepreneurship is also defined as the ability to take risk. Hence the entrepreneur's remuneration is profit, which is essentially, the residual income from business after the payment of rent, wages and interest and other related expenses.

1.6 PRODUCTIVE USE OF RESOURCES

Productivity

Productivity is defined in terms of utilization of resources, like material and labor. In simple terms, productivity is the ratio of output to input, as stated by **Kumar and Suresh**. For example, productivity of labor can be measured as units produced per labor hour worked. Productivity is closely linked with quality, technology and profitability. Hence, there is a strong stress on productivity improvement in competitive business environment. Productivity can be improved by controlling inputs, improving process so that the same input yields higher output, and by improvement of technology. Productivity can be measured at firm level, at industry level, at national level, and at international level.

Factors Affecting Productivity

Economists site a variety of reasons for changes in productivity. However some of the principle factors influencing productivity rate, as given by as given by **Kumar and Suresh** are:

- **Capital/labor ratio:** It is a measure of whether enough investment is being made in plant, machinery, and tools to make effective use of labor hours.
- **Scarcity of some resources:** Resources such as energy, water and number of metals will create productivity problems.
- **Work-force changes:** Change in work-force effect productivity to a larger extent, because of the labor turnover.
- **Innovations and technology:** This is the major cause of increasing productivity.

- **Regulatory effects:** These impose substantial constraints on some firms, which lead to change in productivity.
- **Bargaining power:** Bargaining power of organized labor to command wage increases excess of output increases has had a detrimental effect on productivity.
- **Managerial factors:** Managerial factors are the ways an organization benefits from the unique planning and managerial skills of its manager.
- **Quality of work life:** It is a term that describes the organizational culture, and the extent to which it motivates and satisfies employees.

The objective of production management is 'to produce goods services of right quality and quantity at the right time and right manufacturing cost'. Let us see how resources can be used productively, as discussed by R. N. Roy.

- **Right Quality:** The quality of any product is established based upon customers' needs. The right quality is not necessarily the best quality. It is determined by the cost of the product and the technical characteristics as suited to the specific requirements.
- **Right Quantity:** The manufacturing organization should produce the product in the right quantity. If products are produced in excess of demand, capital will be blocked up in the form of inventory and if the quantity is produced in short of demand, this leads to shortage of products.
- **Right Time:** Timeliness of delivery is one of the important parameters to judge the effectiveness of the production department. So, the production department has to make the optimal utilization of input resources to achieve its objectives.
- **Right Manufacturing Cost:** Manufacturing costs are established before the product is actually manufactured. Hence, all attempts should be made to produce the product at the pre-established level of cost, so as to reduce the variation between actual and the standard (pre-established) cost.
- **Resource Utilization:** Another major objective of operating systems is to utilize resources for the satisfaction of customers. In other words, customer service must be provided with the achievement of effective operations through efficient use of resources. Inefficient use of resources or inadequate customer service leads to commercial failure of an operating system.

Activity

Discuss how the policy of payment for overtime work can affect the long term productivity of any worker.

Kumar and Suresh state that Operations Management is concerned essentially with the utilization of resources, i.e., obtaining the maximum effect from resources or minimizing their loss, under-utilization or wastage. The extent of utilization of the resources' potential might be expressed in terms of the proportion of available time used or occupied, space utilization, levels of activity, etc. Each measure indicates the extent to which the potential or capacity of such resources is utilized. This is referred as the objective of resource utilization.

Operations management is also concerned with the achievement of both satisfactory customer service and resource utilization. An improvement in one will often give rise to deterioration in the other. Many a times both cannot be maximized, and hence a satisfactory performance must be achieved on both objectives. All the activities of operations management must be tackled with these two objectives in mind, and many of the problems will be faced by operations managers because of this conflict. Hence, operations managers must attempt to balance these basic objectives. The type of balance established both between and within these basic objectives will be influenced by market considerations, competitions, the strengths and weaknesses of the organization, etc. Hence, operations managers should make individual contributions when these objectives are set.

1.7 ENVIRONMENTAL CONCERNS OF OPERATIONS

Before we discuss the environmental concerns of operations, it would be useful to discuss the concept of globalization, and its relevance to operations. Globalization can be defined as the process in which of facilities and operations of businesses are deployed around the world. By such deployment, geographic distance undergoes diminishing importance in any organization and cross border economic, political and socio-cultural relations become increasingly important. **Slack, Chambers and Johnston** define globalization as the worldwide drive toward a globalized economic system dominated by supranational corporate trade and banking institutions that are not accountable to democratic processes or national governments.

When a firm sets up its facilities abroad, this involves some added complexities in its operations. Global markets impose new standards on quality and time. Managers should not think about domestic markets first and then global markets later, rather it could be think globally and act locally. Also, they must have a good understanding of their competitors. Some other important challenges of managing multinational operations include other languages and customs, different style of management, unfamiliar laws and regulations, and different costs. Managing global operations would focus on the following key issues:

- To acquire and properly utilize the concepts related to global operations, supply chain, logistics, etc.

- To associate global historical events to key drivers in global operations from different perspectives
- To develop criteria for conceptualization and evaluation of different global operations
- To associate success and failure cases of global operations to political, social, economic and technological environments
- To envision trends in global operations
- To develop an understanding of the world vision regardless of their country of origin, residence or studies in a respectful way of perspectives of people from different races, studies, preferences, religion, politic affiliation, place of origin, etc.

There are a number of issues that are high priorities of many business organizations, one of which is environmental concerns. Let us discuss environmental concerns of operations as discussed by Stevenson.

Concern about global warming and pollution has had an increasing effect on how businesses operate. Stricter environmental regulations, particularly in developed nations, are being imposed. Furthermore, business organizations are coming under increasing pressure to reduce their carbon footprint (i.e., the amount of carbon dioxide generated by their operations and their supply chains) and to generally operate sustainable processes. *Sustainability* refers to service and production processes that use resources in ways that do not harm ecological systems that support both current and future human existence. Sustainability measures often go beyond traditional environmental and economic measures to include measures that incorporate social criteria in decision making. All areas of business will be affected by this. Areas that will be most affected include product and service design, consumer education programs, disaster preparation and response, supply chain waste management, and outsourcing decisions. Note that outsourcing of goods production increases not only transportation costs, but also fuel consumption and carbon released into the atmosphere. Consequently, sustainability thinking may have implications for outsourcing decisions. Because they all fall within the realm of operations, operations management is central to dealing with these issues. Sometimes referred to as "green initiatives," the possibilities include reducing packaging, materials, water and energy use, and the environmental impact of the supply chain, including buying locally. Other possibilities include reconditioning used equipment (e.g., printers and copiers) for resale, and recycling.

Angell observes that as societal concerns over operational impacts on the environment expand, both business leaders and consumers are polarized by environmental issues. Some urge an immediate need to go green, while others project climate change as a fictitious, political tool. Regardless, most practitioners anticipate tightening of environmental regulations in the near future, including potential emissions trading (cap and trade) systems for controlling pollution. Such changes will most likely

transform global supply chain economics, pushing operations managers to modify production methods, outsourcing decisions, and supplier selection criteria.

Activity

What can be the major environmental factors that may govern the operations management in a steel manufacturing plant located in a densely populated area of the city?

1.8 SOCIAL CONCERNS OF OPERATIONS

As K. C. Arora has rightly observed, new technologies have made large contributions in the form of products and services to the mankind at affordable prices. These technologies have made life more comfortable and enjoyable. Along with this, the need, awareness of knowledge and information has motivated a large section of population to become literate. Especially in a country like India, the contribution of technologies in national integration is increased considerably. Large numbers of cities have been built up to act as nodal centers for development, which also reduces pressure on agriculture and agriculture-related industries.

The need for ethical conduct in business is becoming increasingly obvious, given numerous examples of questionable actions in the recent past. In making decisions, managers must consider how such decisions will affect the shareholders, management, employees, customers, the community at large, and the environment. Finding solutions that will be in the best interests of all of these stakeholders is not always easy, but it is a goal that all managers should strive to achieve. Furthermore, even managers with the best intentions will sometimes make mistakes. If mistakes do occur, managers should act responsibly to correct those mistakes as quickly as possible, and to address any negative consequences.

Operations managers, like all managers, have the responsibility to make ethical decisions. Ethical issues arise in many aspects of operations management, including:

- **Financial statements:** accurately representing the organization's financial condition.
- **Worker safety:** providing adequate training, maintaining equipment in good working condition, maintaining a safe working environment.
- **Product safety:** providing products that minimize the risk of injury to users or damage to property or the environment.
- **Quality:** honoring warranties, avoiding hidden defects.
- **The environment:** not doing things that will harm the environment.
- **The community:** being a good neighbor.

- **Hiring and firing workers:** avoiding false pretenses (e.g., promising a long-term job when that is not what is intended).
- **Closing facilities:** taking into account the impact on a community, and honoring commitments that have been made.
- **Workers' rights:** respecting workers' rights, dealing with workers' problems quickly and fairly.

Ethics is a standard of behavior that guides how one should act in various situations. Many organizations have developed codes of ethics to guide the conduct of their employees or members. Stevenson has elaborated on the five principles for thinking ethically, as identified by The Markula Center for Applied Ethics at Santa Clara University:

- **The Utilitarian Principle:** This principle states that the good done by an action should outweigh any harm it causes. An example is not allowing a person who has had too much alcohol to drive.
- **The Rights Principle:** According to this principle, actions should respect and protect the moral rights of others. An example is not taking advantage of a vulnerable person.
- **The Fairness Principle:** Equals should be held to, or evaluated by, the same standards. An example is equal pay for equal work.
- **The Common Good Principle:** As per this principle, actions should contribute to the common good of the community. An example is an ordinance on noise abatement.
- **The Virtue Principle:** Actions should be consistent with certain ideal virtues. Examples include honesty, compassion, generosity, tolerance, fidelity, integrity, and self-control.

Some of the other social issues related to operations management stated by Angell include:

Organized Labor: Organized labor persists as a prominent concern to operations. Trade unions protect worker rights yet potentially impact labor costs, productivity, adoption of technology, and overall competitiveness of domestic production. Thus, unionization presents critical considerations for outsourcing, sourcing, and production.

Immigration: Immigration, both legal and illegal, fills critical, often low-paying operations jobs in industries like agriculture and construction as well as higher-skilled labor needs in industries like technology and health care. Changes in immigration policy of a country are likely to impact labor supply and wages, subsequently affecting production methods and costs.

Labor Treatment: Labor abuses such as sweatshop, bonded, and child labor have lost our attention over the last decade, perhaps due to perceived improvements in corporate labor standards. However, such standards are generally difficult to enforce across global supply chains, and correspondingly, labor exploitation still recurs in a variety of industries, even in developed countries. From an operations management perspective,

corporate concerns over labor abuses influence sourcing decisions, labor costs, and even production methods.

Other social issues relevant to operations management include spurious goods, unethical procurement, etc.

1.9 STRATEGIC ROLE OF OPERATIONS

Primary goals of the organizations are related to market opportunities. Economy and efficiency of conversion operations are the secondary goals, which will be predominant with the study and practice of operations management, as stated by Kumar and Suresh.

A Strategic Perspective

There is a basic downward flow of strategy influence leading to managing conversion operations and results. The general thrust of the process is guided by competitive and market conditions in the industry, which provide the basis for determining the organization's strategy. Where is the industry now and where it will be in the future? What are the existing and potential markets? What market gaps exist, and what competencies do we have for filling them? A careful analysis of market segments and the ability of our competitors and ourselves to meet the needs of these segments will determine the best direction for focusing an organization's efforts. After assessing the potential within an industry, an overall organizational strategy must be developed, including some basic choices of the primary basis for competing. In doing so, priorities are established among the following four characteristics:

- i. Quality (product performance).
- ii. Cost efficiency (low product price).
- iii. Dependability (reliable, timely delivery of orders to customers).
- iv. Flexibility (responding rapidly with new products or changes in volume).

In recent years, most organizations cannot be best on all these dimensions and, by trying to do so, they end up doing nothing well. Furthermore, when a competency exists in one of these areas, an attempt to switch to a different one can lead to a downfall in effectiveness (meeting the primary objectives). Time is emerging as a critical dimension of competition in both manufacturing and service industries. In any industry the firm with the fastest response to customer demands has the potential to achieve an overwhelming market advantage. In an era of time-based competition, a firm's competitive advantage is defined by the total time required to produce a product or service.

Firms able to respond quickly have reported growth rates over three times the industry average and double the profitability. Thus the pay-off for quick response is market dominance. These basic strategic choices set the tone for the shape and content of the operations functions.

Operations Objectives

The overall objective of the operations sub-system is to provide conversion capabilities for meeting the organization's goals and strategy. The sub-goals of the operations subsystem must specify the following:

- Product/service characteristics
- Process characteristics
- Product/service quality
- Efficiency
- Effective employee relations and cost control of labor
 - ❖ Cost control of material
 - ❖ Cost control in facility utilization
- Customer service (schedule)
 - ❖ Producing quantities to meet expected demand
 - ❖ Meeting the required delivery date for goods or services
- Adaptability for future survival

The priorities among these operations' sub-goals and their relative emphases should be direct reflections of the organization's mission. Relating these six operations sub-goals to the broader strategic choices above, it is clear that quality, efficiency, and dependability (customer service) are reflected in the sub-goals. Flexibility encompasses adaptability but also relates to product/service and process characteristics: Once choices about product and process are made, boundaries for meeting the other operations objectives are set.

Operations Alternatives and Tradeoffs

The operations sub-goals can be attained through the decisions that are made in the various operations areas. Each decision involves important tradeoffs between choices about product and process versus choices about quality, efficiency, schedule and adaptability. Once a decision is made, it leads to many choices. Where should facilities be located? How large should they be? What degree of automation should be used? How skilled must labor be to operate the automated equipment? Will the product be produced on site? How do these decisions impact quality, efficiency, schedule (customer service), and adaptability? Are we prepared for changes in product or service, or do these decisions lock in our operations? These are examples of the tough, crucial tradeoffs that are at the heart of understanding the choices that must be made when planning strategically and tactically.

Strategic Planning

Strategic planning is the process of thinking through the current mission of the organization and the current environmental conditions facing it, and then setting forth a guide for tomorrow's decisions and results, point out

Kumar and Suresh. Strategic planning is built on fundamental concepts: those current decisions are based on future conditions and results.

Strategic Planning for Production and Operations

In the production or operations function, strategic planning is the broad, overall planning that precedes the more detailed operational planning. Executives who head the production and operations function are actively involved in strategic planning, developing plans that are consistent with the firm's overall strategies as well as such functions as marketing, finance accounting and engineering. Production and operations strategic plans are the basis for (1) operational planning of facilities (design) and (2) operational planning for the use of these facilities.

Strategic Planning Approaches for Production/Operations

Henry Mintzberg suggests three contrasting modes of strategic planning: the entrepreneurial, the adaptive, and the planning modes. In the entrepreneurial mode, one strong, bold leader takes planning action on behalf of the production/operations function. In the adaptive mode, a manager's plan is formulated in a series of small, disjointed steps in reaction to a disjointed environment. The planning model uses planning essentials combined with the logical analysis of management science.

There are many approaches to strategic planning. The key point is that operations strategies must be consistent with the overall strategies of the firm. Operations typically utilize the overall corporate approach to strategic planning, with special modifications and a focus upon operations issues and opportunities. One general approach to strategic planning is a forced choice model given by Adam and Ebert.

1.10 MULTIDISCIPLINARY NATURE OF OPERATIONS

In operations the design of the process is categorized into manufacturing and services types, propose **Kumar and Suresh**. The choice of process design depends on the volume and variety of the product or service that an organization offers. Generally manufacturing and services providers serve their customers on a continuum between a combination of low variety and high volume products and services to a combination of high variety and low volume products and services.

Manufacturing Process Types

In manufacturing, process types can be considered under the five categories of project, jobbing, batch, mass and continuous. A description of each process type is given here, followed by examples of where each process type might be used.

- **Project:** A project process is used to make a one-off product to a customer specification. An important feature of a project process is that the location of the product is stationary. Examples of the use

of a project process include building construction, movie film production, and custom-built furniture.

- **Jobbing:** Jobbing processes are used to make a one-off or low volume product to a customer specification. Generally these products are of high variety and low volume. The product moves to the location of transforming resources such as equipment. Examples of the use of a jobbing process include bespoke tailors and precision engineers.
- **Batch:** Processes producing products of medium variety and medium volume are termed 'batch'. Batch processes cover a relatively wide range of volume and variety combinations. Products are grouped into batches whose batch size can range from two to hundreds. Examples of use of a batch process include vehicle component assembly and clothing manufacture.
- **Mass:** A mass or line process produces products of high volume and low variety. The process of production will essentially be the same for all the products. Hence it is cost effective to use specialized labor and equipment. Examples of the use of a mass process include vehicle manufacturing and assembly of consumer durables such as televisions.
- **Continuous:** A continuous process operates continually to produce a very high volume of a standard product. The products produced by a continuous operation are usually as a continuous flow, rather than in discrete items, such as oil and gas. Examples of a continuous process include oil refining, electricity production and steel making.

Service Process Types

The classification of service process types is more recent and less standardized than manufacturing process types outlined above and so differs between textbooks. The classification used here is of three service process types – professional service, service shop and mass service – which are categorized in terms of their ability to cope with different volume and variety characteristics.

Companies may also use a combination of process types, for example jobbing and batch, for different product lines within a manufacturing plant. In services there may also be a mix of process types, with front office customer-facing activities undertaken as a professional service, whilst back-office operations are organized as a service shop.

- **Professional Service:** Professional service is characterized by high levels of customization, in which each service delivery will be tailored to meet individual customer needs. Professional service is also characterized by high levels of customer contact and a relatively high proportion of staff supplying the service in relation to customers. Examples include management consultancy, doctors and health and safety inspectors.

- **Service Shop:** Service shop processes operate with a medium amount of variety and volume. There will therefore be a mix of staff and equipment used to deliver the service. Examples of service shops include banks, shops, restaurants and travel agencies.
- **Mass Service:** Mass service processes operate with low variety and high volume. There will be little customization of the service to individual customer needs and limited contact between the customer and people providing the service. Examples of mass service providers are supermarkets, rail services and airports.

Choosing a Process Type

Slack, Chambers and Johnston propose that the main difficulty of choice of process type is that process decisions can take a relatively large amount of time and money to implement, whereas market needs in a competitive environment can change rapidly. The choice of process type for a process may also change over time. This may occur either at the level of the organization or at an individual product or service level. At the level of the organization, a company may be following a growth strategy, which involves standardization of its product or services or a strategy for increasing the range of products and services to avoid competing on price alone. At the level of the individual product or service, there may be a repositioning of that product or service in the marketplace at a new volume/variety mix. Also within the portfolio of products and services that an organization delivers, an individual product or service will progress through a lifecycle in terms of sales, from introduction to maturity to decline. The process that best suits the needs of the firm must yield to changes to match the volume and variety of the output.

Project processes produce products of high variety and low volume. A feature of a project process is that the location of the product is stationary.

Activity

Discuss how the interdisciplinary nature of Operations Management can help in relating the Production Department to the other functional divisions (like HR, Marketing, etc.) of any firm?

1.11 WHITHER OPERATIONS MANAGEMENT IN INDIA

Laudon and Laudon observe that the opening up of the Indian economy with liberalization and globalization has offered new vistas to Indian industry. Having accepted the challenges therein, the thrust of the industry is moving towards improving quality, cost and response time. Manufacturing competence is a strategic goal of organizations by better management of technology, supply chains and other resources.

Currently there is a growing demand for professionals in managing services, especially in industries like banking, insurance, health care, transport, educational and general management consultancy. The focus is on improving quality of service rendered by better response time/reduction of delays and waiting time. Because of global competitive pressures, manufacturing organizations are finding it worthwhile to develop their manufacturing base in India, especially for manufacturing of automobile and electronic components. This has resulted in growing awareness about operations management in the small and medium sectors. This is supplemented by the fast growth of IT, which has made it feasible to have plants at multiple locations.

Recent developments in the area of operations management in countries like Japan, Korea and Singapore seem to have influenced Indian industry to maintain competitive edge on a global scale. Techniques and practices like quality circles, *kaizen*, suggestion schemes, motivational schemes, etc., adopted by the industries in these countries in developing their human resources, are being actively pursued by the practitioners in India.

Prem Vrat (1998) refers that the academia and industry interaction in India is intended to synergize for mutual benefits and is now increasingly being emphasized by both. Academia is helping industry by organizing in-house training, short-term courses and by taking consultancy assignments. Industry help is being sought by academics, particularly for developing course curricula. Recently, in an EU sponsored project on total quality management, industry was very closely associated with IIT in developing curriculum for TQM at undergraduate level.

The major strength in India in the area of operations management is its highly trained faculty in institutions, particularly IITs and IIMs to train and develop the students and practicing executives from industry. One major weakness in the area of operations management is the non-availability of operations management software packages, mainly owing to resource constraints. This seriously limits the study and analysis of manufacturing systems for their better design and operations using computers, despite the easy availability of PCs.

1.12 SUMMARY

Operations Management is the process whereby resources, flowing within a defined system, are combined and transformed by a controlled manner to add value in accordance with policies communicated by the management. The systems view of operations stresses on the input and output process of the whole system, where raw material is converted into final product with the help of planning, organizing and controlling. Scope of production and operations management is concerned with location of facilities, plant layout and material handling, product design, process design, production planning and control, quality control, materials management and maintenance management. Productivity of labor can be measured as units

produced per labor hour worked. Factors influencing productivity are right quality, right quantity, right time, right manufacturing cost and resource utilization. Multidisciplinary nature of operations includes manufacturing process types, service process types and operations process types. With liberalization and globalization, the Indian economy is currently experiencing a growing demand for professionals in managing services, especially in industries like banking, insurance, health care, transport, educational and general management consultancy. Overall, the scope of operations is increasing in India.

1.13 SELF ASSESSMENT TEST

1. Define Production and Operations Management? Explain the difference between Operations and Services.
2. Explain the systems view of operations with diagram.
3. Explain how productivity helps an organization to attain the competitive edge in engineering industries.
4. What do you know about operations strategy? Explain about services operation strategy?
5. What are the environmental concerns of operations? What role do ethics play in operations management?
6. Explain the multidisciplinary nature of operations management?

1.14 CASE STUDY

Sheena

Sheena had worked for the same Fortune 500 Company for almost 15 years. Although the company had gone through some tough times, things were starting to turn around. Customer orders were up, and quality and productivity had improved dramatically from what they had been only a few years earlier, due to company-wide quality improvement programs. So, it came as a real shock to Sheena and about 400 of her co-workers when they were suddenly terminated following the new CEO's decision to downsize the company.

After recovering from the initial shock, Sheena tried to find employment elsewhere. Despite her efforts, after eight months of searching, she was no closer to finding a job than the day she started. Her funds were being depleted and she was getting more discouraged. There was one bright spot, though: she was able to bring in a little money by mowing lawns for her neighbors. She got involved quite by chance when she heard one neighbor commented that now that his children were on their own, nobody was around to cut the grass. Almost jokingly, Sheena asked him how much he'd be willing to pay. Soon Sheena was mowing the lawns of five neighbors. Other neighbors wanted her to work on their

lawns, but she didn't feel that she could spare any more time from her job search.

However, as the rejection letters began to pile up, Sheena knew she had to make an important decision in her life. On a rainy Tuesday morning, she decided to go into business for herself taking care of neighborhood lawns. She was relieved to give up the stress of job hunting, and she was excited about the prospects of being her own boss. But she was also fearful of being completely on her own. Nevertheless, Sheena was determined to make a go of it.

At first, business was a little slow, but once people realized Sheena was available, many asked her to take care of their lawns. Some people were simply glad to turn the work over to her; others switched from professional lawn care services. By the end of her first year in business, Sheena knew she could earn a living this way. She also performed other services such as fertilizing lawns, weeding gardens, and trimming shrubbery. Business became so good that Sheena hired two part-time workers to assist her and, even then, she believed she could expand further if she wanted to.

Questions

- Q1.** In what ways are Sheena's customers most likely to judge the quality of her lawn care services?
- Q2.** Sheena is the operations manager of her business. Among her responsibilities are forecasting, inventory management, scheduling, quality assurance, and maintenance.
 - a.** What kinds of things are likely to require forecasts?
 - b.** What inventory items does Sheena probably have? Name one inventory decision she has to make periodically.
 - c.** What scheduling must she do? What things might occur to disrupt schedules and cause Sheena to reschedule?
 - d.** How important is quality assurance to Sheena's business? Explain.
 - e.** What kinds of maintenance must be performed?

[Source: *William J. Stevenson, Production/Operations Management, Irwin/McGraw-Hill*]

1.15 SUGGESTED READINGS

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UNIT – 2

PRODUCTION SYSTEM: ISSUES AND ENVIRONMENT

OBJECTIVES

After reading this unit you should be able to know about:

- Production functions and role of production management
- Systems view point of production management
- Productivity, its associated factors and techniques of productivity
- Recent advances in production systems

STRUCTURE

- 2.1 Introduction
- 2.2 Role of production management
- 2.3 Production/operations management: a systems view point
- 2.4 Production system design
- 2.5 Productivity improvement
- 2.6 Upcoming issues of production systems
- 2.7 Production system and information technology
- 2.8 Summary
- 2.9 Self assessment test
- 2.10 Case study
- 2.11 Suggested readings

2.1 INTRODUCTION

Geetika, Ghosh and Roy Chowdhury define production as the process of transformation of resources (like land, labor, capital and entrepreneurship) into goods and services of utility to consumers and/or producers. It is the process of creation of value or wealth through the production of goods and services that have economic value to either consumers or other producers. Such process of adding value may occur by change in form (input to output, say steel into car), or by change in place (supply chain, say from factory to dealers/retailer), or by changing hands

(exchange, say from retailer to consumer). Here we shall remind you that as by product we mean services as well, similarly by production we imply providing services as well. Production of goods includes all tangible items such as furniture, house, machine, food, car, television and so on; services include all intangible items, like banking, education, management, consultancy, transportation. Production is defined by **Kumar and Suresh** as 'the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user'. **Buffa** defines production as 'a process by which goods and services are created'.

Kumar and Suresh define production function as 'the part of an organization, which is concerned with the transformation of a range of inputs into the required outputs (products) having the requisite quality level'. According to **Geetika, Ghosh and Roy Chowdhury**, a production function is the technical relationship between inputs and output. A commodity may be produced by various methods using different combinations of inputs, with given state of technology. Take the example of cloth; it may be produced using cotton or silk or polymer as raw material with handloom, power loom or even computerized machines. You can see that various types of raw materials and technology options will create several possible ways of producing the same product. Hence there can be several technically efficient methods of production. Production function includes all such technically efficient methods. It can be said that production function is purely a technological relationship between physical inputs and physical outputs over a given period of time. With a given set of technology and a given period of time, production is a function of inputs, their quality and quantity and interrelation, i.e. complementarities and substitutability.

2.2 ROLE OF PRODUCTION MANAGEMENT

The primary role of production/operations management in an organization is that of planning or decision making. As **Stevenson** points out, the operations manager exerts considerable influence over the degree to which the goals and objectives of the organization are realized. Most decisions in production/operations management involve many possible alternatives that can have quite different impacts on costs or profits. Consequently, it is important to make informed decisions. Operations management professionals make a number of key decisions that affect the entire organization. These include the following:

What: What resources will be needed, and in what amounts?

When: When will each resource be needed? When should the work be scheduled? When should materials and other supplies be ordered? When is corrective action needed?

Where: Where will the work be done?

How: How will the product or service be designed? How will the work be done (organization, methods, equipment)? How will resources be allocated?

Who: Who will do the work?

2.3 PRODUCTION/OPERATIONS MANAGEMENT: A SYSTEMS VIEW POINT

Following Stevenson, a system can be defined as a set of interrelated parts that must work together. A business organization can be thought of as a system composed of subsystems (e.g., marketing sub-system, operations sub-system, and finance sub-system), which in turn are composed of lower sub-systems. The systems approach emphasizes interrelationships among sub-systems, but its main theme is that the whole is greater than the sum of its individual parts. Hence, from a systems viewpoint, the output and objectives of the organization as a whole take precedence over those of any one sub-system. An alternative approach is to concentrate on efficiency within subsystems and thereby achieve overall efficiency. However, this approach overlooks the facts that organizations must operate in an environment of scarce resources and that subsystems are often in direct competition for those scarce resources, so that an orderly approach to the allocation of resources is called for.

Kumar and Suresh refer to a production system as 'that part of an organization, which produces products of an organization. It is that activity whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management'. Global competition and outsourcing are increasing the length of companies' supply chains, making it more important than ever for companies to use a systems approach to take the "big picture" into account in their decision making. A systems approach is essential whenever something is being designed, redesigned, implemented, improved, or otherwise changed. It is important to take into account the impact on all parts of the system. Figure 1 depicts the systems view of production management.

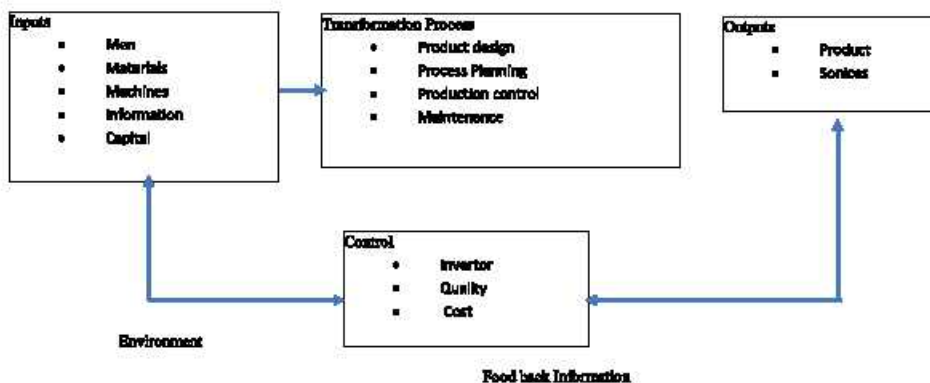


Figure 1: Production/ Operations Management: A Systems View Point
(Source: Kumar and Suresh)

A production system has the following characteristics:

- i. Production is an organized activity, so every production system has an objective.
- ii. The system transforms the various inputs to useful outputs.
- iii. It does not operate in isolation from the other organization system.
- iv. There exists a feedback about the activities, which is essential to control and improve system performance.

2.4 PRODUCTION SYSTEM DESIGN

Classification of Production System

Production systems can be classified as Job-shop, Batch, Mass and Continuous production systems. Let us discuss each of these types following Kumar and Suresh. The graph between Production/Operation Volume and Output/Product Variety is given in Figure 2.

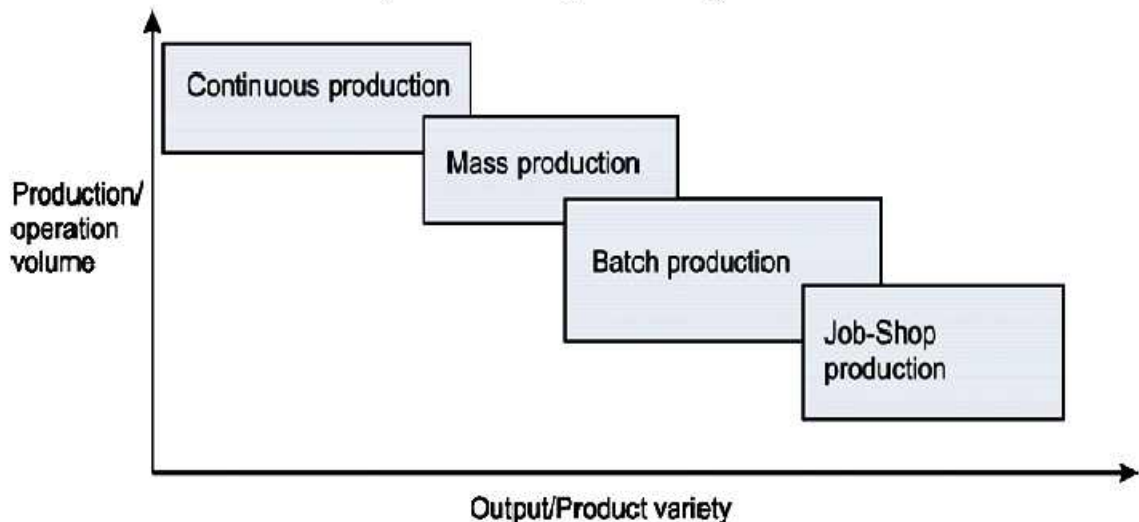


Figure 2: Graph between Production/Operation Volume and Output/Product
(Source: Kumar and Suresh)

I. Job-Shop Production

Job-shop production is characterized by manufacturing of one or few products designed and produced as per the specification of customers within prefixed time and cost. The distinguishing feature of job-shop production is low volume and high variety of products.

A job-shop comprises of general-purpose machines arranged into different departments. Each job demands unique technological requirements and demands processing on machines in a certain sequence. Job-shop production is characterized by:

- High variety of products and low volume.
- Use of general purpose machines and facilities.

- Highly skilled operators who can take up each job as a challenge because of its uniqueness.
- Large inventory of materials, tools and parts.
- Detailed planning for sequencing the requirements of each product, capacities for each work centre and order priorities.

Advantages

- Because of general purpose machines and facilities, a variety of products can be produced.
- Operators will become more skilled and competent, as each job gives them learning opportunities.
- Full potential of operators can be utilized.
- Job-shop production promises opportunity for creative methods and innovative ideas.

Limitations

- Higher cost due to frequent set up changes.
- Higher level of inventory at all levels and hence higher inventory cost.
- Production planning is complicated.
- Larger space requirements.

II. Batch Production

American Production and Inventory Control Society (APICS) define batch production as a form of manufacturing in which the job passes through the functional departments in lots or batches and each lot may have a different routing. It is characterized by the manufacture of limited number of products produced at regular intervals and stocked awaiting sales. Batch production is characterized by:

- Shorter production runs.
- Flexibility in plant and machinery.
- Plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.
- Manufacturing lead-time and cost are lower as compared to job-order production.

Advantages

- Better utilization of plant and machinery.
- Promotes functional specialization.
- Cost per unit is lower as compared to job order production.

- Lower investment in plant and machinery.
- Flexibility to accommodate and process number of products.
- Job satisfaction exists for operators.

Limitations

- Material handling is complex because of irregular and longer flows.
- Production planning and control is complex.
- Work-in-process inventory is higher compared to continuous production.
- Higher set up costs due to frequent changes in set up.

III. Mass Production

Manufacturing of discrete parts or assemblies using a continuous process comprise mass production. This type of production system is justified by very large volume of production. Machines are arranged in a line or product layout. Product and process standardization exists and all outputs follow the same path. Mass production is characterized by:

- Standardization of product and process sequence.
- Dedicated special purpose machines having higher production capacities and output rates.
- Large volume of products.
- Shorter cycle time of production.
- Lower in process inventory.
- Perfectly balanced production lines.
- Flow of materials, components and parts is continuous and without any back tracking.
- Production planning and control is easy.
- Material handling can be completely automatic.

Advantages

- Higher rate of production with reduced cycle time.
- Higher capacity utilization due to line balancing.
- Less skilled operators are required.
- Low process inventory.
- Manufacturing cost per unit is low.

Limitations

- Breakdown of one machine will stop an entire production line.
- Line layout needs major change with the changes in the product design.
- High investment in production facilities.
- The cycle time is determined by the slowest operation.

IV. Continuous Production

In continuous production, the production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc. Continuous production is characterized by:

- Dedicated plant and equipment with zero flexibility.
- Material handling is fully automated.
- Process follows a predetermined sequence of operations.
- Component materials cannot be readily identified with final product.
- Planning and scheduling is a routine action.

Advantages

- Standardization of product and process sequence.
- Higher rate of production with reduced cycle time.
- Higher capacity utilization due to line balancing.
- Manpower is not required for material handling as it is completely automatic.
- Person with limited skills can be used on the production line.
- Unit cost is lower due to high volume of production.

Limitations

- Flexibility to accommodate and process number of products does not exist.
- Very high investment for setting flow lines.
- Product differentiation is limited

Activity

Discuss the interrelationship between quality and productivity for any conventional job shop assembly.

2.5 PRODUCTIVITY IMPROVEMENT

Productivity, as defined by R. N. Roy, is the quantitative relation between what we produce and we use as a resource to produce them, i.e., the arithmetic ratio of amount produced (output) to the amount of resources (input). In other words, productivity can be expressed as:

$\text{Productivity} = \text{Output} / \text{Input}$

Productivity refers to the efficiency of the production system. It is the concept that guides the management of production system. It is an indicator to how well the factors of production (land, capital, labor and energy) are utilized. The European Productivity Agency (EPA) has defined productivity as:

“Productivity is an attitude of mind. It is the mentality of progress, of the constant improvements of that which exists. It is the certainty of being able to do better today than yesterday and continuously. It is the constant adaptation of economic and social life to changing conditions. It is the continual effort to apply new techniques and methods. It is the faith in progress.”

A major problem with productivity is that it means many things to many people. Economists determine it from Gross National Product (GNP), managers view it as cost cutting and speed up, engineers think of it in terms of more output per hour. But the generally accepted meaning is that it is the relationship between goods and services produced and the resources employed in their production.

Factors Increasing Productivity

Factors increasing productivity can be classified broadly into two categories: controllable (or internal) factors and uncontrollable (or external) factors.

I. Controllable (or Internal) Factors

- **Product factor:** Product factor means the extent to which the product meets output requirements, and the product is judged by its usefulness. The cost benefit factor of a product can be enhanced by increasing the benefit at the same cost or by reducing cost for the same benefit.
- **Plant and equipment:** These play a prominent role in enhancing the productivity. The increased availability of the plant through proper maintenance and reduction of idle time increases the productivity. Productivity can be increased by paying proper attention to utilization, age, modernization, cost, investments, etc.
- **Technology:** Innovative and latest technology improves productivity to a greater extent. Automation and information technology help to achieve improvements in material handling, storage, communication system and quality control. The various aspects of technology factors to be considered

are: size and capacity of the plant, timely supply and quality of inputs, production planning and control, repairs and maintenance, waste reduction, and efficient material handling system.

- **Material and energy:** Efforts to reduce materials and energy consumption bring about considerable improvement in productivity. Such efforts include selection of quality material and the right material, control of wastage and scrap, effective stock control, development of sources of supply, optimum energy utilization, and energy savings.
- **Human factors:** Productivity is basically dependent upon human competence and skill. Ability to work effectively is governed by various factors such as education, training, experience, aptitude, etc., of employees. Motivation of employees will influence productivity.
- **Work methods:** Improving the ways in which the work is done (methods) improves productivity. Work study, industrial engineering techniques and training are the areas which improve work methods, which in turn enhance productivity.
- **Management style:** • Management style influences the organizational design, communication in the organization, policies and procedures. A flexible and dynamic management style is a better approach to achieve higher productivity.

II. Uncontrollable (or External) Factors

- **Structural adjustments:** Structural adjustments include both economic and social changes. Economic changes that influence productivity significantly include shift in employment from agriculture to manufacturing industry, import of technology and industrial competitiveness.

Social changes such as women's participation in the labor force, education, cultural values, and attitudes are some of the factors that play a significant role in the improvement of productivity.

- **Natural resources:** Manpower, land and raw materials are vital to productivity improvement.
- **Government and infrastructure:** Government policies and programmes play a significant role in increasing productivity. Policies of government agencies in sectors like transport, communication, power, fiscal policies (interest rates and taxes) influence productivity to a great extent.

Activity

Discuss long term employee welfare and productivity increase with relation to the modern productivity management tools.

Productivity Improvement Techniques (on the basis of Process Improvement)

A. Technology-Based

i. Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM)

According to Kumar and Suresh, CAD refers to design of products, processes or systems with the help of computers. The impact of CAD on human productivity is significant, because of the advantages of speed of evaluation of alternative designs, minimization of risk of functioning, and reduction of errors. CAM is useful in designing and controlling manufacturing. It helps to achieve the effectiveness in production system by line balancing. It also includes the following concepts of assembly line optimization: Production Planning and Control, Capacity Requirements Planning (CRP), Manufacturing Resources Planning and Materials Requirement Planning (MRP), and Automated Inspection.

ii. Computer Integrated Manufacturing

Computers have had a dramatic impact on the development of production automation technologies. Nearly all modern production systems are implemented today using computer systems. The term Computer Integrated Manufacturing (CIM) has been coined to denote the pervasive use of computers to design products, plan production, control operations, and perform various business related functions needed in a manufacturing firm. Computer Integrated Manufacturing is characterized by automatic line balancing, machine loading (scheduling and sequencing), automatic inventory control and inspection. The techniques used in CIM on conventional assembly line include Robotics, laser technology, modern maintenance techniques, energy technology, and Flexible Manufacturing System (FMS).

B. Employee-Based

1. Financial and non-financial incentives at individual and group level
2. Employee promotion
3. Job design, job enlargement, job enrichment and job rotation
4. Worker participation in decision-making
5. Quality Circles (QC), Small Group Activities (SGA)
6. Personal development

C. Material-Based

1. Material planning and control
2. Purchasing, logistics

3. Material storage and retrieval
 4. Source selection and procurement of quality material
 5. Waste elimination
- D. Process-Based**
1. Methods engineering and work simplification
 2. Job design evaluation, job safety
 3. Human factors engineering
- E. Product-Based**
1. Value analysis and value engineering
 2. Product diversification
 3. Standardization and simplification
 4. Reliability engineering
 5. Product mix and promotion
- F. Task-Based**
1. Management style
 2. Communication in the organization
 3. Work culture
 4. Motivation
 5. Promotion group activity

Activity

Discuss and categorize the different productivity improvement tools for the BPO industry.

2.6 UPCOMING ISSUES OF PRODUCTION SYSTEMS

Upcoming International Dimensions of Productivity

Kumar and Suresh observe that industrialized nations are developing two broad strategies to remain competitive in market: moving to new and more advanced products, and employing a better and more flexible system. Let us discuss both these strategies.

i. New Products

High volume products like steel, textiles, etc. which constitute an industrial base are not secure. Nations such as Japan, France and West Germany are shifting their industrial base towards products and processes that make better use of their research capabilities

and skilled workers. Their future lies in microelectronics, precision manufactured castings, specialty steels, custom fabrics, fiber optics, lasers, etc.

ii. Trend towards More Flexible Systems

Production runs of higher valued specialty items and custom designed products are often much shorter than for traditional mass produced goods. But the non-productive time (i.e., downtime) required in setting up equipment for producing different options, new models and new products are very costly. So production facilities must be designed with the utmost flexibility to accommodate change over in rapid fashion. This is where computers and robotics come into play.

In recent years, the managerial techniques and productivity methods in Japanese firms have attracted worldwide attention. Following are some of the characteristics of Japanese firms as compared with their American counterparts.

- **Corporate objectives:** Employees and customers are given priority over shareholders. Honesty in business is important.
- **Time horizon:** Long-term viability is more important than short-term profits.
- **Production systems:** Production systems are largely automated, with extensive use of microprocessors and robotics. Quality is paramount, and things happen as per schedule.
- **Employment relations:** Long-term employment of loyal workers and cooperation of trade unions for the benefit of the total firm are significant features of employment relations. Politeness and harmony in interpersonal relations are emphasized.
- **Materials:** Resources are limited; hence space is used efficiently and inventories are kept to a bare minimum.
- **Financing:** More use is made of debt capital and less of equity capital.
- **Training:** Employees are thoroughly trained and rotated to learn a variety of skills.
- **Worker participation:** Employees are encouraged to contribute to productivity improvement via suggestions, quality circles and consultation with supervisors.

2.7 PRODUCTION SYSTEM AND INFORMATION TECHNOLOGY

The section is divided in two portions: Automation and System-based Information Technology Approaches.

A. Automation

Roy (2005) stresses that automation is a technology concerned with the application of mechanical, electronic, and computer based systems to operate and control production. This technology includes automatic machine tools to process parts, automatic assembly machines, industrial robots, automatic material handling and storage systems, automatic inspection systems for quality control, feedback control and computer process control, computer systems for planning, data collection, and decision-making to support manufacturing activities. Automated production systems can be classified into three basic types: fixed automation, programmable automation, and flexible automation. Let us discuss each in details.

i. Fixed Automation

It is a system in which the sequence of processing (or assembly) operations is fixed by the equipment configuration. The operations in the sequence are usually simple. It is the integration and coordination of many such operations into one piece of equipment that makes the system complex. The typical features of fixed automation are:

- High initial investment for custom-engineered equipment
- High production rates, and
- Relatively inflexible in accommodating product changes.

The economic justification for fixed automation is found in products with very high demand rates and volumes. The high initial cost of the equipment can be spread over a very large number of units, thus making the unit cost attractive, as compared to other alternative methods of production. Examples of fixed automation include mechanized assembly and machining transfer lines.

ii. Programmable Automation

In this system the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a program, which is a set of instructions coded so that the system can read and interpret them. New programs can be prepared and entered into the equipment to produce new products. Some of the features that characterize programmable automation are:

- High investment in general-purpose equipment
- Low production rates relative to fixed automation
- Flexibility to deal with changes in product configuration, and
- Most suitable for batch production.

Automated production systems that are programmable are used in low and medium volume production. The parts or products are typically made in batches. To produce each new batch of a different product, the

system must be reprogrammed with the set of machine instructions that correspond to the new product. The physical setup of the machine must also be changed over. Examples of programmed automation include numerically controlled machine tools and industrial robots.

iii. Flexible Automation

It is an extension of programmable automation. A flexible automated system is one that is capable of producing a variety of products (or parts) with virtually no time lost for changeovers from one product to the next. There is no production time lost while reprogramming the system and altering the physical setup (tooling, fixtures, and machine setting). Consequently, the system can produce various combinations and schedules of products instead of requiring that they be made in separate batches. The features of flexible automation can be summarized as follows:

- High investment for a custom-engineered system
- Continuous production of variable mixtures of products
- Medium production rates, and
- Flexibility to deal with product design variations.

The essential features that distinguish flexible automation from programmable automation are: the capacity to change part programs with no lost production time, and the capability to changeover the physical setup, again with no lost production time. These features allow the automated production system to continue production without the downtime between batches that is a characteristic of programmable automation. Changing the part programs is generally accomplished by preparing the programs off-line on a computer system and then electronically transmitting the programs to the automated production system. Therefore, the time required to do the programming for the next job does not interrupt production on the current job. Advances in computer systems technology are largely responsible for this programming capability in flexible automation.

We have already discussed CIM in details in a previous section. A good relationship exists between automation and CIM with a conceptual model of manufacturing. In a manufacturing firm, the physical activities related to production that take place in the factory can be distinguished from the information-processing activities. The physical activities include all of the manufacturing processing, assembly, materials handling and inspections that are performed on the product. These operations come in direct contact with the physical activities during manufacturing. Raw materials flow in one end of the factory and finished products flow out of the other end. The physical activities (processing, handling, etc.) take place inside the factory. The information-processing functions form a ring that surrounds the factory, providing the data and knowledge required to produce the product successfully. These information processing functions include: business activities, product design, manufacturing planning, and

manufacturing control. These four information processing functions form a cycle of events that must accompany the physical production activities.

Activity

“Modern productivity analysis is more concerned with service sector and its modulation according to the new concepts of productivity”. Do you agree with this statement? Argue.

Reasons for Automation

Shimon states the following reasons for automation:

- **Increased productivity:** Automation of manufacturing operations holds the promise of increasing the productivity of labor. This means greater output per hour of labor input. Higher production rates (i.e., output per hour) are achieved with automation than with the corresponding manual operations.
- **High cost of labor:** The trend in the industrialized societies of the world has been towards cutting down on ever-increasing labor costs. High cost of labor is forcing business leaders to substitute machines for human labor. As a result, higher investment in automated equipment has become economically justifiable to replace manual operations. Because machines can produce at higher rates of output, the use of automation results in a lower cost per unit of product.
- **Labor shortage:** In many advanced nations there has been a general shortage of labor. Labor shortage stimulates the development of automation as a substitute for labor.
- **Trend of labor toward the service sector:** This trend has been especially prevalent in India. There are also social and institutional forces that are responsible for such trend. There has been a tendency for people to view factory work as tedious, demeaning, and dirty. This view has caused them to seek employment in the service sector of the economy, with the government and in sectors like insurance, personal services, legal, sales, etc. Hence, the proportion of the workforce employed in manufacturing is reducing.
- **Safety:** By automating the operation and transferring the operator from an active participation to a supervisory role, work is made safer.
- **High cost of raw materials:** High cost of raw materials in manufacturing results in the need for greater efficiency in using these materials. Reduction of scrap is one of the benefits of automation.

- **Improved product quality:** Automated operations not only produce parts at faster rates, but they also produce parts with greater consistency and conformity to quality specifications.
- **Reduced manufacturing lead time:** With reduced manufacturing lead time automation allows the manufacturer a competitive advantage in promoting good customer service.
- **Reduction of in-process inventory:** Holding large inventories of work-in-process represents a significant cost to the manufacturer because it ties up capital. In-process inventory is of no value. It serves none of the purposes of raw materials stock or finished product inventory. Automation tends to accomplish this goal by reducing the time a work part spends in the factory.
- **High cost of not automating:** A significant competitive advantage is gained by automating a manufacturing plant. The benefits of automation show up in intangible and unexpected ways, such as, improved quality, higher sales, better labor relations, and better company image.

All of these factors act together to make production automation a feasible and attractive alternative to manual methods of manufacturing.

B. System-based Information Technology Approaches

Roy (2005) indicates that the designing of system approaches based on Information Technology is mainly based on Materials Requirements Planning (MRP) and Enterprise Resource Planning (ERP). Let us discuss each of these concepts here.

Materials Requirements Planning (MRP)

Materials Requirements Planning (MRP) is an information system used to calculate the requirements for component materials needed to produce end items. These components have what is called 'dependent demand'. A dependent demand item has a demand which is relatively predictable because it is dependent on other factors. Three main components of the MRP system are Master Production Schedule (MPS), Bill of Materials (BOM), and MRP implementation. Let us describe each of these here.

- **Master Production Schedule (MPS)**

An ideal Master Production Schedule (MPS) is one which most efficiently uses an organization's capacity, while being able to meet customer due dates. The master schedule provides a plan for quantity and timing when orders are required. The MRP system will use this information and take into account delivery; production and supply lead times indicating when materials are needed to achieve the master schedule. The MPS usually shows plans based on time 'buckets' which are based in turn, for example, on a day or a week. The length of the time bucket will generally be longer (for example a month) for planning purposes and become shorter the

closer it gets to the present time for detailed production planning tasks.

The MPS will usually contain a mix of both plans for customer ordered items and plans to produce to forecast sales. A forecast is the best estimate of what future demand will be; this may be derived from past sales and contact with the customer. These forecasts should be replaced by firm orders as the expected order date approaches. If actual orders exceed the forecast, then either the order will be delivered to the customer late or extra capacity must be obtained (e.g., overtime, subcontracting) to meet the customer delivery date.

- **Bill of Materials (BOM)**

The Bill of Materials (BOM) identifies all the components required to produce a scheduled quantity of an assembly and the structure of how these components fit together to make that assembly. The BOM can be viewed as a product structure tree, similar to an organization chart. The MRP system will move through all component of the BOM in the product structure to derive the total number of components required for the product. Note the same component may appear in different parts of the product structure if it is used more than once. What is needed is the total number required for each component to make the final assembly.

The accuracy of BOM is obviously vital in generating the correct schedule of parts at the right time. Inventory Status File (ISF) provides information on the identification and quantity of items in stock. The MRP system will determine if a sufficient quantity of an item is in stock or whether an order must be placed. The ISF will also contain the lead time, or time between order and availability, for each component.

- **MRP Implementation**

MRP can reduce inventory by providing information on the actual inventory required for parent items (rather than stocking enough components for estimated parent demand). It can also help to prioritize orders to ensure that delivery due-dates are met, provide information on resource (labor and equipment) requirements for planning purposes, and provide financial information on projected inventory expenditure. MRP is the most useful in complex scheduling situations, when the number of levels of sub-assemblies and components is high.

Enterprise Resource Planning (ERP) Systems

Enterprise Resource Planning (ERP) Systems provide a single solution from a single supplier with integrated functions for major business areas such as production, distribution, sales, finance and human resources management. They are normally purchased as an off-the-shelf package which is then tailored. ERP is particularly relevant in the

integration of supply chains in enabling organizations in the supply chain to access one another's databases. ERP systems may access other members of the supply chain via Electronic Data Interchange (EDI) facilities. The internet is also increasingly used as a platform to allow secure access to information by members of the supply chain. These systems are sometimes referred to as 'c-commerce' (collaborative commerce). Like ERP, e-business systems facilitate the integration of the supply chain and many ERP vendors have repositioned themselves as suppliers of e-business solutions.

Activity

Discuss the role of automation in productivity increase with reference to a labor intensive industry like carpet weaving.

2.8 SUMMARY

Production system is defined as that part of an organization, which produces products of an organization. Production systems can be classified as job-shop, batch, mass, and continuous production systems. Factors increasing productivity can be classified broadly into two categories: controllable (or internal) factors and uncontrollable (or external) factors. Productivity improvement techniques are also classified on the basis of process improvement as technology-based (Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM)), employee-based, material-based, process-based, product-based, and task-based. Upcoming international dimensions of productivity include moving to new and more advanced products, and employing better and more flexible system. Automation is a technology concerned with the application of mechanical, electronic, and computer based systems to operate and control production. Automated production systems can be classified into three basic types: fixed automation, programmable automation, and flexible automation. System-based Information Technology approaches to production management mainly include Materials Requirements Planning (MRP) and Enterprise Resource Planning (ERP) systems. MRP is an information system used to calculate the requirements for component materials needed to produce end items. ERP systems provide a single solution from a single supplier with integrated functions for major business areas such as production, distribution, sales, finance and human resources management.

2.9 SELF ASSESSMENT TEST

1. Define a productive system. Give two examples each for productive systems concerned with service and manufacturing.
2. Explain what you understand by product-focused systems and process-focused systems.

3. Explain the classification of production system in a modern assembly line system.
4. What is MRP? How can BOM influence MRP?
5. What do you understand by ERP? How does it differ from MRP (Material Resource Planning)?
6. What is automation? Explain the different types of automation used in industries.

2.10 CASE STUDY

Direct and Indirect Effects of Flexible Scheduling on Labor Productivity

Does flexible scheduling produce labor productivity gains? There may be a direct relationship between flexible workplace practices and organizational performance, but the means through which this relationship occurs, the mediating mechanisms by which it affects company-level outcomes, are less well known. The organizational climate itself may act as a mediator. The use of such practices is said to generate a positive organizational climate, which in turn can enhance firm performance. Indeed, providing more autonomy tends to be one of the “high performance” organization tools that may promote additional work effort or intensity per hour.

Rigid daily work schedules may be a contributing factor that is independent of the length of working hours, in that they have indirect effects on worker productivity via health, injury, and fatigue. By their nature, flexible working hours may minimize the interference of family obligations with work productivity. Lack of control over the scheduling of working hours may reinforce, compound or exacerbate the effects of long hours on workers. Greater variation in working hours tends to reduce their well-being when the variation does not reflect their choice. The unpredictability of working hours, in particular for those with lower incomes, can have a corrosive effect on worker job satisfaction levels.

Some of the most direct evidence comes from case studies conducted in large US firms, particularly service providers, where individual worker productivity is a challenge to measure or monitor. For example, in the pharmaceutical sales force, productivity was defined in terms of many monitored metrics such as the number of calls made, the number of presentations and “yield” on activities. After AstraZeneca implemented job sharing and part-time sales forces, the metrics of the employees concerned were consistently found to be in line with the productivity of full-time sales representatives. In a division of GlaxoSmithKline, flexible working time arrangements, such as job sharing, were introduced among customer service representatives. After evaluating the job-share arrangements, the company realized that not only had it met its goal of keeping job-share arrangements “revenue neutral”, job-share positions resulted in greater productivity and extra coverage.

At JP Morgan Chase, 84 per cent of employees rated their area's productivity as good or very good if they had a manager who was sensitive to their concerns, as compared with only 55 per cent of employees whose manager was not. A more empirical statistical study examined the extent to which employee use of alternative work schedules, including job sharing, flexi time, compressed workweeks and part-time work, affected a firm's profit rate, which is calculated as real operating income as a fraction of sales in a given time period.

Giving workers the option to take time off when a family member was sick or to work from home were both associated positively with firms' profits (although job-sharing arrangements actually had a slight negative impact on profits). Profits may be enhanced indirectly if workers value the provision of sick leave so much that they are willing to accept a compensating differential for it, but few employees actually use it. Profits also might be boosted indirectly to the extent that productivity is sustained by the subsequently reduced job dissatisfaction and stress. Workplace flexibility is defined as "the ability of workers to make choices influencing when, where, and for how long they engage in work-related tasks". Its potential benefits for workers improve individual productivity indirectly, via health and the promotion of better work/family reconciliation and balance.

Question

- Q1. On the above account discuss the impact of productivity on shift's nature.
- Q2. The flexible shift nature is given an edge over some industries; discuss its dependence on productivity.
- Q3. Explain how working hours can be planned for productivity improvement over a longer span of time, reference to US firms as given in the account above.

Adapted from: Lonnie Golden, The Effects of Working Time on Productivity and Firm Performance: a research synthesis paper, International Labour Office – Geneva, 2012.

2.11 SUGGESTED READINGS

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UNIT 3

TOTAL QUALITY MANAGEMENT

OBJECTIVES

After reading this unit you should be able to know about:

- Various principles of and approaches to Total Quality Management
- Employee involvement and empowerment
- Various ISO certifications involved in Total Quality Management
- Overview of series of ISO certifications

STRUCTURE

- 4.1 Introduction
- 4.2 TQM: A historical perspective
- 4.3 Quality terminology
- 4.4 Understanding and improving the process
- 4.5 Employee involvement and empowerment
- 4.6 ISO-9000
- 4.7 ISO 14000 series
- 4.8 Summary
- 4.9 Self assessment test
- 4.10 Case study
- 4.11 Suggested readings

3.1 INTRODUCTION

Modern customers demand products or services with greater durability and reliability at the most economic price. This forces producers to strictly follow quality procedures right from design till shipment and installation of products. The goal of any competitive industry is to provide a product or service at the most economical costs, ensuring full customer satisfaction. This can be achieved through Total Quality Management (TQM), because, quality is not a technical function, but a systemic process extending throughout all phases of the business, e.g., marketing, design, development, engineering, purchasing, production/operations.

TQM has been defined in many ways by various authors. As per **Feigebaum**, "Total Quality Management is an effective system of integrating the quality development, quality maintenance and quality improvement efforts of various groups in an organization so as to enable marketing, engineering, production and service at the most economical levels which allow for full customer satisfaction". **Wolkins** has outlined TQM as a tool to integrate fundamental management techniques, existing improvement efforts and technical tools under a disciplined approach focused on continuous improvement. According to **British Quality Association**, 'TQM is a corporate business management philosophy which recognizes that customer needs and business goals are inseparable. It is applicable within both industry and commerce'. **R. N. Roy** considers TQM as a management philosophy for continuously improving overall business performance based on leadership, supplier quality management, vision and plan statement, evaluation, process control and improvement, product design, quality system improvement, employee participation, recognition and reward, education and training, and customer focus.

According to **Reid and Sanders**, making quality a priority means putting customer needs first. It means meeting and exceeding customer expectations by involving everyone in the organization through an integrated effort. Total quality management is an integrated organizational effort designed to improve quality at every level. **R. N. Roy** considers TQM as one of the most effective and the least understood corporate strategies. According to him, TQM is a comprehensive process that can bring a company to the forefront of the global market. It can affect every level, procedure and every person in a company.

If common opinion is to be believed, TQM is nothing new - it is just a common sense way of remaining in business. In fact, any well-run company is already doing TQM without even realizing it. TQM is an operating philosophy, a goal, and a way of doing business. For many companies, it is a major cultural change; from 'solving a crisis' to 'not having a crisis'. The typical 'just do it' approach to business is replaced by clearly defined processes.

Benefits of TQM

The benefits of TQM can be classified on the basis of customer satisfaction and economic improvement. Let us discuss them here.

- I. Customer satisfaction oriented benefits:** The benefits under this category are:
 - Improvement in product quality.
 - Improvement in product design.
 - Improvement in production flow.
 - Improvement in employee morale and quality consciousness.
 - Improvement of product service.
 - Improvement in market place acceptance.

ii. Economic improvement oriented benefits: The benefits under this category are:

- Reduction in operating costs.
- Reduction in operating losses.
- Reduction in field service costs.
- Reduction in liability exposure.

3.2 TQM: A HISTORICAL PERSPECTIVE

The Road to TQM

Until around 1950, Japanese products were perceived in markets all over the world as being very inexpensive, but with poor quality. By the 1980s, the same markets were recognizing made in Japan as a sign of high quality and reliability. Let us understand what had happened during those three decades. Mass production systems were developed mainly by US industries in the early 20th century. Other countries that were then emerging as new powers adopted variations of this scientific management of companies according to their individual contexts. For example, in Japan, rationalization of management in factories was substantially advanced in the 1930s, but imports of goods and ideas from advanced countries were squeezed as the nation approached World War II. After the War, the devastated Japanese economy moved vigorously to restore its previous production level through full-on importation of technologies and ideas from the U.S. and Europe.

In the postwar period, Japanese industries absorbed many modern concepts on management either through the General Headquarters (American occupation headquarters representing the Allied Forces) or directly from various foreign countries. The quality management systems were typical examples. However, Japanese-made still had a connotation of being inexpensive but with poor quality until the early 1950s. The nation's wealth was yet meager: Japan's GDP per capita in 1950 was similar to those of Colombia, Greece, Mexico, Malaysia, and the Philippines, and way below those of Argentina, Brazil, and Chile.

A number of factors contributed to reversing the notorious reputation of Japanese products in the subsequent two decades: development of applied technologies, creative reception of imported systems, successful introduction of industrial policies in harmonization with the private sector, expansion of world trade, gradual liberalization of domestic markets for foreign capital, and so on. Among them, what calls our particular attention in relation to management systems is Japan's 1950s and early 1960s adaptation of US-type quality management. This reception was not passive; Japanese companies modified the concepts: Statistical Quality Control (SQC) was transformed in Japan as Company-Wide Quality Control (CWQC) or Total Quality Control (TQC), and Productive Maintenance (PM) as Company-Wide Productive Maintenance

(CWPM) or Total Productive Maintenance (TPM). Whereas the original concepts of SQC and PM assumed that only expert staff members would be in charge of quality control of products or maintenance of equipment, the Japanese adaptation was to apply those methods to whole sections of companies.

There were two important underlying perceptions of top managers who put forward these movements: strong commitment to quality and particular emphasis on human resources. Management in Japanese companies made sure that its visions and ideas about company missions were disseminated to all employees, from frontline operators to middle managers, with the belief that employees were the most valuable assets in companies. Then, what were the management tools that enabled company-wide movements focusing on quality improvement? The most important vehicle was the concept of Quality Control Circle (QCC), in which small groups of frontline operators follow problem-solving processes to cooperatively solve various problems in the workplace.

Throughout the 1960s and 1970s, TQC and QCC were practiced with strong initiatives and commitment of management in many sectors—particularly management in export-led manufacturing companies, which substantially increased their presence in world markets. After the late 1970s, in line with rapid foreign direct investment by Japanese companies, so-called Japanese management was exported to foreign countries. To be fair, we cannot say that the quality management was the sole factor for vigorous expansion of production and export; however, it was one of the major factors as many observers concur (Miyamoto et al. 1995). In the 1980s, the strong competitiveness of the Japanese export sector produced a huge trade surplus and some conflicts in the US and European markets. There was much talk about an over-presence of Japanese companies. The TQC practiced by these companies evolved, with much refinement, to Total Quality Management (TQM) in the late 1980s.

The record of Japanese companies in the domestic and foreign markets in the 1990s is much more complicated. The long economic recession that began in the Japanese economy in the early 1990s, together with the lower growth of the world economy and trade, seriously affected Japanese companies, and a discrepancy in productivity between some competitive manufacturing subsectors and the protected service industries emerged. Japanese companies have lost some competitiveness as a whole, which has evoked an extreme view in the world that Japanese management is no longer effective. And since Japanese management is deeply associated with TQM, a perception has emerged that the successes accredited to TQM up to the 1980s are somewhat dubious. However, this is an obvious mistake. The need for quality management has been only increasing, and the fact that Japan's economy is troubled does not undermine the potential of TQM and QCC.

[Source: Handbook for TQM and QCC, Vol. 1]

Let us now discuss the historical perspective of TQM in terms of various approaches to TQM, discussed by R. N. Roy.

Deming's Approach to TQM

Edward W. Deming (1986) stressed the responsibilities of top management to take the lead in changing processes and systems, and create and communicate a vision to move the firm towards continuous improvement. Top management is responsible for most quality problems; it should give employees clear standards for what is considered acceptable work, and provide the methods to achieve it. These methods include an appropriate working environment and climate for work free of faultfinding, blame or fear.

Deming also emphasized the importance of identification and measurement of customer requirements, creation of supplier partnership, use of functional teams to identify and solve quality problems, enhancement of employee skills, participation of employees, and pursuit of continuous improvement. According to him, the means to improve quality lie in the ability to control and manage systems and processes properly, and in the role of management responsibilities in achieving this. Deming advocated methodological practices, including the use of specific tools and statistical methods in the design, management, and improvement of process, which aim to reduce the inevitable variation that occurs from "common causes" and "special causes" in production. "Common causes" of variations are systemic and are shared by many operators, machines, or products. They include poor product design, non-conforming incoming materials, and poor working conditions. These are the responsibilities of management. "Special causes" relate to the lack of knowledge or skill, or poor performance. These are the responsibilities of employees.

Deming proposed the following 14 points as the principles of TQM:

- Create constancy of purpose towards improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.
- Adopt the new philosophy. We are in a new economic age. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.
- Cease dependence on mass inspection to quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
- End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move towards a single supplier for any one item, on a long-term relationship of loyalty and trust.
- Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
- Institute training on the job.
- Institute leadership. The aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of

management is in need of overhaul, as well as supervision of production workers.

- Drive out fear, so that people may work effectively for the company.
- Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.
- Eliminate slogans, exhortations, and targets for the workforce asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the workforce.
- Eliminate work standards (quotas) on the factory floor. Substitute leadership. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute leadership.
- Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, inter alia, abolishment of the annual or merit rating and of management by objective.
- Institute a vigorous program of education and self-improvement.
- Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

Juran's Approach to TQM

Joseph M. Juran believed that main quality problems are due to management rather than workers. The attainment of quality requires activities in all functions of a firm. Firm-wide assessment of quality, supplier quality management, using statistical methods, quality information system, and competitive benchmarking are essential to quality improvement. TQM is the system of activities directed at achieving delighted customers, empowered employees, higher revenues, and lower costs (Juran and Gryna, 1993).

According to Juran, it is very important to understand customer needs. This requirement applies to all involved in marketing, design, manufacture, and services. Identifying customer needs requires more vigorous analysis and understanding to ensure the product meets customers' needs and is fit for its intended use, not just meeting product specifications. Thus, market research is essential for identifying customers' needs. In order to ensure design quality, he proposed the use of techniques like quality function deployment, experimental design, reliability engineering and concurrent engineering.

Juran considered quality management as *three basic processes* (renowned as **Juran Trilogy**): *quality control*, *quality improvement*, and *quality planning*. A sporadic problem is detected and acted upon by the process of *quality control*; a chronic problem requires a different process, namely, *quality improvement*. Such chronic problems are traceable to an inadequate *quality planning* process. Juran defined a universal sequence of activities for the three quality processes, whereas the cost related with these three quality functions is of four broad categories, given below:

1. Internal failure costs (scrap, rework, failure analysis, etc.), associated with defects found prior to transfer of the product to the customer.
2. External failure costs (warranty charges, complaint adjustment, returned material, allowances, etc.), associated with defects found after product is shipped to the customer.
3. Appraisal costs (incoming, in-process, and final inspection and testing, product quality audits, maintaining accuracy of testing equipment, etc.), incurred in determining the degree of conformance to quality requirements.
4. Prevention costs (quality planning, new product review, quality audits, supplier quality evaluation, training, etc.), incurred in keeping failure and appraisal costs to a minimum.

Crosby's Approach to TQM

Phillip B. Crosby (1979) identified a number of important principles and practices for a successful quality improvement program, which include, for example, management participation, management responsibility for quality, employee recognition, education, reduction of the cost of quality (prevention costs, appraisal costs, and failure costs), emphasis on prevention rather than after-the-event inspection, doing things right the first time, and zero defects.

Crosby claimed that mistakes are caused by two reasons: lack of knowledge and lack of attention. Education and training can eliminate the first cause and a personal commitment to excellence (zero defects) and attention to detail will cure the second. Crosby also stressed the importance of management style to successful quality improvement. The key to quality improvement is to change the thinking of top managers-to get them not to accept mistakes and defects, as this would in turn reduce work expectations and standards in their jobs.

The five stages of uncertainty, awakening, enlightenment, wisdom and certainty can be used to assess progress in a number of measurement categories such as management understanding and attitude, quality organization status, problem handling, cost of quality as percentage of sales, and summation of firm quality posture. The quality management maturity grid and cost of quality measures are the main tools for managers to evaluate their quality status. Crosby offered a 14-step program that can

guide firms in pursuing quality improvement. These steps are listed as follows:

1. **Management commitment:** To make it clear where management stands on quality.
2. **Quality improvement team:** To run the quality improvement program.
3. **Quality measurement:** To provide a display of current and potential non-conformance problems in a manner that permits objective evaluation and corrective action.
4. **Cost of quality:** To define the ingredients of the cost of quality, and explain its use as a management tool.
5. **Quality awareness:** To provide a method of raising the personal concern felt by all personnel in the company towards the conformance of the product or service and the quality reputation of the company.
6. **Corrective action:** To provide a systematic method of resolving forever the problems that is identical through previous action steps.
7. **Zero defects planning:** To investigate the various activities that must be conducted in preparation for formally launching the zero defects program.
8. **Supervisor training:** To define the type of training those supervisors need in order to actively carry out their part of the quality improvement program.
9. **Zero defects day:** To create an event that will make all employees realize, through a personal experience, that there has been a change.
10. **Goal setting:** To turn pledges and commitment into actions by encouraging individuals to establish improvement goals for themselves and their groups.
11. **Error causal removal:** To give the individual employee a method of communicating to management the situation that makes it difficult for the employee to meet the pledge to improve.
12. **Recognition:** To appreciate those who participate.
13. **Quality councils:** To bring together professional quality people for planned communication on a regular basis.
14. **Do it over again:** To emphasize that the quality improvement program never ends.

Activity

What are the losses reduced by TQM? Would you agree with the statement that "Quality is free"?

Feigenbaum's Approach to TQM

Armand Feigenbaum (1991) defined TQM as an effective system for integrating quality development, quality maintenance, and quality improvement efforts of the various groups in a firm so as to enable marketing, engineering, production, and service at the most economical levels which allow for full customer satisfaction. He claimed that effective quality management consists of four main stages, described as follows:

- Setting quality standards.
- Appraising conformance to these standards.
- Acting when standards are not met.
- Planning for improvement in these standards.

The quality chain, Feigenbaum argued, starts with the identification of all customers' requirements and ends only when the product or service is delivered to the customer, who remains satisfied. Thus, all functional activities, such as marketing, design, purchasing, manufacturing, inspection, shipping, installation and service, etc., are involved in and influence the attainment of quality. Feigenbaum used the term TQC (Total Quality Control) instead of TQM in his book. He claimed that it permits what might be called total quality management to cover the full scope of the product and service "life cycle" from product conception through production and customer service.

A clearly defined total quality system is a powerful foundation for TQM. Total quality system is defined as follows: The agreed firm-wide operating work structure, documented in effective, integrated technical and managerial procedures, for guiding the coordinated actions of the people, the machines, and the information of the firm in the best and most practical ways to assure customer quality satisfaction and economical costs of quality. Feigenbaum emphasized that efforts should be made towards the prevention of poor quality rather than detecting it after the event. He argued that quality is an integral part of the day-to-day work of the line, staff, and operatives of a firm. There are two factors affecting product quality: technological factors (i.e., machines, materials, and processes); and human factors (i.e., operators, foremen, and other firm personnel). Of these two factors, the human is of greater importance by far. Feigenbaum considered top management commitment, employee participation, supplier quality management, information system, evaluation, communication, use of quality costs, and use of statistical technology to be essential components of TQM. He argued that employees should be rewarded for their quality improvement suggestions; quality is everybody's job. He stated that effective employee training and education should focus on the following three main aspects: quality attitudes, quality knowledge, and quality skills.

Ishikawa's Approach to TQM

Kaoru Ishikawa (1985) argued that quality management extends beyond the product and encompasses after-sales service, the quality of

management, the quality of individuals and the firm itself. He claimed that the success of a firm is highly dependent on treating quality improvement as a never-ending quest. A commitment to continuous improvement can ensure that people will never stop learning. He advocated employee participation as the key to the successful implementation of TQM. Ishikawa believed that Quality Circles are an important vehicle to achieve this. Like all other gurus, he emphasized the importance of education, stating that quality begins and ends with it. He has been associated with the development and advocacy of universal education in the seven QC tools (Ishikawa, 1985). These tools are listed below:

- Pareto chart
- Cause and effect diagram (Ishikawa diagram)
- Stratification chart
- Scatter diagram
- Check sheet
- Histogram
- Control chart

Ishikawa used the term TQC (total quality control) instead of TQM in his book. According to ISO 8402—Quality management and quality assurance—vocabulary, TQM is sometimes called “total quality”, “company-wide quality control”, “total quality control”, etc. Ishikawa (1985) suggested that the assessment of customer requirements serves as a tool to foster cross-functional cooperation; selecting suppliers should be on the basis of quality rather than solely on price; cross-functional teams are effective ways for identifying and solving quality problems. Ishikawa’s concept of TQM contains the following six fundamental principles:

1. Quality first-not short-term profits first.
2. Customer orientation-not producer orientation.
3. The next step is your customer-breaking down the barrier of sectionalism.
4. Using facts and data to make presentations-utilization of statistical methods.
5. Respect for humanity as a management philosophy, full participatory management.
6. Cross-functional management.

Activity

Form two groups in your class. Now conduct a discussion on Feigenbaum’s “effective quality management” between the two groups, with special emphasis on its four different stages.

3.3 QUALITY TERMINOLOGY

What is Quality?

Quality is a state of mind. Quality means satisfying the customer. According to TQM, quality is totally defined by customer's perceptions. It doesn't matter what we think; it matters what our customers think, and the customers' perceptions are constantly changing. It is up to us to make sure our organization is fast and flexible enough to respond to their demand of better products/services.

Reid and Sanders mention that quality management, as specified in ISO-9000, is about managing our organization with the objective of satisfying our customers' needs. According to **Fiegenbaum**, the cost of correcting mistakes can easily be 15 to 40 percent of a plant's productivity. The definition of quality depends on the role of the people defining it. The difficulty in defining quality exists regardless of the product, and this is true for both manufacturing and service organizations. Think about how difficult it may be to define quality for products such as airline services, child day-care facilities, college classes, or even textbooks of Operations Management. Further complicating the issue is that the meaning of quality has changed over time.

Today there is no single universal definition of quality. Some people view quality as "performance to standards." Others view it as "meeting the customer's needs" or "satisfying the customer." Let us look at some of the more common terminology related to the definition of quality:

- **Conformance to specifications:** This measures how well the product or service meets the targets and tolerances determined by the designers. For example, the dimensions of a machine part may be specified by its design engineers as 3.05 inches. This would mean that the target dimension is 3 inches, but can vary between 2.95 and 3.05 inches. Similarly, the wait for hotel room service may be specified as 20 minutes, but there may be an acceptable delay of an additional 10 minutes. Also, consider the amount of light delivered by a 60 watt light bulb. If the bulb delivers 50 watts, it does not conform to specifications. As these examples illustrate, conformance to specifications is directly measurable, though it may not be directly related to the consumer's idea of quality.
- **Fitness for use:** Fitness for use focuses on how well the product performs its intended function or use. For example, a Mercedes Benz and a Mahindra Bolero both meet a fitness for use definition if one considers transportation as the intended function. However, if the definition becomes more specific and assumes that the intended use is for transportation on mountain roads, the Bolero has a greater fitness for use. You can also see that fitness for use is a user-based definition in that it is intended to meet the needs of a specific user group.

- **Value for price paid:** Value for price paid is a definition of quality that consumers often use for product or service usefulness. This is the only definition that combines economics with consumer criteria; it assumes that the definition of quality is price sensitive. For example, suppose that you wish to sign up for a seminar that explains tax saving and discover that the same class is being taught at two different colleges at significantly different fees. If you take the less expensive seminar, you will feel that you have received greater value for the price.
- **Support services provided:** These services are often how the quality of a product or service is judged. Quality does not apply only to the product or service itself; it also applies to the people, processes, and organizational environment associated with it. For example, the quality of a university is judged not only by the quality of staff and course offerings, but also by the efficiency and accuracy of processing paperwork.
- **Psychological criterion:** A psychological criterion is a subjective definition that focuses on the judgmental evaluation of what constitutes product or service quality. Different factors contribute to the evaluation, such as the atmosphere of the environment or the perceived prestige of the product. For example, a hospital patient may receive average health care, but a very friendly staff may leave the impression of high quality. Similarly, we commonly associate certain products with excellence because of their reputation; Rolex watches and Mercedes-Benz automobiles are examples.

Activity

What can be the possible reasons for implementation of TQM in textile industry?

3.4 UNDERSTANDING AND IMPROVING THE PROCESS

An appropriate documented Quality Management System will help an organization not only achieve the objectives set out in its policy and strategy, but also, and equally importantly, sustain and build upon them. It is imperative that the leaders take responsibility for the adoption and documentation of an appropriate management system in their organization if they are serious about the quality journey. Once the strategic direction for the organization's quality journey has been set, it needs performance measures to monitor and control the journey, and to ensure that the desired level of performance is being achieved and sustained.

The whole process of understanding and improvement has been discussed by Reid and Sanders with the help of a cycle known as The Plan-Do-Study-Act Cycle. The Plan-Do-Study-Act (PDSA) cycle

describes the activities a company needs to perform in order to incorporate continuous improvement in its operation. The circular nature of this cycle shows that continuous improvement is a never-ending process. Let us now discuss the specific steps in the cycle.

- **Plan:** The first step in the PDSA cycle is to plan. Managers must evaluate the current process and make plans based on any problems they find. They need to document all the current procedures, collect data, and identify the problems whatsoever. This information should then be studied and used to develop a plan for improvement as well as specific measures to evaluate performance.
- **Do:** The next step in the cycle is implementing the plan (do). During the implementation process managers should document all changes made and collect data for evaluation.
- **Study:** The third step is to study the data collected in the previous phase. The data are evaluated to see whether the plan is achieving the goals established in the plan phase or not.
- **Act:** The last phase of the cycle is to act on the basis of the results of the first three phases. The best way to accomplish this is to communicate the results to other members in the company and then implement the new procedure if it has been successful. Note that this is a cycle; the next step is to plan again. After we have acted, we need to continue evaluating the process, planning, and repeating the cycle again.

3.5 EMPLOYEE INVOLVEMENT AND EMPOWERMENT

Thamizhmanii and Hasan state that empowerment means engaging employees in the thinking processes of an organization. Involvement means having input. Empowerment means having input that is heard and seriously considered. Empowerment requires a change in an organization culture, but does not mean that top management abdicates its responsibility or authority. Employee empowerment is necessary for the effective functioning of an employee. Each employee in a team should be given a chance to act mentally to achieve their goal or targets. In an organization that practices TQM, a team work and an employee empowerment is essential for the effective utilization of resources, man power. This improves problem solving skills and makes an employee a good decision maker. However, the decision maker should bear in mind that the decision arrived at was of their own organization.

Some researchers have examined the impact of team empowerment on creativity and innovation, while the other research discusses the hampering role of performance measures in team empowerments. Employees' empowerment and improved levels of job satisfaction are facilitated by the top management leadership and commitment to the TQM goal of customer satisfactions by creating an organizational climate that emphasizes total quality and customer satisfaction. The rationale for

empowerment is that it is the best way to increase creative thinking and initiate on the part of employees. The main inhibitor of empowerment is resistance to change. Resistance might come from employees, unions, and management. Management-related inhibitors include training, organizational structure and management practices. Employee-related inhibitors include insecurity, personal values, ego, personality characteristics and exclusion. Employee involvement can be ensured by introducing a suggestion system that involves improving both the system and individual suggestions. The system can be improved by ensuring that all suggestions receive a formal response, that all suggestions are responded to immediately, and that participation, system costs and savings are monitored. Poor suggestions can be handled without damaging morale by listening carefully, expressing appreciation, carefully explaining own position, encouraging feedback, and looking for compromise. Full appreciation of the suggestion system can be achieved by removing hidden barriers, encouraging new employees, and coaching reluctant employees.

Part of the TQM philosophy is to empower all employees to seek out quality problems and correct them. With the old concept of quality, employees were afraid to identify problems for fear that they would be reprimanded. Often poor quality was passed on to someone else, in order to make it "someone else's problem." The new concept of quality, namely TQM, provides incentives for employees to identify quality problems. Employees are rewarded for uncovering quality problems, not punished.

In TQM, the role of employees is very different from what it was in traditional systems. Workers are empowered to make decisions related to quality in the production process. They are considered a vital element of the effort to achieve high quality. Contributions of employees are highly valued, and their suggestions are implemented as well. In order to perform this function, employees are given continual and extensive training in quality measurement tools.

To further stress the role of employees in quality, TQM differentiates between external and internal customers. External customers are those that purchase the company's goods and services. Internal customers are the employees of the organization who receive goods or services from others in the company. For example, the packaging department of an organization is an internal customer of the assembly department. Just as a defective item would not be passed to an external customer, a defective item should not be passed to an internal customer either.

According to Reid and Sanders, the Team Approach in TQM stresses that quality is an organizational effort. To facilitate the solving of quality problems, it places great emphasis on teamwork. The use of teams is based on the old adage that "two heads are better than one". Using techniques such as brainstorming, discussion, and quality control tools, teams work regularly to correct problems. The contributions of teams are considered vital to the success of the company. For this reason, companies set aside time in the workday for team meetings.

Teams vary in their degree of structure and formality, and different types of teams solve different types of problems. One of the most common types of teams is the quality circle, which is a team of volunteer production employees and their supervisors, whose purpose is to solve quality problems. The circle is usually composed of eight to ten members, and decisions are made through group consensus. The teams usually meet weekly during work hours in a place designated for this purpose. They follow a preset process for analyzing and solving quality problems. Open discussion is promoted, and criticism is not allowed. Although the functioning of quality circles is friendly and casual, it is serious business. Quality circles are not mere “gab sessions.” Rather, they do important work for the company and have been very successful in many firms.

3.6 ISO-9000

ISO-9000 is the generic name used to describe the International Standard Organization (ISO) 9000 series of management system standards. Let us first understand what ISO is. According to Kumar and Suresh, the purpose of ISO is to facilitate international trade and cooperation in commercial, intellectual, scientific and economic endeavors by developing international standards. ISO originally focused on industrial and mechanical engineering standards. Now, it has ventured into setting standards for an organization’s processes, policies, and practices. The peak standard of ISO-9000 series is the ISO-9001, which is titled ‘Quality Systems-Model for quality assurance in design/development, production, installation and servicing’. This is the standard to which an organization can be certificated for the design, development, installation, and maintenance of products and services (e.g., software development, operation, and support). ISO-9001 is known by different names in different countries, like ANSI/ASQC ISO-9001 in USA, EN ISO-9001 in Europe, BS/EN ISO-9001 in the UK, AS/NZS ISO-9001 in New Zealand and Australia, and SS ISO-9001 in Singapore.

ISO-9002

- For organizations that do not do their own design.
- Titled ‘Quality Systems-Model for quality assurance in production, installation and servicing’.

ISO-9003

- This is used by organizations that perform final inspection and testing of products purchased from external suppliers.
- Titled ‘Quality Systems-Model for quality assurance in final inspection and test’.

ISO-9000.3

- Titled ‘Quality Management and Quality System elements-Guidelines for development, supply and maintenance of software’.

- It is a guideline on the use of ISO-9001 in computer software development.

ISO-9004.2

- Titled 'Quality management and quality system elements-Guidelines for services'.
- It is a guideline on the application of ISO-9001 and ISO-9002 to services. An organization cannot be certificated to ISO-9004.2 and it is not used during the certification process.
- This can be applied to the following:

Hospitality services: catering, hotels, tourist services, entertainments, radio, TV, etc.

Communications: airports, airlines, roads, rail, sea transport, telecommunications, post office, etc.

Health: medical practitioners, hospitals, ambulances, medical labs, dentists, opticians, etc.

Maintenance: electrical, mechanical, vehicles, heating systems, air-conditioning, building, computer.

Utilities: cleansing, waste management, water supply, grounds maintenance, electricity, gas and energy supply, fire, police, public services, etc.

Trading: wholesale, retail, stockist, distributor, marketing, and packaging.

Financial: banking, insurance, pensions, property services, accounting.

Professional: architecture, surveying, legal, law enforcement, security, education, engineering, quality management, etc.

Administration: personnel, computing, office services, etc.

Technical: consultancy, photography, test labs, etc.

Scientific: research, development, studies, decision aids, etc.

ISO-9004.4

'Guidelines for quality improvement' provides a concise reference source for information and technique relating to quality improvement.

ISO-10011

'Guidelines for auditing quality systems' is a valuable guide for internal auditors.

ISO-10013

'Guidelines for developing quality manuals'

ISO-9126

'Information technology—software product evaluation—quality characteristics and guidelines for their use', defines the terminology to be used as the basis for software quality metrics.

ISO 9000 SERIES

Let us discuss the ISO 9000 series as explained by Kumar and Suresh. The ISO is an international body, which consists of representatives from more than 90 countries. The national standard bodies of these countries are the members of this organization. The Bureau of Indian Standards (BIS) is the Indian representative to ISO, ISO and International Electro Technical Commission (IEC)), operate jointly as a single system. These are non-governmental organizations, which exist to provide common standards on international trade of goods and services.

ISO 9000 standards expect firms to have a quality manual that meets ISO guidelines, documents, quality procedures and job instructions, and verification of compliance by third-party auditors. ISO 9000 series has five international standards on quality managements. They are:

1. ISO 9000 — Quality management and Quality assurance standards
2. ISO 9001 — Quality systems: Quality in design
3. ISO 9002 — Quality systems: Production and Installation
4. ISO 9003 — Quality systems: Final inspection and test
5. ISO 9004 — Quality management and systems

Objectives of ISO 9000 Series

The objectives of ISO 9000 series are as follows:

ISO 9000: This provides guidelines on selection and use of quality management and quality assurance standards.

ISO 9001: It has 20 elements covering design, development, production, installation and servicing.

ISO 9002: It has 18 elements covering production and installation. It is same as ISO 9001 without the first two tasks, viz. design and development. This is applicable for the units excluding R&D functions.

ISO 9003: It has 12 elements covering final inspection and testing for laboratories and warehouses, etc.

ISO 9004: This provides guidelines to interpret the quality management and quality assurance. It also has suggestions which are not mandatory.

Benefits of ISO 9000 Series

The ISO 9000 series provides several tangible and intangible benefits which are listed below:

- This gives competitive advantage to an organization in the global market.
- It gives consistency in quality, since ISO helps in detecting non-conformity early which makes it possible to take corrective action.
- Documentation of quality procedures adds clarity to quality system.
- ISO 9000 ensures adequate and regular quality training for all members of the organization.
- ISO helps customers to have cost effective purchase procedure.
- The customers while making purchases from companies with ISO certificate need not spend much on inspection and testing. This will reduce the quality cost and lead-time.
- This will help in increasing productivity.
- It will aid to improved morale and involvement of workers.
- The level of job satisfaction would be more.
- It would reduce firefighting and free managers from constant intervention in the operation of the business. This is achieved as the staff will be given the means to control their own operations.
- This would provide the means for enabling the right tasks to be identified and specified in a way that will yield the right results. The standard requires planning in advance of the work and putting in place procedures, standards and guidelines which help people choose the right things to do.
- This would also provide a means of documenting the organization's experience in a structured manner that will provide a basis for education and training of staff and the systematic improvement of performance. This is taken care of by the documentation requirements under the standard which not only call for the quality system to be documented but also to be continually reviewed and maintained.
- It provides a means for identifying and resolving problems and preventing their recurrence. The standard calls for the installing of measures for detecting deviations from practices and specifications, for discovering the cause of the deviations and for planning and implementing corrective actions.
- It also provides the means for enabling people to perform tasks right the first time. This is achieved through the provision of work instructions, effective controls, appropriate and adequate resources, training, motivation and a conducive environment.
- This would provide objective evidence that can be used to demonstrate the quality of the organization's products and services and to demonstrate to any external evaluators that the various

operations are under control. The standard enables this by identifying, producing and maintaining records of key operations.

- It provides data that can be used to determine the performance of operating processes, products and services and for improving organizational performance and customer satisfaction. This is made possible through the collection, analysis and review of the records generated by the quality system.

Steps in ISO 9000 Registration

- i. Selection of appropriate standard from ISO 9001, ISO 9002 and ISO 9003, using the guidelines given in ISO 9000.
- ii. Preparation of quality manual to cover all the elements in the selected model.
- iii. Preparation of procedures and shop floor instructions which are used at the time of implementing the system. Also document these items.
- iv. Self-auditing to check compliance of the selected model.
- v. Selection of a registrar and making application to obtain certificate for the selected model. A registrar is an independent body with knowledge and experience to evaluate any one of the three models of the company's quality system (ISO 9002). Registrars are approved and certified by acridities.
- vi. The registrar, on successful verification and assessment will register the company. Before selecting a registrar, one should know the following: accreditors of the registrar, background and credibility of the registrar, cost of registration through the proposed registrar, and expected harmony between the company and the potential registrar while working towards implementing ISO model in the company.

Activity

What is the purpose of ISO 9000 quality system in manufacturing-based industries?

3.7 ISO 14000 SERIES

Overview

Let us discuss the ISO 14000 series as mentioned by R. N. Roy. The ISO 14000 series of environmental management standards are intended to assist organizations manage the environmental effect of their business practices. The ISO 14000 series is similar to the ISO 9000 series published in 1987. Both series of standards were published by the ISO. The purpose of the ISO 9000 series is to encourage organizations to institute quality

assurance management programs. Although ISO 9000 deals with the overall management of an organization and ISO 14000 deals with the management of the environmental effects of an organization, both standards are concerned with processes, and there is talk of combining the two series into one.

The environmental standards of ISO 14000 deal with how a company manages the environment inside its facilities and the immediate outside environment. However, the standards also call for analysis of the entire life cycle of a product, from raw material to eventual disposal. These standards do not mandate a particular level of pollution or performance, but focus on awareness of the processes and procedures that can affect the environment. It should be noted that adherence to the ISO 14000 standards does not in any way release a company from any national or local regulations regarding specific performance issues regarding the environment.

Some of the standards in the ISO 14000 series are:

- ISO 14001: Specification of Environmental Management Systems
- ISO 14004: Guideline Standard
- ISO 14010 through ISO 14015: Environmental Auditing and Related Activities
- ISO 14020 through ISO 14024: Environmental Labeling
- ISO 14031 through ISO 14032: Environmental Performance Evaluation
- ISO 14040 through ISO 14043: Life Cycle Assessment
- ISO 14050: Terms and Definitions

Although the ISO 14000 standards are similar to the ISO 9000 standards, the nature of the environmental standards creates a need for people who are technical environment professionals in addition to those required to maintain the documentation necessary for certification.

Benefits of ISO 14000 Certification

The benefits of acquiring ISO certification go beyond the satisfaction of doing a good deed. Adhering to the standard may result in better conformance to environmental regulations, greater marketability, better use of resources, higher quality goods and services, increased levels of safety, improved image, and increased profits. Let us discuss some the benefits here:

- The environmental awareness and the documentation that are required by the ISO 14000 standards assist a company in conforming to environmental regulations. This means that a company, by diligently adhering to the standard, is less likely to violate environmental regulations, and is always ready for inspection by a regulatory agency. In addition, the certification and documentation may aid a company in acquiring capital, in

defending itself during environmental litigation and in receiving insurance or permits.

- A wider market for a company's goods and services may result from certification. Many corporations and governments will be looking for suppliers that are ISO 14000 certified in order to maintain their own certification and environment-friendly image.
- Producers of consumer goods may find that many consumers not only try to purchase goods from environment-friendly companies, but will spend a little more if they feel they are helping the environment. In order to reap this benefit, a company must make their environmental efforts known through advertising and labeling.
- The process analyses that go along with ISO 14000 certification may result in streamlining processes and more efficient use of resources and raw materials and subsequently reduce a company's costs.
- Reducing the amount of potentially dangerous substances in an end product may result in less use of dangerous chemicals in a plant. This leads to a safer internal environment for employees and the possibility of reduced insurance premiums. Improved employee morale may result when employees feel that the workplace is safer and they are contributing to the environmental effort.

Activity

How does the conceptual approach to ISO 14001 differ from ISO 9001? Discuss taking examples from automobile firms.

3.8 SUMMARY

TQM is a management philosophy for continuously improving overall business performance based on leadership, supplier quality management, vision and plan statement, evaluation, process control and improvement, product design, quality system improvement, employee participation, recognition and reward, education and training, and customer focus. The historical perspective of TQM traces the evolution of TQM from its emergence in Japan, and its eventual adoption in other countries. Another perspective describes approaches to TQM by experts like Deming, Juran, Crosby, Feigenbaum and Ishikawa. Quality management, as specified in ISO-9000, is about managing an organization with the objective of satisfying customers' needs. ISO-9000 is the generic name used to describe the International Standard Organization (ISO) 9000 series of management system standards. The peak standard of ISO-9000 series is ISO-9001, which is titled 'Quality Systems—Model for quality assurance in design/development, production, installation and servicing'. ISO 9000 standards expect firms to have a quality manual that meets ISO guidelines, documents, quality procedures and job instructions, and

verification of compliance by third-party auditors. The ISO 14000 series of environmental management standards are intended to assist organizations manage the environmental effect of their business practices. While ISO 9000 deals with the overall management of an organization, ISO 14000 deals with the management of the environmental effects of an organization.

3.9 SELF ASSESSMENT TEST

1. Explain the concept of empowerment. How can it be improved in an organization?
2. Explain supplier selection on the basis of Total quality management.
3. List down the pillars of Total Quality Management.
4. Explain the need for the quality systems in an organization?
5. What are the activities of quality planning?
6. Discuss ISO certifications along with the benefits of each.

3.10 CASE STUDY

Gold Coast Advertising (GCA)

George Stein sat in his large office overlooking Chicago's Michigan Avenue. As the CEO of Gold Coast Advertising, he seemed to always be confronted with one problem or another. Today was no exception. George had just come out of a long meeting with Jim Gerard, head of the Board for the small advertising agency. Jim was concerned about a growing problem with lowered sales expectations and a decreasing customer base. Jim warned George that something had to be done quickly or Jim would have to go to the Board for action. George acknowledged that sales were down but attributed this to general economic conditions. He assured Jim that the problems would be addressed immediately.

As George pondered his next course of action, he admitted to himself that the customer base of GCA was slowly decreasing. The agency did not quite understand the reason for this decrease. Many regular customers were not coming back and the rate of new customers seemed to be slowly declining. GCA's competitors seemed to be doing well. George did not understand the problem.

GCA was a Chicago-based advertising agency that developed campaigns and promotions for small- and medium-sized firms. Their expertise was in the retail area, but they worked with a wide range of firms from the food service industry to the medical fields. GCA competed on price and speed of product development. Advertising in the retail area was competitive and price had always been important. Also, since retail fashions change rapidly, speed in advertising development was thought to be critical. George reminded himself that price and speed had always been

what customers wanted. Now he felt confused that he really didn't know his customers. This was just another crisis that would pass, he told himself. But he needed to deal with it immediately.

Questions

- Q1.** What is wrong with how Gold Coast Advertising measures its quality? Explain why Gold Coast should ask its customers about how they defined quality?
- Q2.** Offer suggestions to George Stein on ways of identifying quality dimensions GCA's customers consider important.
- Q3.** Develop a short questionnaire to be filled out by GCA's customers that evaluates how customers define quality?

[Source: R. Dan Reid and Nada R. Sanders, *Operations Management: An Integrated Approach*, 2nd edition, John Wiley & Sons, 2005]

3.11 SUGGESTED READINGS

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UNIT 4

LATEST TECHNIQUES IN PRODUCTION MANAGEMENT

OBJECTIVES

After reading this unit you should be able to know about:

- Various techniques involved in production management
- Flexible manufacturing systems
- CAD, CAM and Kaizen
- Production management and measurement systems including work study

STRUCTURE

- 7.1 Information technology and production management
- 7.2 Flexible manufacturing systems
- 7.3 CAD and CAM
- 7.4 Kaizen Theory
- 7.5 Work study
- 7.6 Importance of rating and allowances in time study
- 7.7 Summary
- 7.8 Self assessment test
- 7.9 Case study
- 7.10 Suggested readings

4.1 INFORMATION TECHNOLOGY AND PRODUCTION MANAGEMENT

An Information System, according to **Laudon and Laudon**, is designed by a user according to the business operation involved and the need for his decision making. It is a vehicle which supplies necessary information for decision making. Before computers being used in any business environment, Information System also existed in some form or the other to support management in decision making. Modern business environment has become very complex and highly competitive. If an organization has to survive, it has to plan and develop its own Information System. Of

course, the size, structure and set up may vary depending upon the need of the organization, its policies and capability. Information Technology (IT) is also recasting the management process by providing powerful new tools for more precise planning, forecasting, and monitoring. For instance, it is now possible for managers to obtain information on organizational performance down to the level of specific transactions from just about anywhere in the organization at any time. Product managers at Frito-Lay Corporation, the world's largest manufacturer of salty snack foods, can know within hours precisely how many bags of Fritos have sold on any street in America at its customers' stores, how much they sold for, and what the competition's sales volumes and prices are.

Laudon and Laudon further observe that communications technology has eliminated distance as a factor for many types of work in different situations. Salespersons can spend more time in the field with customers and have more up-to-date information with them while carrying much less paper. Many employees can work remotely from their homes or cars, and companies can reserve space at smaller central offices for meeting clients or other employees. Collaborative teamwork across thousands of miles has become a reality as designers work on a new product together, even if they are located in different continents.

Reorganizing Work Flows

Information systems have been progressively replacing manual work procedures with automated work procedures, work flows, and work processes. Electronic work flows have reduced the cost of operations in many companies by displacing paper and the accompanying manual routines. Improved work flow management has enabled many corporations not only to cut costs significantly, but also to improve customer service at the same time. Redesigned work flows can have a profound impact on organizational efficiency, and can even lead to new organizational structures, products, and services.

Increasing Flexibility of Organizations

Companies can use communications technology to organize in more flexible ways, increasing their ability to sense and respond to changes in the marketplace and to take advantage of new opportunities. Information systems can give both large and small organizations additional flexibility to overcome some of the limitations posed by their size. Small organizations can use information systems to acquire some of the muscle and reach of larger organizations. They can perform coordinating activities, such as processing bids or keeping track of inventory, and many manufacturing tasks with very few managers, clerks, or production workers.

Activity

Form two groups, one in support of and other against, and discuss the usage of IT in production floor. Similarly discuss the role of Information Technology on the long term employment capability of any firm.

4.2 FLEXIBLE MANUFACTURING SYSTEMS

Globalization, flicking market requirements, and modern lifestyle trends have put up tremendous challenges to manufacturing industries. In the current business scenario the competitiveness of any manufacturing industry is determined by its ability to respond quickly to the rapidly changing market and to produce high quality products at low costs. However, product cost is no longer the predominant factor affecting the manufacturers' perception. Other competitive factors such as flexibility, quality, efficient delivery and customer satisfaction are drawing equal attention. Manufacturing industries are striving to achieve these capabilities through automation, robotics and other innovative concepts such as Just-In-Time (JIT), Production Planning and Control (PPC), Enterprise Resource Planning (ERP), etc. Flexible manufacturing is a concept that allows manufacturing systems to be built under high customized production requirements.

Issues such as reduction of inventories and market-response time to meet customer demands, flexibility to adapt to changes in the market, reducing the cost of products and services to grab more market shares, etc. have made it almost obligatory for many firms to switch over to flexible manufacturing systems (FMSs) as a viable means to accomplish the above requirements while producing consistently good quality and cost effective products. FMS is actually an automated set of numerically controlled machine tools and material handling systems, capable of performing a wide range manufacturing operations with quick tooling and instruction changeovers.

Flexibility is an attribute that allows a mixed model manufacturing system to cope up with a certain level of variations in part or product style, without having any interruption in production due to changeovers between models. Flexibility measures the ability to adapt "to a wide range of possible environment". To be flexible, a manufacturing system must possess the following capabilities:

- Identification of the different production units to perform the correct operation.
- Quick changeover of operating instructions to the computer controlled production machines.
- Quick changeover of physical setups of fixtures, tools and other working units.

These capabilities are often difficult to engineer through manually operated manufacturing systems. So, an automated system assisted with sensor system is required to accomplish the needs and requirements of contemporary business milieu. FMS has come up as a viable means to achieve these pre-requisites. The term Flexible Manufacturing System refers to a highly automated Group Technology (GT) machine cell, consisting of a group of Computer Numerical Control (CNC) machine tools and supporting workstations, interconnected by an automated

material handling and storage system, and all controlled by a distributed computer system. The reason FMS is called "flexible" is that it is capable of processing a variety of different part styles simultaneously with the quick tooling and instruction changeovers. Also, quantities of production can be adjusted easily to changing demand patterns.

The different types of flexibility that are exhibited by manufacturing systems are given below:

- I. **Machine Flexibility:** Machine flexibility is the capability to adapt a given machine in the system to a wide range of production operations and part styles. The greater the range of operations and part styles, the greater will be the machine flexibility. The various factors on which machine flexibility depends are as follows:
 - Setup or changeover time
 - Ease with which part-programs can be downloaded to machines
 - Tool storage capacity of machines
 - Skill and versatility of workers in the system
- II. **Production Flexibility:** Production flexibility is the range of part styles that can be produced on the systems. The range of part styles that can be produced by a manufacturing system at moderate cost and time is determined by the process envelope. It depends on the following factors:
 - Machine flexibility of individual stations
 - Range of machine flexibilities of all stations in the system
- III. **Mixed Flexibility:** Mixed flexibility is defined as the ability to change the product mix while maintaining the same total production quantity that is, producing the same parts only in different proportions. It is also known as process flexibility. Mix flexibility provides protection against market variability by accommodating changes in product mix due to the use of shared resources. However, high mix variations may result in requirements for a greater number of tools, fixtures, and other resources. Mixed flexibility depends on factors such as:
 - Similarity of parts in the mix
 - Machine flexibility
 - Relative work content times of parts produced
- IV. **Product Flexibility:** Product flexibility refers to the ability to change over to a new set of products economically and quickly in response to the changing market requirements. The change over time includes the time for designing, planning, tooling, and fixturing of new products introduced in the manufacturing line-up. It depends upon the following factors:

- Relatedness of new part design with the existing part family
- Off-line part program preparation
- Machine flexibility

V. Routing Flexibility: Routing flexibility can define as capacity to produce parts on alternative workstation in case of equipment breakdowns, tool failure, and other interruptions at any particular station. It helps in increasing throughput, in the presence of external changes such as product mix, engineering changes, or new product introductions. Following are the factors which decide routing flexibility:

- Similarity of parts in the mix
- Similarity of workstations
- Common tooling

VI. Volume Flexibility: This refers to the ability of the system to vary the production volumes of different products to accommodate changes in demand while remaining profitable. It can also be termed as capacity flexibility. Factors affecting volume flexibility are:

- Level of manual labor performing production
- Amount invested in capital equipment

VII. Expansion Flexibility: Expansion flexibility is defined as the ease with which the system can be expanded to foster total production volume. It depends on the following factors:

- Cost incurred in adding new workstations and trained workers
- Easiness in expansion of layout
- Type of part handling system used

Since flexibility is inversely proportional to the sensitivity to change, a measure of flexibility must quantify the term "Penalty of Change (POC)", which is defined as follows:

$$\text{POC} = \text{Penalty} * \text{Probability of the risk of occurrence}$$

Most FMS systems consist of three main systems:

- Work machines which are often using computerized machines,
- Material handling system to optimize parts flow, and
- The central control computer which controls material movements and machine flow.

Flexible manufacturing system can also be distinguished depending upon the kinds of operation they perform. Following are the different types of FMS:

- **Processing operation:** Such operation transforms a work material from one state to another, moving towards the final desired part or product. It adds value by changing the geometry, properties or appearance of the starting materials.
- **Assembly operation:** Assembly operation involves joining of two or more components to create a new entity which is called an assembly or sub-assembly. Permanent joining processes include welding, brazing, soldering, adhesive bonding, rivets, press fitting, and expansion fits.

[Source: <http://www.ignou.ac.in/upload/UNIT6-55.pdf>]

Activity

Discuss the importance of Flexible Manufacturing System for a technical sensitive industry like transformer manufacturing.

4.3 CAD and CAM

Computer Aided Design (CAD)

According to Sullivan, CAD refers to design of products, processes or systems with the help of computers. The advantages of CAD include: speed of evaluation of alternative designs, minimization of risk of functioning, and reduction of errors. The general process of design may be seen as an iterative process with some key phases, discussed as follows:

- **Recognition of need:** This involves the realization that a problem or need exists that may be solved by design. This may mean identifying some deficiency in a current machine design by an engineer, or perceiving some new product opportunity by a salesperson.
- **Problem definition:** This involves a thorough specification of the item to be designed. Specifications include physical characteristics, function, cost, quality, and operating performance.
- **Synthesis:** Synthesis refers to the bundling of information that occurs after problem definition, and concurrently during analysis, and after re-analysis.
- **Analysis and optimization:** Closely related to the previous step, analysis is concerned with the investigation of design specification information, and the optimization of this information, as well as a synthesis of new information, as required.
- **Evaluation:** This involves measuring the design against the specifications established in the problem definition phase.

Evaluation may require the building and testing of prototype models to assess operative performance metrics for the proposed design. This may lead to the re-design of certain or all elements.

- **Presentation:** This is the final phase, where the design is documented by means of drawings, material specifications, assembly lists, and so on. Documentation means that the design database is created.

Computer Aided Manufacturing (CAM)

CAM is very much useful to design and control the manufacturing. It helps to achieve the effectiveness in production system by line balancing. Line balancing is achieved by practicing the following techniques that are implemented by CAM:

- Production Planning and Control
- Capacity Requirements Planning (CRP), Manufacturing Resources Planning (MRP II) and Materials Requirement Planning (MRP)
- Automated Inspection

Computer-Aided Manufacturing (CAM) is the effective use of computer technology in manufacturing planning and control. It is closely associated with certain functions in manufacturing engineering, such as process planning and numerical control (NC) part programming. It is applied in two broad categories: manufacturing planning, and manufacturing control.

Applications of CAM for Manufacturing Planning

- **Computer-aided process planning (CAPP):** This is concerned with creation and dissemination of route sheets that list the sequence of operations and work centers required to produce the product and its components.
- **Computer-aided NC part programming:** This application supports the creation of computer-assisted part programs for numerical control, which represents a more efficient solution for their creation over traditional manual methods.
- **Computerized machinability data systems:** This is concerned with creation and dissemination of part programs that can determine optimal cutting conditions for machine tools in the factory.
- **Computerized work standards:** These are computer packages that can be deployed to determine time standards for direct labor jobs in the factory. They supersede tedious manual time-and-motion studies used to perform the same task.
- **Cost estimating:** This is a program that can estimate the cost of a new product by computerizing several of the key steps required to prepare the estimate (such as the application of labor and overhead rates to the sequence of planned operations).

- **Production and inventory planning:** Functions here include maintenance of inventory records, automatic re-ordering of stock items when inventory is depleted, production scheduling, and maintaining current priorities for the different production orders, material requirements planning, and capacity planning.
- **Computer-aided line balancing:** This program helps to find the best allocation of work elements among stations on an assembly line. It can be used in situations where the line balancing problem is particularly complex and difficult, owing to the number of workstations, and complicating factors.

Product design serves an important function in the production system. It helps determine the eventual commercial success of a product; it determines how the production system should be created, and exactly what equipment should be bought; and it determines how easily, and how cheaply the product can be manufactured. The manufacturing support system contains procedures and systems used to manage production and solve the technical and logistical problems associated with designing the products, planning the processes, ordering the materials, controlling work-in-process as it moves through the plant and delivering products to customers. Product design and its associated use of CAD/CAM systems represent one of the most important aspects of the manufacturing support system. In CAD/CAM, both design and manufacturing are tightly integrated into a continuum of activities. Continuing the integration, we have Computer Integrated Manufacturing (CIM), which includes CAD/CAM, but also extends to embrace the business functions of a manufacturing firm.

4.4 Kaizen Theory

Kumar and Suresh propose that Kaizen (*Japanese "kai" meaning do/change, "zen" meaning well*) is a kind of thinking and management. This philosophy of quality improvement has originated in Japan and is being used not only in management field but also in everyday life in Japan. Kaizen means gradual and continuous progress, increase of value, intensification and improvement. Kaizen philosophy entails a manner of continuous improvement of processes and products. Kaizen needs attaching great value to details and common sense to make work cleverer. Usage of Kaizen ideas and motivation of every worker at every stage of production make the chosen factory of General Motors Manufacturing, Poland one of the most modern and the best managed among the biggest car concerns in the world.

Karkoszka and Honorowicz refer to Kaizen as "the way of thinking". Kaizen is also known as "Japanese style of quality management", and became an object of interest of European and American industrialists when the Japanese economy had achieved success in 1980s. During this time, Japanese organizations were seen as a kind of ideal and their way to success were perceived as myths. However, this

system is far from ideality, as it requires strained work in return for relatively low salaries and it doesn't guarantee the proper social conditions to the majority of employees. It also needs small-group activities – informal, voluntary, intercompany groups based on Kaizen-minded and self-disciplined employees. Two functions related to executable work are distinguished in Japan:

- Maintenance of the existing condition relying on the operations related to complying with current standard of technology and management,
- Improvement of the existing condition-kaizen, being the function playing the main role while the procedures and instructions are strictly implemented.

Application process of Kaizen method basically consists of:

- Definition of the improvement area
- Analysis and selection of the key problem
- Identification of the cause of improvement
- Planning the remedial centre measures
- Implementation of the improving project
- Measuring, analyzing and comparison of results
- Standardization

Process of Kaizen idea application is closed in PDCA cycle, where:

- Plan (P) refers to establishing the aim for improvement
- Do (D) is connected with implementing the plan
- Check (C) defines determining whether the implementation has brought the planned improvement
- Act (A) characterizes standardizing as the preventing recurrence of the original problem or setting goals for the new improvement.

Implementation of the particular improving projects in the range of kaizen passes on to three phases, discussed below:

The first phase relies on realizing by each employee the capability of the occurrence in the processes of different problems and swindling the habit of searching them. The most popular and the simplest method of problem identification are observing small incompatibilities in the results of work and than finding sources of incompatibilities. Objects of improvement can also be actions and operations, which are not the source of visible incompatibilities.

The second phase includes the conceptualization of the idea-the presentation of other, alternative solutions taking advantage of inapplicable methods or procedures, and then implementation of the new

idea. Each employee, who improves course of his own work by accustoming new concept, has to observe its efficiency and if it is necessary, take the necessary correcting operations.

Indicators for each employee on the way to Kaizen implementation are:

- Giving up the conventionally established ideas
- Discontinuance of tactic of excuses, critical interpretation of schemes and practices
- Revising, how to make it, not why it hadn't been done
- Immediate correction of the committed mistakes
- Taking advantage of wisdom, not mindlessly spending money
- Continuous searching the answer to the "why?" question.

The last phase of Kaizen implementation is application of the system of submitting the motions concerning the improvement of ideas. The form and procedure of submitting should be clearly defined. Assessment groups can be created on various levels of organizations. Each enterprise should be also obliged to elaborate on a clear and fair system of estimating the submitted motions. The results of the submitted motions assessment are the basic criterion of employees' work estimation. Results are declared or published in order to enable the whole staff the full insight. Such an approach promotes creation for positive relation between employee and work, high culture and continuous improvement of the achieved results.

Kaizen and Innovation

According to **Kumar and Suresh**, the basis of Kaizen is constituted by the concept of 5S, defined by Japanese specialists as a set of good customs and manners, deriving from the traditional manner of behavior in-house and school. These 5S are derived from the following Japanese words:

1. **Seiri (Selection):** Proper (suitable) preparation of a workplace, manner and instrument of work; with the elimination of everything useless.
2. **Seito-order (Systemic):** Tidiness in a workplace and preparation of every required tool in the manner enabling simple and quick utilization.
3. **Seiso-clearness (Cleaning):** Order in a workplace allowing on increase of safety of workplace, control of equipment and responsibility for the means of production.
4. **Seiketsu-consolidation (Standardization):** Reminding employees about their duties in the aspect of care of used tools and equipment and about keeping the workplace order.

5. **Shitsuke-discipline (Self-discipline):** Adaptation of employees to the principles accepted by the organization, independent elimination of bad custom, training.

Proper implementation of the 5S principles allows for application of the Kaizen concept – continuous improvement performed by all the employees involved in the process of change and including the whole organization. That is why Kaizen is unequal to the classic Western manner of improvement in the fundamental respect – it creates the process by taking advantage of human factor. The classic western approach is based mainly on the innovative operations being characterized by necessity of executing considerable investment in newest the instruments and technologies and involving the specialist. Such operations lead to considerable and variable changes. Unfortunately, most often, these changes most often are not the subject of standardization. In spite of so many differences, the proper combination between the Kaizen method and operations of the innovative character gives the biggest effects and benefits. Innovations allow following the newest trends and modern technologies, Kaizen guarantees the continuity competences and essential standardization. Techniques connected with Kaizen there are no strictly defined principles and instruments, which must be used by management and employees, in order to achieve benefits and control the processes of continuous improvement. However, several definitions and techniques are connected with Kaizen. These are:

- **Technique 5 Why's:** basic for Kaizen and, at the same time, the simplest organizing technique simultaneously, captivated in motto “when you find a problem, ask “why” five times”; it asks so many times as you will find the deepest reason of problem.
- **Practice 5s:** system of practice ordering the workplace and increasing involvement of employee in the improvement process.
- **7 kinds of productive loss (Muda):** according to the basic classification of productive loss, one can differentiate losses resulting from excessive inventories, over-production, waiting for next operation (raw materials, employees, etc.), transport, inappropriate way of processing, unnecessary unergonomic motion, and internal and external incompatibilities.
- **7 instruments of quality control:** practical methods of registration and analyses of data; the most popular are check list, Pareto diagram, reasons and results diagram (Ishikawa diagram), histogram, scheme, punctual diagram, check card most often with x-R diagram.
- **Andon:** signal used to show the place in the process requiring additional attention; signal is given by the employee who has noticed the defect.

- **Chaku-chaku (load-load line):** organization of the productive nest in such a manner that the operator deals only with setting-up parts to machines; throwing out the processed part is realized automatically (*hanedashi*).
- **Gemba, Gembutsu, Genjitsu:** basic for Kaizen principle of objectivism; for solving problems, everyone should be concentrated on the workplace, where the problem appears in which (*gemba*), on the real object (*gembutsu*) and on the facts (*genjitsu*); three of this notion are *sangenshugi* – “three reality”.
- **Jidoka (autonomation):** control process held, one of the basic solutions improving assurance of the quality of production; defects of the processed part are automatically found by the machine, which immediately stops its working mode.
- **Kaikaku:** radical improvement or reform; the most often in area of business processes.
- **Nagara:** balancing of work concerning only one operator, not a group; the most popular solution is parallel execution of incoherent tasks by one operator; *nagara* has similar meaning to the word “meanwhile”.
- **PDCA cycle:** cycle of continuous improvement; Plan-Do-Check-Act.
- **Poka-Yoke (error proof):** system of means eliminating defects being the results of inaccuracy; *poka-yoke* solutions find application in stable processes and enable to drop of frequency of defects for six sigma level.
- **Sensel:** guardian, instructor, mentor, very often from outside the organization, in assisting employee to practice Kaizen.
- **Shoujin ka:** productive line with elastic ration of labor force; solution applicable in situations, when the priority is full utilization of infrastructure.

4.5 Work Study

Kumar and Suresh refer to **work study** as a generic term for those techniques, method study and work measurement which are used in the examination of human work in all its contexts, and which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement. As is evident from Figure 1, work study includes method study and work measurement.

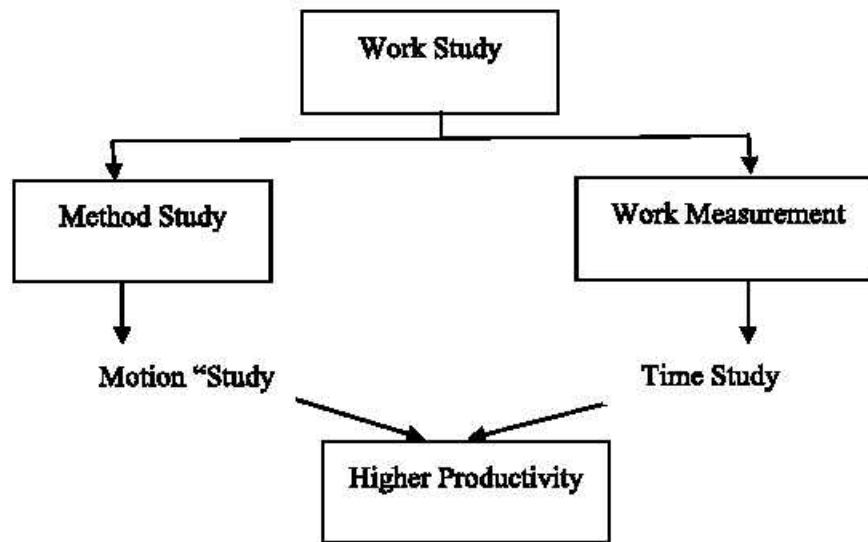


Figure 1: Work Study Methods

(Source: Kumar and Suresh)

Work study is a means of enhancing the production efficiency (productivity) of the firm by elimination of waste and unnecessary operations. It is a technique to identify non-value adding operations by investigation of all the factors affecting the job. It is the only accurate and systematic procedure-oriented technique to establish time standards. Work study contributes to making profit, as the savings will start immediately and continue throughout the life of the product. Method study and work measurement are parts of work study. Motion study comes under method study, while time study is under work measurement.

Following are the advantages of work study:

- It helps to achieve smooth production flow with minimum interruptions.
- It helps to reduce the cost of the product by eliminating waste and unnecessary operations.
- It ensures better worker-management relations.
- It helps meet the delivery commitment.
- It reduces rejections and scrap and ensures higher utilization of resources of the organization.
- It helps to achieve better working conditions.
- It promotes Better workplace layout.
- It improves upon the existing process or methods and helps in standardization and simplification.
- It helps to establish the standard time for an operation or job which has got application in manpower planning and production planning.

Method/Motion Study

According to **Kumar and Suresh**, method study enables the industrial engineer to subject each operation to systematic analysis. The main purpose of method study is to eliminate unnecessary operations and to achieve the best method of performing the operation. Method study is also called *methods engineering* or *work design*. Method engineering is used to describe a collection of analysis techniques which focus on improving the effectiveness of men and machines. According to British Standards Institution (BS 3138): "*Method study is the systematic recording and critical examination of existing and proposed ways of doing work as a means of developing and applying easier and more effective methods and reducing cost.*"

Fundamentally method study involves the breakdown of an operation or procedure into its component elements and their systematic analysis. In carrying out method study, the right attitude of mind is important. The method study man should ideally have: the desire and determination to produce results, ability to achieve results, and an understanding of the human factors involved.

Objectives of Method Study

Method study is essentially concerned with finding better ways of doing things. It adds value and increases efficiency by eliminating unnecessary operations, avoidable delays and other forms of waste. Improvement in efficiency is achieved through:

- Improved layout and design of workplace
- Improved and efficient work procedures
- Effective utilization of men, machines and materials
- Improved design or specification of the final product

The objectives of method study techniques are:

- To present and analyze true facts concerning the situation.
- To examine those facts critically.
- To develop the best answer possible under given circumstances based on critical examination of facts.

Scope of Method Study

The scope of method study lies in improving work methods through process and operation analysis, such as:

- Manufacturing operations and their sequence
- Workmen
- Materials, tools and gauges
- Layout of physical facilities and work station design
- Movement of men and material handling

- Work environment

The areas to which method study can be applied successfully in manufacturing are:

- Improvement of work methods and procedures.
- Determination of the best sequence of doing work.
- Smoothening of material flow with minimum of back tracking and improvement of layout.
- Improvement in the working conditions and hence to improve labor efficiency.
- Reduction of monotony in work.
- Improvement of plant utilization and material utilization.
- Elimination of waste and unproductive operations.
- Reduction of manufacturing costs through reducing cycle time of operations.

However, the scope of method study is not restricted to only manufacturing industries. Method study techniques can be applied effectively in offices, hospitals, banks and other service organizations as well.

Steps Involved in Method Study

The basic approach to method study consists of the following eight steps. The detailed procedure for conducting the method study is as given below:

1. **SELECT** the work to be studied and define its boundaries.
2. **RECORD** the relevant facts about the job by direct observation and collect such additional data as may be needed from appropriate sources.
3. **EXAMINE** the way the job is being performed and challenge its purpose, place, sequence and method of performance.
4. **DEVELOP** the most practical, economic and effective method, drawing on the contributions of those concerned.
5. **EVALUATE** different alternatives to developing a new improved method comparing the cost-effectiveness of the selected new method with the current method of performance.
6. **DEFINE** the new method, as a result, in a clear manner and present it to those concerned, i.e., management, supervisors and workers.
7. **INSTALL** the new method as a standard practice and train the persons involved in applying it.
8. **MAINTAIN** the new method and introduce control procedures to prevent a drifting back to the previous method of work.

Activity

Discuss the advantages and disadvantages of motion study and work study with respect to a steel manufacturing firm involving large number of job shops.

Work Measurement

Kumar and Suresh refer to work measurement as 'time study'. Work measurement is absolutely essential for both the planning and control of operations. Without measurement data, we cannot determine the capacity of facilities or it is not possible to quote delivery dates or costs; we cannot determine the rate of production and also labor utilization and efficiency. It may not also be possible to introduce incentive schemes and standard costs for budget control.

Objectives of Work Measurement

The use of work measurement as a basis for incentives is only a small part of its total application. The objectives of work measurement are to provide a sound basis for:

- Comparing alternative methods.
- Assessing the correct initial manning (manpower requirement planning).
- Planning and control.
- Realistic costing.
- Financial incentive schemes.
- Delivery date of goods.
- Cost reduction and cost control.
- Identifying substandard workers.
- Training new employees.

Techniques of Work Measurement

For the purpose of work measurement, work can be regarded as:

1. **Repetitive work:** The type of work in which the main operation or group of operations is repeated continuously during the time spent at the job. These apply to work cycles of extremely short duration.
2. **Non-repetitive work:** It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

The various techniques of work measurement are:

1. Time study (stop watch technique)
2. Synthesis
3. Work sampling

4. Predetermined motion and time study
5. Analytical estimating

Time study and work sampling involve direct observation, and the remaining are data based and analytical in nature.

1. **Time study:** Time study is a work measurement technique for recording the time and rates of working for the elements of a specified job carried out under specified conditions and for analyzing the data so as to determine the time necessary for carrying out the job at the defined level of performance. In other words, measuring time through stop watch is called time study.
2. **Synthetic data:** Synthetic data refers to a work measurement technique for building up the time for a job or parts of the job at a defined level of performance by totaling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.
3. **Work sampling:** This is a technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.
4. **Predetermined Motion Time Study (PMTS):** PMTS refers to a work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as **Methods Time Measurement (MTM)**.
5. **Analytical estimating:** Analytical estimating is a work measurement technique, being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.

Time Study

According to **Kumar and Suresh**, time study, also called work measurement, is essential for both planning and control of operations. According to the British Standard Institute, time study has been defined as *"The application of techniques designed to establish the time for a*

qualified worker to carry out a specified job at a defined level of performance."

Steps in Making Time Study

Stop watch time is the basic technique for determining accurate time standards. They are economical for repetitive type of work. Steps in taking time study are:

1. Select the work to be studied.
2. Obtain and record all the information available about the job, the operator and the working conditions likely to affect the time study work.
3. Break down the operation into elements. An element is a distinct part of a specified activity composed of one or more fundamental motions selected for convenience of observation and timing.
4. Measure the time by means of a stop watch taken by the operator to perform each element of the operation. Either continuous method or snap back method of timing could be used.
5. At the same time, assess the operator's effective speed of work relative to the observer's concept of 'normal' speed. This is called performance rating.
6. Adjust the observed time by rating factor to obtain normal time for each element, where:

Normal = Observed time Rating/100

7. Add suitable allowances to compensate for fatigue, personal needs, contingencies, etc. to give standard time for each element.
8. Compute allowed time for the entire job by adding elemental standard times, considering frequency of occurrence of each element.
9. Make a detailed job description describing the method for which the standard time is established.
10. Test and review standards wherever necessary.

Computation of Standard Time

Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance. Various allowances are added to the normal time, as applicable, to get the standard time. Standard time may broadly be defined as the amount of time required to complete a unit of work: (a) under existing working conditions, (b) using the specified method and machinery, (c) by an operator able to the work in a proper manner, and (d) at a standard pace.

Thus the basic constituents of standard time are:

- Elemental (observed time)

- Performance rating to compensate for difference in pace of working
- Relaxation allowance
- Interference and contingency allowance
- Policy allowance

Figure 2 describes the steps in time study.

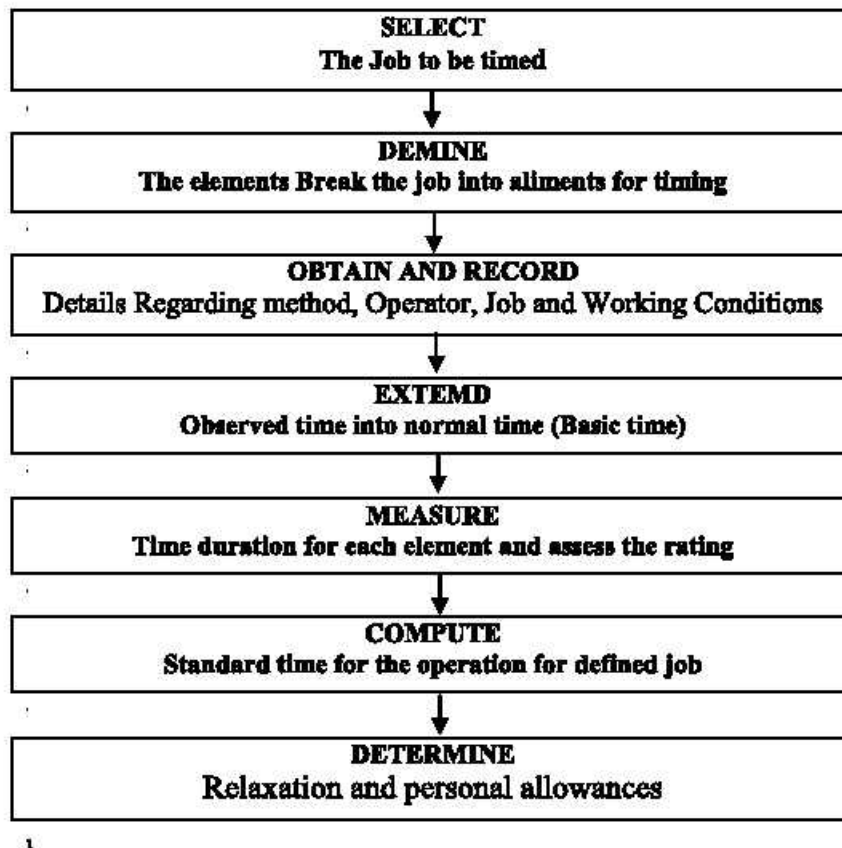


Figure 2: Steps in Time study

(Source: Kumar and Suresh)

Activity

Discuss the broad steps that must be fulfilled before starting the time study for a hardware manufacturing job shop.

4.6 IMPORTANCE OF RATING AND ALLOWANCES IN TIME STUDY

The normal time for an operation, according to **Kumar and Suresh**, does not contain any allowances for the worker. It is impossible to work throughout the day even though the most practicable, effective method has been developed. Even under the best working method situation, the job will still demand the expenditure of human effort and

some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances must also be made to enable the worker to attend to his personal needs. Allowances are categorized as: relaxation allowance, interference allowance, and contingency allowance. All three of these are discussed as follows:

i. Relaxation Allowance

Relaxation allowance is calculated so as to allow the worker to recover from fatigue. Such an allowance is an addition to the basic time intended to provide the worker, with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions, and also to allow attention to personal needs. The amount of allowance will depend on nature of the job. Relaxation allowances are of two types: fixed allowances and variable allowances. Fixed allowances constitute:

Personal needs allowance: Such allowance is intended to compensate the operator for the time necessary to leave the workplace to attend to personal needs like drinking water, smoking, washing hands, etc. Women require longer personal allowance than men. A fair personal allowance is 5% for men, and 7% for women.

Allowances for basic fatigue: This allowance is given to compensate for energy expended during working. A common figure considered as allowance is 4% of the basic time.

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job. The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organization to organization.

ii. Interference Allowance

This is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him. This allowance is applicable for machine or process controlled jobs. Interference allowance varies in proportion to number of machines assigned to the operator. The interference of the machine increases the work content.

iii. Contingency Allowance

A contingency allowance is a small allowance of time which may be included in the standard time to meet legitimate and expected items of work or delays, the precise measurement of which is uneconomical because of their infrequent or irregular occurrence. This allowance provides for small unavoidable delays as well as

for occasional minor extra work. Some of the examples calling for contingency allowance are:

- (a) Tool breakage involving removal of tool from the holder and all other activities to insert new tool into the tool holder.
- (b) Power failures of small duration.
- (c) Obtaining the necessary tools and gauges from central tool store. Contingency allowance should not exceed 5%.

Policy Allowance

Policy allowances are not a genuine part of time study and should be used with utmost care and only in clearly defined circumstances. The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions. Policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, e.g., work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances. Policy allowances are sometimes made as imperfect functioning of a division or part of a plant.

4.7 SUMMARY

Information Technology (IT) is recasting the management process by providing powerful new tools for more precise planning, forecasting and monitoring. Flexibility measures the ability to adapt to a wide range of possible environments. These capabilities are often difficult to engineer through manually operated manufacturing systems. So, an automated system assisted with sensor system is required to accomplish the needs and requirements of contemporary business. Computer-Aided Designing (CAD) refers to design of products, processes or systems with the help of computers. The advantages of CAD include: speed of evaluation of alternative designs, minimization of risk of functioning, and reduction of errors. Computer-Aided Manufacturing (CAM) is the effective use of computer technology in manufacturing planning and control. Kaizen is also known as "Japanese style of quality management". The basis of Kaizen are constituted by the concept of 5S, defined by Japanese specialists as a set of good customs and manners, deriving from the traditional manner of behavior in-house and school. Work study is a generic term for those techniques, method study and work measurement which are used in the examination of human work in all its contexts. Under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances are categorized as: relaxation allowance, interference allowance, and contingency allowance.

4.8 SELF ASSESSMENT TEST

1. Assuming that the total observed time for an operation of assembling an electric switch is 1.00 minutes, if the rating is 120%, find normal time. If an allowance of 10% is allowed for the operation, determine the standard time.

[Hint: Observed time (or) selected time = 1.00 min

Rating = 120%

Allowance = 10%

As we know that, normal time = (Observed time $\times$ Rating)/100
 $= (1.00 \times 120)/100 = 1.20 \text{ min}$

Allowance @ 10% = $(1.20 \times 10)/100$
 $= 0.12 \text{ min}$

Standard time = Normal time + Allowances
 $= 1.20 + 0.12 = 1.32 \text{ min.}]$

2. Explain how Information Technology and Production Management are interrelated.
3. Explain the need for Flexible Manufacturing System. Discuss the different types of Flexible Manufacturing System.
4. What do you understand by Computer Aided Manufacturing? How is its applicable in line balancing process?
5. What is the meaning of the term "time study"? What is the difference between time study and method study?
6. Explain the various principles of Kaizen Theory.

4.9 CASE STUDY

Toys and Job Design at Hovey and Beard Company

The following is a situation that occurred in the Hovey and Beard Company, as reported by J. V. Clark.

This company manufactured a line of wooden toys. One part of the process involved spray painting partially assembled toys, after which the toys were hung on moving hooks that carried them through a drying oven. The operation, staffed entirely by women, was plagued with absenteeism, high turnover, and low morale. Each woman at her paint booth would take a toy from the tray beside her, position it in a fixture, and spray on the color according to the required pattern. She then would release the toy and hang it on the conveyor hook. The rate at which the hooks moved had

been calculated so that each woman, once fully trained, would be able to hang a painted toy on each hook before it passed beyond her reach.

The women who worked in the paint room were on a group incentive plan that tied their earnings to the production of the entire group. Since the operation was new, they received a learning allowance that decreased by regular amounts each month. The learning allowance was scheduled to fall to zero in six months because it was expected that the women could meet standard output or more by that time. By the second month of the training period, trouble had developed. Women had progressed more slowly than had been anticipated, and it appeared that their production level would stabilize somewhat below the planned level. Some of the women complained about the speed that was expected of them, and a few of them quit. There was evidence of resistance to the new situation.

Through the counsel of a consultant, the supervisor finally decided to bring the women together for general discussions of working conditions. After two meetings in which relations between the work group and the supervisor were somewhat improved, a third meeting produced the suggestion that control of the conveyor speed be turned over to the work group. The women explained that they felt that they could keep up with the speed of the conveyor but that they could not work at that pace all day long. They wished to be able to adjust the speed of the belt, depending on how they felt.

After consultation, the supervisor had a control marked, "low, medium, and fast" installed at the booth of the group leader, who could adjust the speed of the conveyor anywhere between the lower and upper limits that had been set. The women were delighted and spent many lunch hours deciding how the speed should be varied from hour to hour throughout the day. Within a week, a pattern had emerged: the first half-hour of the shift was run on what the women called "medium speed" (a dial setting slightly above the point marked "medium"). The next two and one-half hours were run at high speed, and the half-hour before lunch and the half-hour after lunch were run at low speed. The rest of the afternoon was run at high speed, with the exception of the last 45 minutes of the shift, which were run at medium speed.

In view of the women's report of satisfaction and ease in their work, it is interesting to note that the original speed was slightly below medium on the dial of the new control. The average speed at which the women were running the belt was on the high side of the dial. Few, if any, empty hooks entered the drying oven, and inspection showed no increase of rejects from the paint room. Production increased, and within three

weeks the women were operating at 30 to 50 percent above the level that had been expected according to the original design.

Questions

- Q1.** Evaluate the experience of the Hovey and Beard Company as it reflects on job design, human relationships, and the supervisor's role.
- Q2.** How would you react as the supervisor to the situation where workers determine how the work will be performed? If you were designing the spray-painting set-up, would you design it differently?

[Adapted from J. V. Clark, "A Healthy Organization," California Management Review, Vol. 4, 1962]

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॥ सात्यमेव जयते ॥
Uttar Pradesh Rajarshi Tandon
Open University

**Master of Business
Administration**

**M.B.A.-2.2
Production Management**

BLOCK

2

PRODUCTION AND FORECASTING ISSUES

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QUANTITATIVE METHODS OF FORECASTING

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परिभाषक

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सहयोगी टीम

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प्रूफ रीडर

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UNIT - 5

Production and Forecasting Issues

STRUCTURE

- 5.1 Introduction & Concept of Forecast**
 - 5.1.1 Need of Forecast in Production and Operation Management**
 - 5.1.2 Objective of Demand Forecasting**
- 5.2 Steps in the Forecast Process**
- 5.3 Importance and Application of Forecast in Production and Operation Management**
- 5.4 Summary**
- 5.5 Self Assessment Questions**

5.1 INTRODUCTION & CONCEPT OF FORECAST

Forecasts are a basic input in the decision processes of operations management because they provide information on future demand. The importance of forecasting to operations management cannot be overstated. The primary goal of operations management is to match supply to demand. Having a forecast of demand is essential for determining how much capacity or supply will be needed to meet demand. For instance, operations needs to know what capacity will be needed to make staffing and equipment decisions, budgets must be prepared, purchasing needs information for ordering from suppliers, and supply chain partners need to make their plans.

Two aspects of forecasts are important. One is the expected level of demand; the other is the degree of accuracy that can be assigned to a forecast (i.e., the potential size of forecast error). The expected level of demand can be a function of some structural variation, such as a trend or seasonal variation. Forecast accuracy is a function of the ability of forecasters to correctly model demand, random variation, and sometimes unforeseen events. Forecasts are made with reference to a specific time horizon. The time horizon may be fairly short (e.g., an hour, day, week, or month), or somewhat longer (e.g., the next six months, the next year, the next five years, or the life of a product or service). Short-term forecasts pertain to ongoing operations. Long-range forecasts can be an important strategic planning tool.

Long term forecasts pertain to new products or services, new equipment, new facilities, or something else that will require a somewhat long lead time to develop, construct, or otherwise implement. Forecasts are the basis for budgeting, planning capacity, sales, production and inventory, personnel, purchasing, and more.

Forecasts play an important role in the planning process because they enable managers to anticipate the future so they can plan accordingly. Forecasts affect decisions and activities throughout an organization, in accounting, finance, human resources, marketing, and management information systems (MIS), as well as in operations and other parts of an organization. Following are the areas where forecasting is very useful;

New product / process accounting: New product / process cost estimates, profit projections, cash management.

Finance: Equipment/equipment replacement needs timing and amount of funding / borrowing needs.

Human resources: Hiring activities, including recruitment, interviewing, and training; layoff planning, including outplacement counseling.

Marketing: Pricing and promotion, e-business strategies, global competition strategies.

MIS: New/revised information systems, Internet services.

Operations: Schedules, capacity planning, work assignments and workloads, inventory planning, make-or-buy decisions, outsourcing, project management.

Product/service design: Revision of current features, design of new products or services.

5.1.1 NEED OF FORECAST IN PRODUCTION AND OPERATION MANAGEMENT

In most of these uses of forecasts, decisions in one area have consequences in other areas. Therefore, it is very important for all affected areas to agree on a common forecast

FEATURES COMMON TO ALL FORECASTS

A wide variety of forecasting techniques are in use. In many respects, they are quite different from each other, as you shall soon discover. Nonetheless, certain features are common to all, and it is important to recognize them.

1. Forecasting techniques generally assume that the same underlying causal system that existed in the past will continue to exist in the future.
2. Forecasts are not perfect; actual results usually differ from predicted values; the presence of randomness precludes a perfect forecast. Allowances should be made for forecast errors.
3. Forecasts for groups of items tend to be more accurate than forecasts for individual items because forecasting errors among items in a group usually

have a canceling effect. Opportunities for grouping may arise if parts or raw materials are used for multiple products or if a product or service is demanded by a number of independent sources.

4. Forecast accuracy decreases as the time period covered by the forecast—the time horizon —increases. Generally speaking, short-range forecasts must contend with fewer uncertainties than longer-range forecasts, so they tend to be more accurate.

An important consequence of the last point is that flexible business organizations—those that can respond quickly to changes in demand—require a shorter forecasting horizon and, hence, benefit from more accurate short-range forecasts than competitors who are less flexible and who must therefore use longer forecast horizons.

5.1.3 OBJECTIVE OF DEMAND FORECASTING

A properly prepared forecast should fulfil certain requirements:

1. The forecast should be timely. Usually, a certain amount of time is needed to respond to the information contained in a forecast. For example, capacity cannot be expanded overnight, nor can inventory levels be changed immediately. Hence, the forecasting horizon must cover the time necessary to implement possible changes.
2. The forecast should be accurate, and the degree of accuracy should be stated. This will enable users to plan for possible errors and will provide a basis for comparing alternative forecasts.
3. The forecast should be reliable; it should work consistently. A technique that sometimes provides a good forecast and sometimes a poor one will leave users with the uneasy feeling that they may get burned every time a new forecast is issued.
4. The forecast should be expressed in meaningful units. Financial planners need to know how many dollars will be needed, production planners need to know how many units will be needed, and schedulers need to know what machines and skills will be required. The choice of units depends on user needs.
5. The forecast should be in writing. Although this will not guarantee that all concerned are using the same information, it will at least increase the likelihood of it. In addition, a written forecast will permit an objective basis for evaluating the forecast once actual results are in.
6. The forecasting technique should be simple to understand and use. Users often lack confidence in forecasts based on sophisticated techniques; they do not understand either the circumstances in which the techniques are appropriate or the limitations of the techniques. Misuse of techniques is an obvious consequence. Not

surprisingly, fairly simple forecasting techniques enjoy widespread popularity because users are more comfortable working with them.

7. The forecast should be cost-effective: The benefits should outweigh the costs.

5.2 STEPS IN THE FORECAST PROCESS

There are six basic steps in the forecasting process:

1. Determine the purpose of the forecast. How will it be used and when will it be needed? This step will provide an indication of the level of detail required in the forecast, the amount of resources (personnel, computer time, dollars) that can be justified, and the level of accuracy necessary.
2. Establish a time horizon. The forecast must indicate a time interval, keeping in mind that accuracy decreases as the time horizon increases.
3. Obtain, clean, and analyze appropriate data. Obtaining the data can involve significant effort. Once obtained, the data may need to be "cleaned" to get rid of outliers and obviously incorrect data before analysis.
4. Select a forecasting technique.
5. Make the forecast.
6. Monitor the forecast. A forecast has to be monitored to determine whether it is performing in a satisfactory manner. If it is not, reexamine the method, assumptions, validity of data, and so on; modify as needed; and prepare a revised forecast.

Note too that additional action may be necessary. For example, if demand was much less than the forecast, an action such as a price reduction or a promotion may be needed. Conversely, if demand was much more than predicted, increased output may be advantageous. That may involve working overtime, outsourcing, or taking other measures.

5.3 IMPORTANCE AND APPLICATION OF FORECAST IN PRODUCTION AND OPERATION MANAGEMENT

1. Forecasting plays a pivotal role in the operations of modern management. It is an important and necessary aid to planning and planning is the backbone of effective operations. Many organizations have failed because of lack of forecasting or faulty forecasting on which the planning was based.
2. Production and distribution are two main activities of a business enterprise. Demand forecasts tries to maintain a balance between production and distribution policies of the enterprise.

3. An efficient demand forecast helps the management to take suitable decisions regarding plant capacity, raw material requirements, space and building needs and availability of labour and capital.
4. Demand forecasting is a necessary and effective tool in the hands of the management of an enterprise to have finished goods of right quality and quantity at right time with minimum cost.
5. Forecasting implies the act of making a detailed analysis of the future and planning is impossible without either predicting the future as accurately as possible or making intelligent assumptions about it.
6. Forecasting may be a form of intentional and considered judgement based on feelings, opinions and experiences, and these judgements, at best will be educated guesses. It could also be based upon a rational study and analysis of pertinent data and this process is known as "scientific forecasting". It would depend upon an analysis of past events and current conditions with a view to drawing inferences and conclusions about future events.

5.4 SUMMARY

Demand forecasting is the activity of estimating the quantity of a product or service that consumers will purchase. Demand forecasting involves techniques including both informal methods, such as educated guesses, and quantitative methods, such as the use of historical sales data or current data from test markets. Demand forecasting moving the organization from uncertainty to certainty and it plays immense important role in production and operation management.

5.5 SELF ASSESSMENT QUESTIONS

1. What is forecasting?
2. Elaborate the concept of forecasting in modern management.
3. "Can you imagine production and operation management without forecasting"? Give rationale behind your answer.
4. Detail down the process of forecasting.
5. Elaborate the importance of forecasting with some real examples from production and operation management.

UNIT - 6

QUALITATIVE METHODS OF FORECASTING-I

STRUCTURE

- 6.1 Introduction of Judgment Forecasting**
- 6.2 Delphi Technique**
 - 6.2.1 Key characteristics**
 - 6.2.2 Process of Delphi Method**
 - 6.2.3 Applications**
 - 6.2.4 When should the Delphi technique be used?**
 - 6.2.5 Guidelines for selecting the Delphi Panelist**
 - 6.2.6 Advantages of Delphi technique**
 - 6.2.7 Pitfalls in Delphi technique**
 - 6.2.8 Variants of Delphi method**
- 6.3 Summary**
- 6.4 Self Assessment Questions**

6.1 JUDGMENTAL FORECASTING

It is one of the most widely used and influential forecasting techniques where the opinions and intuition of management is utilized. The process brings together in an organized manner, personal judgments about the process being analyzed. Main Reliance is on human judgment.

In this method, the executive uses his own anticipation and what he hears from other. Outside experts are also consulted and the other executive heads are also required to give their opinion in the matter, Salesmen are to provide information about customer's attitude and preferences and the activities of competitors. Thus all the possible information from the opinions of various persons is combined together to change the subjective opinions into quantitative forecast.

Advantages:

- 1. Simple and Easy to understand.**
- 2. No specialized skill is required**
- 3. Low cost**

4. Is based on the information or opinion of the persons who are directly involved in the system.
5. Can be used when satisfactory data is not available.

Disadvantages:

1. Opinions and institution are highly subjective.
2. Personal estimates are likely to be biased.
3. Time required to take the decision may be more.
4. Results can be easily distorted.
5. Lacks scientific validity.
6. It is not based on valid facts.
7. The method is not useful for long term planning.

The method can be more useful for many new products or new service estimators where sufficient past experience is not required.

6.2 DELPHI TECHNIQUE

The Delphi method was originally developed in the early 1950s at the RAND Corporation by Olaf Helmer and Norman Dalkey to systematically solicit the view of experts related to national defense and later in controversial sociopolitical areas of discourse.

The term originates from Greek mythology. Delphi was the site of the Delphic oracle, the most important oracle in the classical Greek world. Thus, the Delphi method may think of as an expert brainstorm.

In Delphi decision groups, a series of questionnaires, surveys, etc. are sent to selected respondents (the Delphi group) through a facilitator who oversees responses of their panel of experts. The group does not meet face-to-face. All communication is normally in writing (letters or email). Members of the groups are selected because they are experts or they have relevant information.

The responses are collected and analyzed to determine conflicting viewpoints on each point. The process continues in order to work towards synthesis and building consensus.

6.2.1 KEY CHARACTERISTICS

The following key characteristics of the Delphi method help the participants to focus on the issues at hand and separate Delphi from other methodologies:

Anonymity of the participants

Usually all participants remain anonymous. Their identity is not revealed, even after the completion of the final report. This prevents the authority, personality, or reputation of some participants from dominating

others in the process. Arguably, it also frees participants (to some extent) from their personal biases, minimizes the "[bandwagon effect](#)" or "[halo effect](#)", allows free expression of opinions, encourages open critique, and facilitates admission of errors when revising earlier judgments.

Structuring of information flow

The initial contributions from the experts are collected in the form of answers to questionnaires and their comments to these answers. The panel director controls the interactions among the participants by processing the information and filtering out irrelevant content. This avoids the negative effects of face-to-face panel discussions and solves the usual problems of group dynamics.

Regular feedback

Participants comment on their own forecasts, the responses of others and on the progress of the panel as a whole. At any moment they can revise their earlier statements. While in regular group meetings participants tend to stick to previously stated opinions and often conform too much to the group leader, the Delphi method prevents it.

Role of the facilitator

The person coordinating the Delphi method is usually known as a *facilitator* or Leader, and facilitates the responses of their *panel of experts*, who are selected for a reason, usually that they hold knowledge on an opinion or view. The facilitator sends out questionnaires, surveys etc. and if the panel of experts accept, they follow instructions and present their views. Responses are collected and analyzed, then common and conflicting viewpoints are identified. If consensus is not reached, the process continues through thesis and antithesis, to gradually work towards synthesis, and building consensus.

6.2.2 PROCESS OF DELPHI METHOD

The process works as follows:

- ◆ Members are selected for the Delphi panel due to their expertise.
- ◆ They are kept separated and answer through an open-ended questionnaires, surveys, etc. in order to solicit specific information about a subject or content area. Keeping them separated avoids the negative effects of face-to-face discussions and avoids problems associated with group dynamics.
- ◆ Members are asked to share their assessment and explanation of a problem or predict a future state of affairs.
- ◆ The facilitator (panel director) controls the interactions among the participants by processing the information and filtering out irrelevant content.
- ◆ Replies are gathered, summarized, and then fed back to all the group members.

- ❖ Members then make another decision based upon the new information.
- ❖ The process is repeated until the the responses converge satisfactory, that is, it yields consensus.

The success of this process depends upon the member's expertise and communication skill. Also, each response requires adequate time for reflection and analysis. The major merits of the Delphi process are:

- ❖ Elimination of interpersonal problems.
- ❖ Efficient use of expert's time.
- ❖ Diversity of ideals.
- ❖ Accuracy of solutions and predictions.

6.2.3 APPLICATIONS

Use in forecasting

1. First applications of the Delphi method were in the field of science and technology forecasting. The objective of the method was to combine expert opinions on likelihood and expected development time, of the particular technology, in a single indicator. One of the first such reports, prepared in 1964 by Gordon and Helmer, assessed the direction of long-term trends in science and technology development, covering such topics as scientific breakthroughs, [population control](#), [automation](#), space progress, war prevention and weapon systems.
2. Other forecasts of technology were dealing with vehicle-highway systems, industrial robots, intelligent internet, broadband connections, and technology in education.
3. Later the Delphi method was applied in other areas, especially those related to public policy issues, such as economic trends, health and education. It was also applied successfully and with high accuracy in business forecasting. For example, in one case reported by Basu and Schroeder (1977), the Delphi method predicted the sales of a new product during the first two years with inaccuracy of 3–4% compared with actual sales. Quantitative methods produced errors of 10–15%, and traditional unstructured forecast methods had errors of about 20%.

6.2.4 WHEN SHOULD THE DELPHI TECHNIQUE BE USED?

Linstone and Turoff provide a comprehensive list of situations where it would be best to employ the Delphi technique. These are:

1. The problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis.

2. The individuals needed to contribute to the examination of a broad or complex problem have no history of adequate communication and may represent diverse backgrounds with respect to experience or expertise.
3. More individuals are needed than can effectively interact in a face-to-face exchange.
4. Time and cost make frequent group meetings infeasible.
5. The efficiency of face to face meeting can be increased by a supplemental groups communication process.
6. Disagreements among individuals are so severe or politically unpalatable that the communication process must be refereed and/or anonymity assured.
7. The heterogeneity for the participants must be preserved to assure validity of the results ie. Avoidance of domination by quantity or by strength of personality ('bandwagon effect').

6.2.5 GUIDELINES FOR SELECTING THE DELPHI PANELIST

1. Select panel members based on knowledge of the issue and diversity of perspective
2. Provide enough incentive to maintain panelists' motivation to persist to the conclusion of the study
3. Ensure that panelists feel that their contributions are valued
4. Communicate to panelists that they are members of a group with similar expertise to theirs

6.2.6 ADVANTAGES OF DELPHI TECHNIQUE

Following advantages are associated with Delphi method;

1. A formal and structured questionnaire is used.
2. Questionnaire items may be generated by the moderator, the panelists, or both.
3. Either quantitative or qualitative scales may be used.
4. Questionnaires may or may not include open-ended questions.
5. Feedback from each round is in the form of statistical feedback, usually involving some measure of central tendency and some measure of dispersion.
6. Individual responses to items are kept anonymous.

7. Iteration with feedback continues until consensus is reached, as determined by the moderator.
8. Participants do not meet face to face and may be geographically dispersed.

6.2.7 PITFALLS IN DELPHI TECHNIQUE

1. In Delphi technique there were the time and expense of designing paper and pencil questionnaires, mailing surveys, compiling responses, and following up with non respondents for multiple iterations of the process.
2. Potentially high attrition rate. Because the method requires lengthy responses in the early rounds of the process and the active participation of panelists over several weeks, the potential for a high drop-out rate of panelists exists

6.2.8 VARIANTS OF DELPHI METHOD

Traditionally the Delphi method has aimed at a consensus of the most probable future by iteration. Other versions, such as the Policy Delphi, is instead a decision support method aiming at structuring and discussing the diverse views of the preferred future.

In Europe, more recent web-based experiments have used the Delphi method as a communication technique for interactive [decision making](#) and e-democracy

The Argument Delphi, was developed by Osmo Kuusi, focuses on ongoing discussion and finding relevant arguments rather than focusing on the output.

The Disaggregative Policy Delphi, developed by Petri Tapio, uses cluster analysis as a systematic tool to construct various scenarios of the future in the latest Delphi round. The respondent's view on the probable and the preferable future are dealt with as separate cases.

6.3 SUMMARY

Qualitative methods tell us about in details regarding forecasting. These methods are not easy to implement as the implementation of these methods require expertise. The output or forecasting through these methods is appropriate where we do not have quantitative information to carry out results.

6.4 SELF ASSESSMENT QUESTIONS

- 1. Define “Judgement Forecasting” and explain its advantages and disadvantages.**
- 2. Explain “Delphi Technique” and compare this technique with “Opinion Capture Technique”.**
- 3. Explain the process of Delphi technique with its operational details.**
- 4. Explain decision analysis Delphi.**
- 5. Give a detailed outline of guidelines for conducting a Delphi study.**
- 6. What is ‘argument delphi’?**
- 7. What are various advantages of using Delphi method?**

UNIT - 07

QUALITATIVE METHODS OF FORECASTING-II

STRUCTURE

- 7.1 Forecasting based on cross-impact analysis**
 - 7.1.1 Cross impact matrix**
 - 7.1.2 The cross impact matrix based on Bayesian rule**
 - 7.1.3 Simulation based on cross impact**
- 7.2 Summary**
- 7.3 Self Assessment Questions**

7.1 FORECASTING BASED ON CROSS-IMPACT ANALYSIS

Cross-impact analysis is a methodology developed by Theodore Gordon and Olaf Helmer in 1966 to help determine how relationships between events would impact resulting events and reduce uncertainty in the future.

Cross-impact analysis seems to have two schools of thought and ways of approach. The first is the futures forecasting style that originally developed the methodology. The second is a sub-school of intelligence analysts which modified the original methodology to better address their needs. Nevertheless, Cross Impact Analysis is based upon the premise that events and activities do not happen in a vacuum and other events and the surrounding environment can significantly influence the probability of certain events to occur.

Cross-impact analysis attempts to connect relationships between events and variables. These relationships are then categorized as positive or negative to each other, and are used to determine which events or scenarios are most probable or likely to occur within a given time frame.

7.1.1 CROSS IMPACT MATRIX

A major part of the intelligence analysis style of cross-impact analysis is the cross-impact matrix. The matrix is a visualization of the cross-impact analysis and allows for modification. It also allows an analyst to find the most influential variables and those variables that are impacted by the most other variables, not just direct, one-to-one relationships. While several traditional Cross Impact Analysis methods suggest the creation of a matrix, the priority still relies in probabilities, one-to-one relationships, and the order of events.

In the intelligence analysis style cross-impact matrix, analysts use pluses and minuses instead of numerical values allowing for non-event variables and allowing the analyst to compare variables directly to all other variables without calculations.

7.1.2 CROSS IMPACT ANALYSIS BASED ON BAYESIAN RULE

In [probability theory](#) and [statistics](#), Bayes' theorem (alternatively Bayes' law or [Bayes' rule](#)) describes the [probability](#) of an [event](#), based on conditions that might be related to the event. For example, suppose one is interested in whether Addison has cancer, and that she is 65. If cancer is related to age, information about Addison's age can be used to more accurately assess the probability of her having cancer using Bayes' Theorem.

When applied, the probabilities involved in Bayes' theorem may have different [probability interpretations](#). In one of these interpretations, the theorem is used directly as part of a particular approach to [statistical inference](#). With the [Bayesian probability](#) interpretation the theorem expresses how a subjective degree of belief should rationally change to account for evidence: this is [Bayesian inference](#), which is fundamental to [Bayesian statistics](#). However, Bayes' theorem has applications in a wide range of calculations involving probabilities, not just in Bayesian inference.

Bayes' theorem is stated mathematically as the following equation;

$$P(A|B) = \frac{P(A) P(B|A)}{P(B)},$$

where A and B are [events](#).

- $P(A)$ and $P(B)$ are the [probabilities](#) of A and B without regard to each other.
- $P(A | B)$, a [conditional probability](#), is the probability of observing event A given that B is true.
- $P(B | A)$, is the probability of observing event B given that A is true.

7.1.3S IMULATION IN CROSS IMPACT ANALYSIS

We assume that decision makers have identified a set of relevant events, together with an estimate of the marginal probability that these events will occur, as well as a causal cross-impact matrix. Our subsequent methodology then involves four computational steps, discussed in the next four subsections respectively:

- computation of revised marginal probabilities,
- computation of consistent occurrence conditional probabilities,

- computation of a likely causal cross-impact matrix or a revised causal cross-impact matrix, and
- ranking of events.

7.2 SUMMARY

Cross impact analysis evaluate the relationship between cause and impact. By means of cross impact matrix, we would know about the strength and weaknesses of cause and impact. It is application based concept and having direct impact on our life.

7.3 SELF ASSESSMENT QUESTIONS

1. Explain cross impact analysis by means of cross impact matrix.
2. What is simulation, how simulation is an integral part of cross impact analysis?
3. Explain Baye's Theorem.
4. Design a cross impact matrix between age and height.

UNIT - 8

QUANTITATIVE METHODS OF FORECASTING

STRUCTURE

- 8.1 Application of Forecasting & Operation Management
- 8.2 Specific forecasting methods & classes of forecasting methods
 - 8.2.1 Time series forecasting
 - 8.2.2 Causal Model
- 8.3 Forecasting Error
- 8.4 Selection of forecasting model
- 8.5 Summary
- 8.6 Self Assessment Questions

8.1 APPLICATION OF FORECASTING

Forecasting has applications in a wide range of fields where estimates of future conditions are useful. Not everything can be forecasted reliably, if the factors that relate to what is being forecast are known and well understood and there is a significant amount of data that can be used very reliable forecasts can often be obtained. If this is not the case or if the actual outcome is affected by the forecasts, the reliability of the forecasts can be significantly lower.

Forecasting has also been used to predict the development of conflict situations. Forecasters perform research that uses empirical results to gauge the effectiveness of certain forecasting models.^[15] However research has shown that there is little difference between the accuracy of the forecasts of experts knowledgeable in the conflict situation and those by individuals who knew much less

Similarly, experts in some studies argue that role thinking does not contribute to the accuracy of the forecast. The discipline of demand planning, also sometimes referred to as supply chain forecasting, embraces both statistical forecasting and a consensus process. An important, albeit often ignored aspect of forecasting, is the relationship it holds with [planning](#). Forecasting can be described as predicting what the future will look like, whereas planning predicts what the future should look like. There is no single right forecasting method to use. Selection of a method should be based on your objectives and your conditions (data etc.). Forecasting has application in many situations:

- [Supply chain management](#)
- [Economic forecasting](#)
- [Earthquake prediction](#)
- [Egain forecasting](#)
- [Land use forecasting](#)
- [Player and team performance in sports](#)
- [Political forecasting](#)
- [Product forecasting](#)
- [Sales forecasting](#)
- [Technology forecasting](#)
- [Telecommunications forecasting](#)
- [Transport planning](#) and [Transportation forecasting](#)
- [Weather forecasting](#), [Flood forecasting](#) and [Meteorology](#)

8.2 SPECIFIC QUANTITATIVE FORECASTING METHODS

Average approach

In this approach the predictions of all future values are equal to the mean of the past data. This approach can be used with any sort of data where past data is available. In time series notation:

$$\hat{y}_{T+h|T} = \bar{y} = (y_1 + \dots + y_T)/T \quad [2]$$

where $y_1, \dots, y_T$ is the past data.

Naïve approach

Naïve forecasts are the most cost-effective forecasting model, and provide a benchmark against which more sophisticated models can be compared. In time series data, using naive approach would produce forecasts that are equal to the last observed value. This method works quite well for economic and financial time series, which often have patterns that are difficult to reliably and accurately predict. [2] If the time series is believed to have seasonality, seasonal naive approach may be more appropriate where the forecasts are equal to the value from last season. The naive method may also use a drift, which will take the last observation plus the average change from the first observation to the last observation. [2] In time series notation:

$$\hat{y}_{T+h|T} = y_T$$

Drift method

A variation on the naïve method is to allow the forecasts to increase or decrease over time, where the amount of change over time (called the drift) is set to be the average change seen in the historical data. So the forecast for time $T + h$ is given by

$$\hat{y}_{T+h|T} = y_T + \frac{h}{T-1} \sum_{t=2}^T (y_t - y_{t-1}) = y_T + h \left(\frac{y_T - y_1}{T-1} \right). \quad [2]$$

This is equivalent to drawing a line between the first and last observation, and extrapolating it into the future.

Seasonal naïve approach

The seasonal naïve method accounts for seasonality by setting each prediction to be equal to the last observed value of the same season. For example, the prediction value for all subsequent months of April will be equal to the previous value observed for April. The forecast for time $T + h$ is:^[2]

$$\hat{y}_{T+h|T} = y_{T+h-km} \text{ Where } m = \text{seasonal period and } k \text{ is the smallest integer greater than } (h-1)/m.$$

The seasonal naïve method is particularly useful for data that has a very high level of seasonality.

8.2.1 TIME SERIES FORECASTING

A time series is a sequence of [data points](#), typically consisting of successive measurements made over a time interval. Examples of time series are ocean [tides](#), counts of [sunspots](#), and the daily closing value of the [Dow Jones Industrial Average](#). Time series are very frequently plotted via [line charts](#). Time series are used in [statistics](#), [signal processing](#), [pattern recognition](#), [econometrics](#), [mathematical finance](#), [weather forecasting](#), intelligent transport and trajectory forecasting, etc

Time series *analysis* comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series *forecasting* is the use of a [model](#) to predict future values based on previously observed values. While [regression analysis](#) is often employed in such a way as to test theories that the current values of one or more independent time series affect the current value of another time series, this type of analysis of time series is not called "time series analysis", which focuses on comparing values of a single time series or multiple dependent time series at different points in time.

Time series data have a natural temporal ordering. This makes time series analysis distinct from [cross-sectional studies](#), in which there is no natural ordering of the observations (e.g. explaining people's wages by reference to their respective education levels, where the individuals' data could be entered in any order). Time series analysis is also distinct

from [spatial data analysis](#) where the observations typically relate to geographical locations (e.g. accounting for house prices by the location as well as the intrinsic characteristics of the houses). A [stochastic](#) model for a time series will generally reflect the fact that observations close together in time will be more closely related than observations further apart. In addition, time series models will often make use of the natural one-way ordering of time so that values for a given period will be expressed as deriving in some way from past values, rather than from future values

8.2.2 CAUSAL MODEL

Some forecasting methods try to identify the underlying factors that might influence the variable that is being forecast. For example, including information about climate patterns might improve the ability of a model to predict umbrella sales. Forecasting models often take account of regular seasonal variations. In addition to climate, such variations can also be due to holidays and customs: for example, one might predict that sales of college football apparel will be higher during the football season than during the off season.

Several informal methods used in causal forecasting do not employ strict algorithms, but instead use the judgment of the forecaster. Some forecasts take account of past relationships between variables: if one variable has, for example, been approximately linearly related to another for a long period of time, it may be appropriate to extrapolate such a relationship into the future, without necessarily understanding the reasons for the relationship.

Causal methods include:

- [Regression analysis](#) includes a large group of methods for predicting future values of a variable using information about other variables. These methods include both [parametric](#) (linear or non-linear) and [non-parametric](#) techniques.
- **Autoregressive moving average with exogenous inputs (ARMAX)**

Quantitative forecasting models are often judged against each other by comparing their in-sample or out-of-sample [mean square error](#), although some researchers have advised against this

8.3 FORECASTING ERROR

The forecast error is the difference between the actual value and the forecast value for the corresponding period.

$$E_t = Y_t - F_t$$

Where E is the forecast error at period t, Y is the actual value at period t, and F is the forecast for period t.

8.4 SELECTION OF FORECASTING MODEL

In virtually every decision they make, executives today consider some kind of forecast. Sound predictions of demands and trends are no longer luxury items, but a necessity, if managers are to cope with seasonality, sudden changes in demand levels, price-cutting manoeuvres of the competition, strikes, and large swings of the economy.

To handle the increasing variety and complexity of managerial forecasting problems, many forecasting techniques have been developed in recent years. Each has its special use, and care must be taken to select the correct technique for a particular application. The manager as well as the forecaster has a role to play in technique selection; and the better they understand the range of forecasting possibilities, the more likely it is that a company's forecasting efforts will bear fruit.

The selection of a method depends on many factors—the context of the forecast, the relevance and availability of historical data, the degree of accuracy desirable, the time period to be forecast, the cost/ benefit (or *value*) of the forecast to the company, and the time available for making the analysis.

These factors must be weighed constantly, and on a variety of levels. In general, for example, the forecaster should choose a technique that makes the best use of available data. If the forecaster can readily apply one technique of acceptable accuracy, he or she should not try to “gold plate” by using a more advanced technique that offers potentially greater accuracy but that requires nonexistent information or information that is costly to obtain. This kind of trade-off is relatively easy to make, but others, as we shall see, require considerably more thought.

Furthermore, where a company wishes to forecast with reference to a particular product, it must consider *the stage of the product's life cycle for which it is making the forecast*. The availability of data and the possibility of establishing relationships between the factors depend directly on the maturity of a product, and hence the life-cycle stage is a prime determinant of the forecasting method to be used.

Our purpose here is to present an overview of this field by discussing the way a company ought to approach a forecasting problem, describing the methods available, and explaining how to match method to problem. We shall illustrate the use of the various techniques from our experience with them at Corning, and then close with our own forecast for the future of forecasting.

8.5 SUMMARY

Quantitative methods are playing a significant role in any forecasting for business. While selecting a quantitative method, one should understand the limitations of that technique for more accurate and reliable forecasting else there are very high chances of error in the result. For good and more accurate results, we should understand the functionality of the issue.

8.6 SELF ASSESSMENT QUESTIONS

1. Explain the functional importance of quantitative methods of forecasting.
2. Elaborate the relationship between operations management and forecasting.
3. What are the various types of quantitative methods of forecasting?
4. Explain "Forecasting Error".
5. What are the criteria of selecting best forecasting method?



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Master of Business

M.B.A.-2.2 Production Management

BLOCK

3

PRODUCTION PLANNING

UNIT 9

133-152

Facility Location Planning : Introduction; Operating Strategies for Multiple Facilities, Factors Affecting Facility; Location Planning: Locating Foreign Operations; Factors and Location Rating; Break-even Analysis for Facility Location Planning; Simple Median Model; The Centre of Gravity Method; Transportation Model using MS Excel XP; Ardalan Heuristics for Location Planning of Service Facilities

UNIT 10

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UNIT 11

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UNIT 12

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परिशिष्ट-4
आन्तरिक कवर-दो का प्रारूप
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अनुवाद की स्थिति में

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मूल परिभाषक	परिभाषक

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UNIT - 9

FACILITY LOCATION PLANNING

STRUCTURE

- 9.0** Introduction;
- 9.1** Operating Strategies for Multiple Facilities,
- 9.2** Factors Affecting Facility;
- 9.3** Location Planning:
 - 9.3.1** Locating Foreign Operations;
- 9.4** Factors and Location Rating;
 - 9.4.1** Break-even Analysis for Facility Location Planning;
 - 9.4.2** Simple Median Model;
 - 9.4.3** The Centre of Gravity Method;
 - 9.4.4** Transportation Model using MS Excel XP;
 - 9.4.5** Ardalan Heuristics for Location Planning of Service Facilities
- 9.5** Summary

9.0 INTRODUCTION

Location can be defined as “a place to put something”. Facility location means a place to put the facility. Facility location decisions are strategic, long term, and non-repetitive in nature. Without sound location planning in the beginning, the new facility may pose continuous operating disadvantages for the future operations. Location decisions are affected by many factors, both internal and external, to the organization's operations. Internal factors include the technology used, the capacity, the financial position, and the work force required. External factors include the economic, political, and social conditions in the various localities. Thus, for long term benefits of the facility, a sound and careful location planning is required.

Facility Location is the right location for the manufacturing facility, it will have sufficient access to the customers, workers, transportation, etc. For commercial success, and competitive advantage following are the critical factors: Overall objective of an organization is to satisfy and delight customers with its product and services. Therefore, for an organization it becomes important to have strategy formulated around its manufacturing unit. A manufacturing unit is the place where all inputs

such as raw material, equipment, skilled labours, etc. come together and manufacture products for customers. One of the most critical factors determining the success of the manufacturing unit is the location.

9.1 OPERATING STRATEGIES FOR MULTIPLE FACILITIES

When companies have several manufacturing facilities there are several different ways for a company to organize their operations. These ways include: assigning different product lines to different plants, assigning different market areas to different plants, or assigning different processes to different plants. These strategies carry their own cost and managerial implications, but they also carry a certain competitive advantage.

There are four different types of plant strategies:

1. Product Plant Strategy

- Products or product lines are produced in separate plants, and each plant is usually responsible for supplying the entire domestic market.
- It is a decentralized approach as each plant focuses on a narrow set of requirements that includes specialization of labour, materials, and equipment along product lines.
- Specialization involved in this strategy usually results in economies of scale and, compared to multipurpose plants, lower operating costs.
- The plant locations may either be widely scattered or placed relatively close to one another.

2. Market Area Plant Strategy

- Here, plants are designed to serve a particular geographic segment of a market.
- The individual plants can produce either most, or all of the company's products and supply a limited geographical area.
- The operating costs of this strategy are often times higher than those of product plants, but savings on shipping costs for comparable products can be made.
- This strategy is useful when shipping costs are high due to volume, weight, or other factors.
- It can also bring the added benefits of faster delivery and response times to local needs.
- It requires a centralized coordination of decisions to add or delete plants, or to expand or downsize current plants because of changing market conditions.

3. Process Plant Strategy

- Here, different plants concentrate on different aspects of a process.
- This strategy is most useful when products have numerous components; separating the production of components results in less confusion than if all the production were done in the same location.
- A major issue with this strategy is the coordination of production throughout the system, and it requires a highly informed, centralized administration in order to be an effective operation.
- It can bring about additional shipping costs, but a key benefit is that individual plants are highly specialized and generate volumes that brings economies of scale.

4. General-Purpose Plant Strategy

- Plants are flexible and have the ability to handle a range of products
- It allows for a quick response to products and market changes, but can be less productive than a more focused approach.
- A benefit to this approach is the increase in learning opportunities that happens when similar operations are being done in different plants. Solutions to problems as well as improvements made at one plant can be shared with the other plants.

9.2 FACTORS AFFECTING FACILITY

For a company which operates in a global environment; cost, available infrastructure, labour skill, government policies and environment are very important factors. A right location provides adequate access to customers, skilled labors, transportation, etc. A right location ensures success of the organization in current global competitive environment. A geographic area becomes a focal point for various facility locations based on many factors, parameters and issues. These factors are can be divided into primary factors and secondary factors. A primary factor which leads to industrialization of a particular area for particular manufacturing of products is material, labour and presence of similar manufacturing facilities. Secondary factors are available of credit FINANCE, communication infrastructure and insurance. The goal of an organization is customer delight for that it needs access to the customers at minimum possible cost. This is achieved by developing location strategy. Location strategy helps the company in determining product offering, market, demand forecast in different markets, best location to access customers and best manufacturing and service location.

If the organization can configure the right location for the manufacturing facility, it will have sufficient access to the customers, workers, transportation, etc. For commercial success, and competitive advantage following are the critical factors:

Customer Proximity: Facility locations are selected closer to the customer as to reduce transportation cost and decrease time in reaching the customer.

Business Area: Presence of other similar manufacturing units around makes business area conducive for facility establishment.

Availability of Skill Labour: Education, experience and skill of available labour are another important, which determines facility location.

Free Trade Zone/Agreement: Free-trade zones promote the establishment of manufacturing facility by providing incentives in custom duties and levies. On another hand free trade agreement is among countries providing an incentive to establish business, in particular, country.

Suppliers: Continuous and quality supply of the raw materials is another critical factor in determining the location of manufacturing facility.

Environmental Policy: In current globalized world pollution, control is very important, therefore understanding of environmental policy for the facility location is another critical factor.

ERRORS IN LOCATION SELECTION

Facility location is critical for business continuity and success of the organization. So it is important to avoid mistakes while making selection for a location. Errors in selection can be divided into two broad categories behavioural and non-behavioural. Behavioural errors are decision made by executives of the company where personal factors are considered before success of location, for example, movement of personal establishment from hometown to new location facility. Non-behavioural errors include lack of proper investigative practice and analysis, ignoring critical factors and characteristics of the industry.

9.3 LOCATION PLANNING

Every firm must use location planning techniques. There are many options for location planning. Corporations choose from expanding an existing location, shutting down one location and moving to another, adding new locations while retaining existing facilities, or doing nothing. There are a variety of methods used to decide the best location or alternatives for the corporation. Methods such as identifying the country, general region, small number of community alternatives, and site alternatives.

Several factors that influence location positioning include the location of raw materials, proximity to the market, climate, and culture. Models for evaluating whether a location is best for an organization

consist of cost-profit analysis for locations, the center of gravity model, the transportation model, and factor rating.

The main factors that affect location decisions include regional factors, community considerations, and site-related factors. Community factors consist of quality of life, services, attitudes, taxes, environmental regulations, utilities, and development support.

9.3.1 LOCATING FOREIGN OPERATIONS

A. Tangible Reasons

The tangible reasons for setting up an operations facility abroad could be as follows:

Reaching the customer: One obvious reason for locating a facility abroad is that of capturing a share of the market expanding worldwide. The phenomenal growth of the GDP of India is a big reason for the multinationals to have their operations facilities in our country. An important reason is that of providing service to the customer promptly and economically which is logistics-dependent. Therefore, cost and ease of logistics is a reason for setting up manufacturing facilities abroad. By logistics set of activities closes the gap between production of goods/services and reaching of these intended goods/services to the customer to his satisfaction. Reaching the customer is thus the main objective. The tangible and intangible gains and costs depend upon the company defining for itself as to what that 'reaching' means. The tangible costs could be the logistics related costs; the intangible costs may be the risk of operating in a foreign country. The tangible gains are the immediate gains; the intangible gains are an outcome of what the company defines the concepts of reaching and customer for itself.

The other tangible reasons could be as follows:

- (a) The host country may offer substantial tax advantages compared to the home country.
- (b) The costs of manufacturing and running operations may be substantially less in that foreign country. This may be due to lower labour costs, lower raw material cost, better availability of the inputs like materials, energy, water, ores, metals, key personnel etc.
- (c) The company may overcome the tariff barriers by setting up a manufacturing plant in a foreign country rather than exporting the items to that country.

B. Intangible Reasons

The intangible reasons for considering setting up an operations facility abroad could be as follows:

1. Customer-related Reasons

- (a)** With an operations facility in the foreign country, the firm's customers may feel secure that the firm is more accessible. Accessibility is an important 'service quality' determinant.
- (b)** The firm may be able to give a personal touch.
- (c)** The firm may interact more intimately with its customers and may thus understand their requirements better.
- (d)** It may also discover other potential customers in the foreign location.

2. Organisational Learning-related Reasons

- (a)** The firm can learn advanced technology. For example, it is possible that cutting-edge technologies can be learned by having operations in a technologically more advanced country. The firm can learn from advanced research laboratories/universities in that country. Such learning may help the entire product-line of the company.
- (b)** The firm can learn from its customers abroad. A physical location there may be essential towards this goal.
- (c)** It can also learn from its competitors operating in that country. For this reason, it may have to be physically present where the action is.
- (d)** The firm may also learn from its suppliers abroad. If the firm has a manufacturing plant there, it will have intensive interaction with the suppliers in that country from whom there may be much to learn in terms of modern and appropriate technology, modern management methods, and new trends in business worldwide.

3. Other Strategic Reasons

- (a)** The firm by being physically present in the host country may gain some 'local boy' kind of psychological advantage. The firm is no more a 'foreign' company just sending its products across international borders. This may help the firm in lobbying with the government of that country and with the business associations in that country.
- (b)** The firm may avoid 'political risk' by having operations in multiple countries.
- (c)** By being in the foreign country, the firm can build alternative sources of supply. The firm could, thus, reduce its supply risks.
- (d)** The firm could hunt for human capital in different countries by having operations in those countries. Thus, the firm can gather the best of people from across the globe.

- (e) Foreign locations in addition to the domestic locations would lower the market risks for the firm. If one market goes slow the other may be doing well, thus lowering the overall risk.

EVALUATING LOCATION ALTERNATIVES- Various models are available which help to identify the ideal location. Some of the popular models are:

9.4 FACTOR RATING METHOD

The process of selecting a new facility location involves a series of following steps:

1. Identify the important location factors.
2. Rate each factor according to its relative importance, i.e., higher the ratings is indicative of prominent factor.
3. Assign each location according to the merits of the location for each factor.
4. Calculate the rating for each location by multiplying factor assigned to each location with basic factors considered.
5. Find the sum of product calculated for each factor and select best location having highest total score.

ILLUSTRATION: Let us assume that a new medical facility, Health-care, is to be located in Delhi. The location factors, factor rating and scores for two potential sites are shown in the following table. Which is the best location based on factor rating method?

Sl. No.	Location factor	Factor rating	Rating	
			Location 1	Location 2
1	Facility utilization	8	3	5
2	Total patient per month	5	4	3
3	Average time per emergency trip	6	4	5
4	Land and construction costs	3	1	2
5	Employee preferences	5	5	3

Solution

Sl. No.	Location factor	Factor rating (1)	Location 1		Location 2	
			(Rating) (2)	Total = (1) . (2)	(Rating) (3)	Total = (1) . (3)
1	Facility utilization	8	3	24	5	40
2	Total patient per month	5	4	20	3	15
3	Average time per emergency trip	6	4	24	5	30
4	Land and construction costs	3	1	3	2	6
5	Employee preferences	5	5	25	3	15
			Total	96	Total	106

The total score for location 2 is higher than that of location 1. Hence location 2, is the best choice.

Weighted Factor Rating Method

In this method to merge quantitative and qualitative factors, factors are assigned weights based on relative importance and weightage score for each site using a preference matrix is calculated. The site with the highest weighted score is selected as the best choice.

ILLUSTRATION: Let us assume that a new medical facility, Health-care, is to be located in Delhi. The location factors, weights, and scores (1 = poor, 5 = excellent) for two potential sites are shown in the following table. What is the weighted score for these sites? Which is the best location?

Sl. No.	Location factor	Weight	Scores	
			Location 1	Location 2
1.	Facility utilization	25	3	5
2.	Total patient km per month	25	4	3
3.	Average time per emergency trip	25	3	3
4.	Land and construction costs	15	1	2
5.	Employee preferences	10	5	3

SOLUTION: The weighted score for this particular site is calculated by multiplying each factor's weight by its score and adding the results:

$$\begin{aligned}
 \text{Weighted score location 1} &= 25 \times 3 + 25 \times 4 + 25 \times 3 + 15 \times 1 + 10 \times 5 \\
 &= 75 + 100 + 75 + 15 + 50 \\
 &= 315
 \end{aligned}$$

$$\begin{aligned}
 \text{Weighted score location 2} &= 25 \times 5 + 25 \times 3 + 25 \times 3 + 15 \times 2 + 10 \times 3 \\
 &= 125 + 75 + 75 + 30 + 30 \\
 &= 335
 \end{aligned}$$

Location 2 is the best site based on total weighted scores.

9.4.1 BREAK EVEN ANALYSIS

Break even analysis implies that at some point in the operations, total revenue equals total cost. Break even analysis is concerned with finding the point at which revenues and costs agree exactly. It is called 'Break-even Point'. The Figure portrays the Break Even Chart: Break-even point is the volume of output at which neither a profit is made nor a loss is incurred.

The Break Even Point (BEP) in units can be calculated by using the relation:

$$\text{BEP} = \frac{\text{Fixed Cost}}{\text{Contribution per unit}} = \frac{\text{Fixed Cost}}{\text{Selling Price} - \text{Variable Cost per unit}} = \frac{F}{S - V} \text{ units}$$

The Break Even Point (BEP) in Rs. can be calculated by using the relation:

$$\text{BEP} = \frac{\text{Fixed Cost}}{\text{PV Ratio}} = \frac{\text{Fixed Cost}}{\left\{ \frac{\text{Sales} - \text{Variable Cost}}{\text{Sales}} \right\}} = \frac{F}{\phi} \text{ Rs.}$$

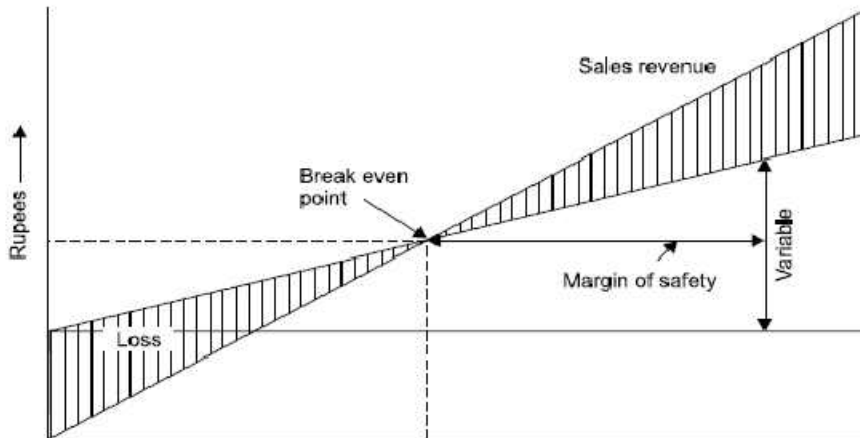


Fig. Units of output or percentage of capacity

Plotting the break even chart for each location can make economic comparisons of locations. This will be helpful in identifying the range of production volume over which location can be selected.

ILLUSTRATION: Potential locations X, Y and Z have the cost structures shown below. The ABC company has a demand of 1,30,000 units of a new product. Three potential locations X, Y and Z having following cost structures shown are available. Select which location is to be selected and also identify the volume ranges where each location is suited?

	Location X	Location Y	Location Z
Fixed Costs	Rs. 150,000	Rs. 350,000	Rs. 950,000
Variable Costs	Rs. 10	Rs. 8	Rs. 6

Solution

Solve for the crossover between X and Y:

$$10X + 150,000 = 8X + 350,000$$

$$2X = 200,000$$

$$X = 100,000 \text{ units}$$

Solve for the crossover between Y and Z:

$$8X + 350,000 = 6X + 950,000$$

$$2X = 600,000$$

$$X = 300,000 \text{ units}$$

Therefore, at a volume of 1,30,000 units, Y is the appropriate strategy.

From the graph we can interpret that location X is suitable up to 100,000 units, location Y is suitable up to between 100,000 to 300,000 units and location Z is suitable if the demand is more than 300,000 units.

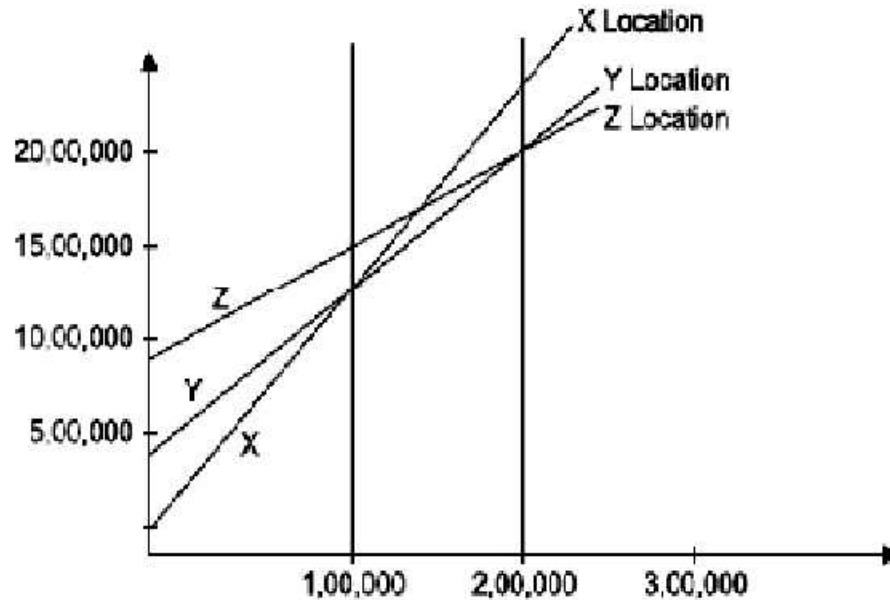


Fig. BEP chart

9.4.2 SIMPLE MEDIAN MODEL

Suppose we want to locate a new plant that will annually receive shipments of raw materials from two sources: F1 and F2. The plant will create finished goods that must be shipped to two distribution warehouses, F3 and F4. Given these four facilities where should we locate the new plant to minimize annual transportation costs for this network of facilities?

The Model

The *simple median model* (SMM) can help answer this question. This model considers the volume of loads transported on *rectangular* paths. All movements are made in east-west or north-south directions; diagonal moves are not considered. The SMM provides an optimal solution. This is discussed with the help of Figure and the Table.

Let L_i = Loads to be shipped annually between each existing facility F_i , and

C_i = Cost to move a load one distance unit to or from F_i .

D_i = Distance units between facility F_i and the new plant.

Then, the total transit cost is the sum of the products $C_i L_i D_i$ for all i .

$$\text{Total cost of transportation} = \sum_{i=1}^n C_i L_i D_i \quad (2.3)$$

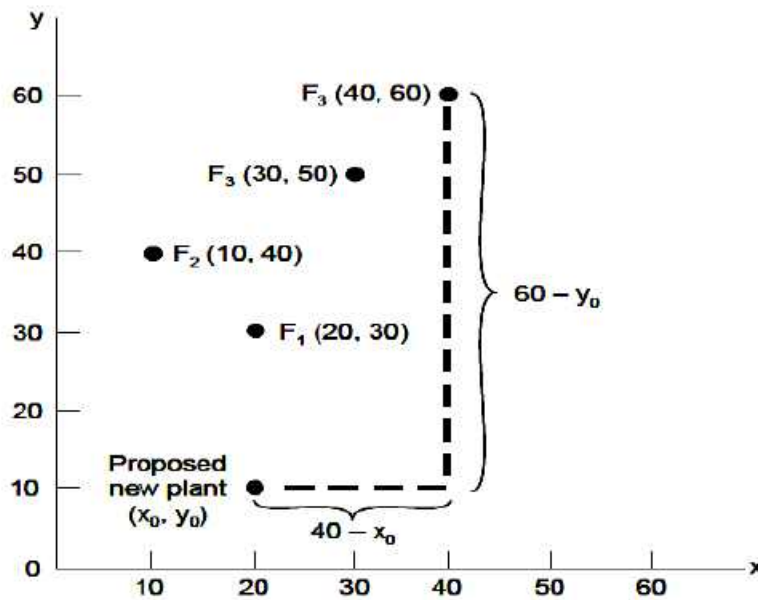


Figure Sources of raw materials and distribution warehouses.

Table - Data related to C_i , L_i and D_i

F_i	L_i	C_i	(X_i, Y_i) of F_i
F_1	755	\$1	(20, 30)
F_2	900	1	(10, 40)
F_3	450	1	(30, 50)
F_4	500	1	(40, 60)
Total	2605		

Since all loads must be on rectangular paths, distance between each existing facility and the new plant will be measured by the difference in the x -coordinates and the difference in the y -coordinates. If we let (x_0, y_0) be the coordinates of a proposed new plant, then

$$D_i = |x_0 - x_i| + |y_0 - y_i| \quad (2.2)$$

Notice that we calculate the absolute value of the differences, because distance is always positive.

We could have written Eqn.(2.2) as

$$D_i = |x_i - x_0| + |y_i - y_0| \quad (2.3)$$

Our goal is to find values for x_0 and y_0 for the *new plant* that result in minimum transportation costs.

We follow three steps:

1. Identify the median value of the loads L_i moved.
2. Find the x -coordinate of the existing facility that sends (or receives) the median load.

3. Find the y -coordinate value of the existing facility that sends or receives) the median load

The x and y coordinates found in steps 2 and 3 define the new plant's best location.

9.4.3 CENTRE OF GRAVITY

Centre of gravity is based primarily on cost considerations. This method can be used to assist managers in balancing cost and service objectives. The centre of gravity method takes into account the locations of plants and markets, the volume of goods moved, and transportation costs in arriving at the best location for a single intermediate warehouse.

The centre of gravity is defined to be the location that minimizes the weighted distance between the warehouse and its supply and distribution points, where the distance is weighted by the number of tones supplied or consumed. The first step in this procedure is to place the locations on a coordinate system. The origin of the coordinate system and scale used are arbitrary, just as long as the relative distances are correctly represented. This can be easily done by placing a grid over an ordinary map.

The centre of gravity is determined by the formula.

$$C_X = \frac{\sum D_{ix} \cdot W_i}{\sum W_i} \quad C_Y = \frac{\sum D_{iy} \cdot W_i}{\sum W_i}$$

where C_x = x -coordinate of the centre of gravity

C_y = y -coordinate of the centre of gravity

D_{ix} = x -coordinate of location i

D_{iy} = y -coordinate of location i

ILLUSTRATION: *The new Health-care facility is targeted to serve seven census tracts in Delhi. The table given below shows the coordinates for the centre of each census tract, along with the projected populations, measured in thousands. Customers will travel from the seven census tract centres to the new facility when they need healthcare. Two locations being considered for the new facility are at (5.5, 4.5) and (7, 2), which are the centres of census tracts C and F. Details of seven census tract centres, coordinate distances along with the population for each centre are given below. Find the target area's centre of gravity for the Health-care medical facility.*

Sl. No.	Census tract	(x, y)	Population (I)
1	A	(2.5, 4.5)	2
2	B	(2.5, 2.5)	5
3	C	(5.5, 4.5)	10
4	D	(5, 2)	7
5	E	(8, 5)	10
6	F	(7, 2)	20
7	G	(9, 2.5)	14

SOLUTION: To calculate the centre of gravity, start with the following information, where population is given in thousands.

Sl. No.	Census tract	(x, y)	Population (l)	Lx	Ly
1	A	(2.5, 4.5)	2	5	9
2	B	(2.5, 2.5)	5	12.5	12.5
3	C	(5.5, 4.5)	10	55	45
4	D	(5, 2)	7	35	14
5	E	(8, 5)	10	80	50
6	F	(7, 2)	20	140	40
7	G	(9, 2.5)	14	126	35
		Total	68	453.50	205.50

Next we find C_x and C_y .

$$C_x = 453.5/68 = 6.67$$

$$C_y = 205.5/68 = 3.02$$

The centre of gravity is (6.67, 3.02). Using the centre of gravity as starting point, managers can now search in its vicinity for the optimal location.

9.4.4 TRANSPORTATION MODEL USING MS EXCEL XP

Transportation can be used to solve specific location problems. It could be used to evaluate the cost impact of adding potential location sites to the network of existing facilities. It could also be used to evaluate adding multiple new sites or completely redesigning the network. Transportation modelling finds the least-cost means of shipping supplies from several origins to several destinations. Origin points (or sources) can be factories, warehouses, car rental agencies like Avis, or any other points from which goods are shipped. Destinations are any points that receive goods.

To use the transportation model, we need to know the following:

1. The origin points and the capacity or supply per period at each.
2. The destination points and the demand per period at each.
3. The cost of shipping one unit from each origin to each destination.

The Northwest-Corner Rule

The northwest-corner rule requires that we start in the upper left-hand cell (or northwest corner) of the table and allocate units to shipping routes as follows:

1. Exhaust the supply (factory capacity) of each row (e.g., Des Moines: 100) before moving down to the next row.
2. Exhaust the (warehouse) requirements of each column (e.g., Albuquerque: 300) before moving to the next column on the right.

3. Check to ensure that all supplies and demands are met.

The Intuitive Lowest-Cost Method

The intuitive method makes initial allocations based on lowest cost. This straightforward approach uses the following steps:

1. Identify the cell with the lowest cost. Break any ties for the lowest cost arbitrarily.
2. Allocate as many units as possible to that cell without exceeding the supply or demand. Then cross out that row or column (or both) that is exhausted by this assignment.
3. Find the cell with the lowest cost from the remaining (not crossed out) cells.
4. Repeat steps 2 and 3 until all units have been allocated.

THE STEPPING-STONE METHOD

The stepping-stone method will help us move from an initial feasible solution to an optimal solution. It is used to evaluate the cost effectiveness of shipping goods via transportation routes not currently in the solution. When applying it, we test each unused cell, or square, in the transportation table by asking: What would happen to total shipping costs if one unit of the product (for example, one bathtub) was tentatively shipped on an unused route?

We conduct the test as follows:

1. Select any unused square to evaluate.
2. Beginning at this square, trace a closed path back to the original square via squares that are currently being used (only horizontal and vertical moves are permissible). You may, however, step over either an empty or an occupied square.
3. Beginning with a plus (+) sign at the unused square, place alternating minus signs and plus signs on each corner square of the closed path just traced.
4. Calculate an improvement index by first adding the unit-cost figures found in each square containing a plus sign and then by subtracting the unit costs in each square containing a minus sign.
5. Repeat steps 1 through 4 until you have calculated an improvement index for all unused squares. If all indices computed are *greater than or equal to zero*, you have reached an optimal solution. If not, the current solution can be improved further to decrease total shipping costs.

USING SOFTWARE TO SOLVE TRANSPORTATION PROBLEMS

Excel, Excel OM, and POM for Windows may all be used to solve transportation problems. Excel uses Solver, which requires that you enter your own constraints. Excel OM also uses Solver but is pre-structured so

that you need enter only the actual data. POM for Windows similarly requires that only demand data, supply data, and shipping costs be entered.

Excel Transportation module uses Excel's built-in Solver routine to find optimal solutions to transportation problems.

FROM \ TO	ALBUQUERQUE	BOSTON	CLEVELAND
DES MOINES	\$5	\$4	\$3
EVANSVILLE	\$8	\$4	\$3
FORT LAUDERDALE	\$9	\$7	\$5

TABLE-Transportation Costs per Bathtub for Arizona Plumbing

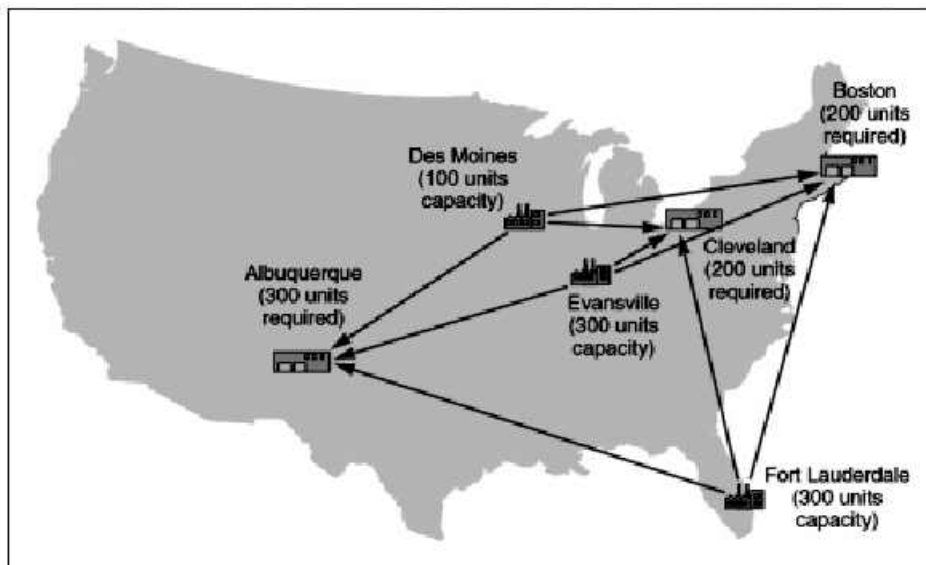


FIGURE - Transportation Problem

From \ To	Albuquerque	Boston	Cleveland	Factory capacity
Des Moines	\$5	\$4	\$3	100
Evansville	\$8	\$4	\$3	300
Fort Lauderdale	\$9	\$7	\$5	300
Warehouse requirement	300	200	200	700

Des Moines capacity constraint

Cell representing a possible source-to-destination shipping assignment (Evansville to Cleveland)

Cost of shipping 1 unit from Fort Lauderdale factory to Boston warehouse

Cleveland warehouse demand

Total demand and total supply

FIGURE-Transportation Matrix for Arizona Plumbing

Program illustrates the input data (from Arizona Plumbing) and total-cost formulas. To reach an optimal solution, we must go to Excel's *Tools* bar, request *Solver*, and then select *Solve*.

The output appears in Program.

Our target cell is the total cost cell (B21), which we wish to minimize by changing the shipment cells (B16 through D18). The constraints ensure that the number shipped is equal to the number demanded, that the shipments are integer and nonnegative, and that we don't ship more than we have on hand.

Enter the origin and destination names, the shipping costs, and the total supply and demand figures.

These are the cells in which Solver will place the shipments.

The total shipments to and from each location are calculated here.

The total cost is created here by multiplying the data table by the shipment table using the SUMPRODUCT function.

	Albuquerque	Boston	Cleveland	Supply
Des Moines	5	4	3	100
Evansville	8	4	3	300
Ft. Lauderdale	9	7	5	300
Demand	300	200	200	700

	Albuquerque	Boston	Cleveland	Row Total
Des Moines	100	0	0	100
Evansville	0	200	100	300
Ft. Lauderdale	200	0	100	300
Column Total	300	200	200	700

Excel OM Input Screen and Formulas, Using Arizona Plumbing Data

Solver found a solution. All constraints and optimality conditions are satisfied.

Keep Solver Solution

Restore Original Values

OK Cancel Save Scenario... Help

	Albuquerque	Boston	Cleveland	Supply
Des Moines	5	4	3	100
Evansville	8	4	3	300
Ft. Lauderdale	9	7	5	300
Demand	300	200	200	700

	Albuquerque	Boston	Cleveland	Row Total
Des Moines	100	0	0	100
Evansville	0	200	100	300
Ft. Lauderdale	200	0	100	300
Column Total	300	200	200	700

9.4.5 ARDALAN HEURISTICS FOR LOCATION PLANNING OF SERVICE FACILITIES

It Need a matrix of distances or costs from each customer location to every other location.

- Demand at each location
- Weight – give higher weight to more important customers – their pain of traveling a longer distance is worth more.
- Only consider locating where customers are
- Identify the one best place to locate at, then the second one to add, then the third, etc.
- Compute cost of satisfying each demand from each possible distribution center location.
- Step 1: Multiply distances * demand
A to B: $11 * 10 = 110$
- Multiply distances times demand, and sum

To	A	B	C	D	*	Dem =	A	B	C	D
A	0	11	8	12	*	10	0	110	80	120
B	11	0	10	7	*	8	88	0	80	56
C	8	10	0	9	*	20	160	200	0	180
D	9.5	7	9	0	*	12	114	84	108	0
Total						362	394	268	356	

- Choose Smallest total as first location

A	B	C	D	
A	0	110	80	120
B	88	0	80	56
C	160	200	0	180
D	114	84	108	0
Total	362	394	268	356

If we only build one facility, we should build it in C, and the total transportation costs will be 268 truckload miles.

Notice that even if we built a facility in B or D, it will continue to be cheaper to serve A from C. In the next step, we will make use of that.

- Compare each cost in row to the cost in the chosen, and switch is lower

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
A	0	80	80	80
B	80	0	80	56
C	0	0	0	0
D	108	84	108	0
Total	188	164	268	136

- Don't need first chosen city any more.
- Choose second cheapest city

	<u>A</u>	<u>B</u>	<u>D</u>
A	0	80	80
B	80	0	56
C	0	0	0
D	108	84	0
Total	188	164	136

- Compare non-chosen cities' costs to cost of chosen, and choose the lower cost

<u>From</u>	<u>A</u>	<u>B</u>	<u>D</u>
A	0	80	80
B	56	0	56
C	0	0	0
D	0	0	0
Total	56	80	136

- Compare non-chosen cities' costs to cost of chosen, and choose the lower cost

<u>From</u>	<u>A</u>	<u>B</u>
A	0	0
B	56	0
C	0	0
D	0	0
Total	56	0

	<u>Total</u>	<u>Transp</u>	<u>Transp</u>	
	<u># DCs</u>	<u>Locations</u>	<u>Total</u>	<u>Savings</u>
1	C	268		
2	C,D	136	152	
3	C,D,A	56	80	
4	C,D,A,B	0	0	56

- Assumes that we have to locate in the same city as one of our customers, which is not always the case.
- However, it can be used to find more than one location
- Center of Gravity does not try to locate in the same city as one of the customers, but only one site.

- If we choose the same sites as customers A and X, we obviously don't really have to put the warehouses in those exact cities.

9.5 Summary

Facility location decisions are strategic, long term, and non-repetitive in nature. There are four types of plant strategies: Product Plant Strategy, Market Area Plant Strategy, Process Plant Strategy and General-Purpose Plant Strategy. A right location provides adequate access to customers, skilled labours, transportation, etc. There are several factors that affect facilities: Customer Proximity, Business Area, Availability of Skill Labour, Free Trade Zone/Agreement, Suppliers, and Environmental Policy. There may be some errors in location selection as well. There are several foreign operation. There are factor's rating method, weighted method, break even analysis, simple median model, centre of gravity method, transportation model using various techniques.

Self Assessment Questions

- Explain Operating Strategies for Multiple Facilities?
- What are the Factors Affecting Facility;
- What is Location Planning?
- Explain Locating Foreign Operations?
- Explain Break-even Analysis for Facility Location Planning?
- What is Simple Median Model?
- Explain The Centre of Gravity Method?
- Explain Transportation Model using MS Excel XP?

UNIT - 10

CAPACITY PLANNING

STRUCTURE

- 10.0 Introduction**
- 10.1 Aspects of Capacity Planning,**
- 10.2 Determination of Capacity Requirement,**
- 10.3 Capacity Planning for a Single-Stage System,**
- 10.4 Capacity Planning for a Multiple Stage System.**
- 10.5 Evaluation of Alternative Plant Size,**
- 10.6 Traditional Economic Requirements for a Single Production Stage,**
- 10.7 Determination of the Stage Efficiency Stage.**
- 10.8 Summary**

10.0 INTRODUCTION

What is Capacity? A dictionary meaning of Capacity is the ability to hold, receive, store, or accommodate. The capacity is also defined as the maximum output of a system in a given period of time under ideal conditions. Management of capacity basically involves capacity planning, balance between various issues against economic advantages and disadvantages and its proper utilization, before discussing the planning and management of capacity let understand the process of measurement of capacity.

Capacity refers to a system's potential for producing goods or delivering services over a specified time interval. Capacity planning involves long-term and short term considerations. Long-term considerations relate to the overall level of capacity; short-term considerations relate to variations in capacity requirements due to seasonal, random, and irregular fluctuations in demand.

Excess capacity arises when actual production is less than what is achievable or optimal for a firm. This often means that the demand in the MARKET for the product is below what the firm could potentially supply to the market. Excess capacity is inefficient and will cause manufacturers to incur extra costs or lose market share. Capacity can be broken down in two categories: Design Capacity and Effective Capacity: refers to the maximum designed service capacity or output rate.

Effective capacity is design capacity minus personal and other allowances. Product and service factors effect capacity tremendously.

Capacity is the ability of a systems potential for producing goods or delivering services over a specific time interval. The capacity decisions within a company are very important because they help determine the limit of output and provide a major insight to determining operating costs. Basic decisions about capacity often have long term consequences and this chapter explains the ramifications of those choices. When considering capacity planning within a company, three key inputs should be considered. The three inputs are the kind of capacity to be determined, how much of the products will be needed, and when will the product be needed.

The most important concept of capacity planning is to find a medium between long term supply and capabilities of an organization and the predicted level of long term demand. Organizations also have to plan for actual changes in capacity, changes in consumer wants and demand, technology and even the environment. When evaluating alternatives in capacity planning, managers have to consider qualitative and quantitative aspects of the business. These aspects involve economic factors, public opinions, personal preferences of managers.

The capacity decision is strategic and long-term in nature. Capacity planning is described as matching the capabilities of an organization with the predicted level of future demand. Many organizations become involved with capacity planning due to changes in demand, technology, the environment, etc. Organizations have capacities or limits that their system can handle. Three key inputs to capacity planning:

1. The kind of capacity that will be needed
2. How much capacity will be needed?
3. When will it be needed *Accurate forecasts are critical to the planning process

Capacity Planning Classification

Capacity planning based on the timeline is classified into three main categories long range, medium range and short range.

Long Term Capacity: Long range capacity of an organization is dependent on various other capacities like design capacity, production capacity, sustainable capacity and effective capacity. Design capacity is the maximum output possible as indicated by equipment manufacturer under ideal working condition.

Production capacity is the maximum output possible from equipment under normal working condition or day.

Sustainable capacity is the maximum production level achievable in realistic work condition and considering normal machine breakdown, maintenance, etc.

Effective capacity is the optimum production level under pre-defined job and work-schedules, normal machine breakdown, maintenance, etc.

Medium Term Capacity: The strategic capacity planning undertaken by organization for 2 to 3 years of a time frame is referred to as medium term capacity planning.

Short Term Capacity: The strategic planning undertaken by organization for a daily weekly or quarterly time frame is referred to as short term capacity planning.

Goal of Capacity Planning

The ultimate goal of capacity planning is to meet the current and future level of the requirement at a minimal wastage. The three types of capacity planning based on goal are lead capacity planning, lag strategy planning and match strategy planning.

Factors Affecting Capacity Planning

Effective capacity planning is dependent upon factors like production facility (layout, design, and location), product line or matrix, production technology, human capital (job design, compensation), operational structure (scheduling, quality assurance) and external structure (policy, safety regulations)

Forecasting v/s Capacity Planning

There would be a scenario where capacity planning done on a basis of forecasting may not exactly match. For example, there could be a scenario where demand is more than production capacity; in this situation, a company needs to full fill its requirement by buying from outside. If demand is equal to production capacity, company is in a position to use its production capacity to the fullest. If the demand is less than the production capacity, company can choose to reduce the production or share it output with other manufacturers.

Steps in the Capacity Planning Process

1. Estimate future capacity requirements
2. Evaluate existing capacity and facilities and identify gaps
3. Identify alternatives for meeting requirements
4. Conduct FINANCIAL analyses of each alternative
5. Assess key qualitative issues for each alternative
6. Select the alternative to pursue that will be best in the long term
7. Implement the selected alternative
8. Monitor results

10.2 Determination of Capacity Requirements

- **Facilities:** The size and provision for expansion are key in the design of facilities. Other facility factors include locational factors (transportation costs, distance to market, labour supply, and energy sources). The layout of the work area can determine how smoothly work can be performed.
- **Product and Service Factors:** The more uniform the output, the more opportunities there are for standardization of methods and materials. This leads to greater capacity.
- **Process Factors:** Quantity capability is an important determinant of capacity, but so is output quality. If the quality does not meet standards, then output rate decreases because of need of inspection and rework activities. Process improvements that increase quality and productivity can result in increased capacity. Another process factor to consider is the time it takes to change over equipment settings for different products or services.
- **Human Factors:** the tasks that are needed in certain jobs, the array of activities involved and the training, skill, and experience required to perform a job all affect the potential and actual output. Employee motivation, absenteeism, and labour turnover all affect the output rate as well.
- **Policy Factors:** Management policy can affect capacity by allowing or not allowing capacity options such as overtime or second or third shifts
- **Operational Factors:** Scheduling problems may occur when an organization has differences in equipment capabilities among different pieces of equipment or differences in job requirements. Other areas of impact on effective capacity include inventory stocking decisions, late deliveries, purchasing requirements, acceptability of purchased materials and parts, and quality inspection and control procedures.
- **Supply Chain Factors:** Questions include: What impact will the changes have on suppliers, warehousing, transportation, and distributors? If capacity will be increased, will these elements of the supply chain be able to handle the increase? If capacity is to be decreased, what impact will the loss of business have on these elements of the supply chain?
- **External Factors:** Minimum quality and performance standards can restrict management's options for increasing and using capacity.
- Inadequate planning can be a major limiting determining of effective capacity.

Importance of Capacity Decisions

1. Impacts ability to meet future demands
2. Affects operating costs
3. Major determinant of initial costs
4. Involves long-term commitment
5. Affects competitiveness
6. Affects ease of management
7. Globalization adds complexity
8. Impacts long range planning

Efficiency: Measure of how well a facility or machine is performing when used

Efficiency= Actual output / Effective Capacity

Utilization: Measure of planned or actual capacity usage of a facility, work center, or machine

Utilization= Actual Output / Design Capacity

Example

Design capacity = 50 trucks/day

Effective capacity = 40 trucks/day

Actual output = 36 units/day

$$\text{Efficiency} = \frac{\text{Actual output}}{\text{Effective capacity}} = \frac{36 \text{ units/day}}{40 \text{ units/day}} = 90\%$$

$$\text{Utilization} = \frac{\text{Actual output}}{\text{Design capacity}} = \frac{36 \text{ units/day}}{50 \text{ units/day}} = 72\%$$

10.3 CAPACITY PLANNING FOR A SINGLE-STAGE SYSTEM

The problem addressed is the determination of lot sizes for multiple products to be produced on a single production facility with limited capacity. Demand is assumed to be deterministic and time-varying and must be met without backordering. The objective is to minimize the sum of setup and inventory holding costs. A heuristic solution procedure of the period-by-period type is presented. Moreover, the interaction between lot sizing and smoothing of capacity requirements is investigated in a case study.

Key Decisions in Capacity Planning

1. Amount of capacity needed
2. Timing of changes (frequency of capacity additions)
3. Need to maintain balance
4. Extent of flexibility of facilities
5. External sources of capacity

Steps for Capacity Planning

1. Estimate future capacity requirements
2. Evaluate existing capacity
3. Identify alternatives
4. Conduct financial analysis
5. Assess key qualitative issues
6. Select the best alternative
7. Implement the alternative chosen
8. Monitor results

Input measures of capacity

- Firms operating in low volume, high variety situation find it relevant
 - Refining capacity of BPCL refinery in Mumbai is 260,000 barrels of crude per day
 - Television manufacturer often measures its capacity by millions of picture tubes that it produces
 - Tool room facility will measure its capacity in terms of machine hours
 - A hospital will measure the capacity in terms of number of beds.

Output measures of capacity

- When the volume of production is high and the variety is relatively low output measures are useful
 - Toyota Kirloskar Auto Parts measures its capacity in terms of number of transmission gear boxes it can produce
 - Tata Bearings, a division of Tata Steel, has a capacity of 25 million pieces per annum
 - MICO Bosch has an installed capacity of one lakh distributor pumps at its Jaipur plant
 - An automated car wash facility's capacity can be measured in terms of number of cars serviced per day

Japanese notion of capacity

- **Capacity = Work + Waste**
- **Nine types of waste according to Canon production system:**
 - **Waste in Operations**
 - **Waste in Startup**
 - **Waste in Equipment**
 - **Waste in Defects**
 - **Waste in Materials**
 - **Waste in Indirect Labour**
 - **Waste in Human Resources**
 - **Waste in expense**

Capacity Augmentation Alternatives

- **Waste Elimination**
- **Multi-tasking of workforce**
- **Sub-contracting/Outsourcing**
- **De-bottlenecking**
- **Addition of new capacity**

PROBLEM

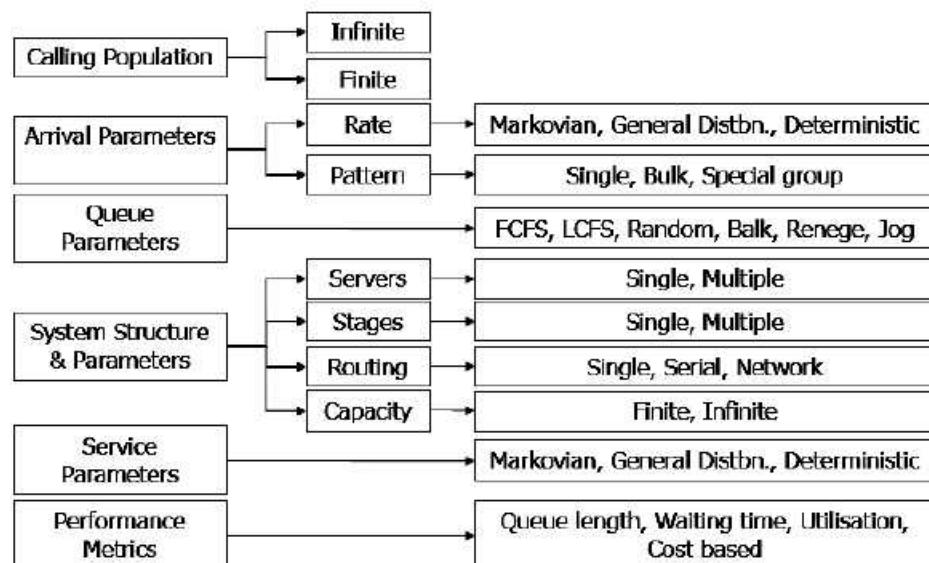
- **A product is manufactured in a shop using a five-stage process. The first step in the process is to cut the sheet metal to required shapes and sizes using a shearing process. After the shearing process, the components are subjected to pressing operations to alter the shape of the flat sheet as per the design. In the third stage of the process welding is done to join the components. The next step in the process is a painting operation. After painting, the components are packed and kept ready for dispatch.**
- **The time take for each of these operations are 20, 30, 15, 12 and 6 minutes respectively.**
- **Presently, each stage has only one machine for operation.**
- **Map the process and analyse the capacity with respect to the following scenarios:**
 - **If the shop works for an 8-hour shift with an effective available time of 450 minutes, what is the production capacity of the shop?**
 - **Where is the bottleneck in the system? If we want to add one machine, where should we make the investment?**

- Identify the additional capacity required for a daily production target of 25 units. Compute the utilisation of the machines as per the revised capacity calculations.

Capacity Planning under uncertainty Use of waiting line models

- Often demand placed on resources is uncertain making capacity requirement estimation difficult
- In such cases, waiting line models
 - make use of queueing theory fundamentals
 - to analyse the impact of alternative capacity choices
 - on important operational measures such as queue length, waiting time and utilisation of resources
- In service systems, waiting time is an important operational measure that determines the service quality
 - Computerised passenger reservation facility of Indian Railways
 - Banking system or BSNL's bill payment counters

Components of Queuing Systems



10.4 CAPACITY PLANNING FOR A MULTIPLE STAGE SYSTEM

The four-stage model of the strategic role of operations

Stage 1 Internally Neutral The operations function is internally focused and reactive. They are viewed as a 'necessary evil'. The best that the organization hopes for is that operations 'don't screw up'.

Stage 2 Externally Neutral The operations function tries to be as good as the competition, or to achieve parity with industry norms. Such an organization is likely to benchmark its operations against its competitors, and adopt best practice in its industry so that it does not hold the organization back.

Stage 3 Internally Supportive The operations function seeks to provide credible support for the organization's business strategy. An operations strategy will be developed which will be derived from, and support, the business strategy. The organization's operations are likely to be amongst the best in its industry.

Stage 4 Externally Supportive The operations function provides the basis of competitive advantage for the organization, by setting the standard in their industry. The operations function is likely to aim to be world class by seeking to emulate best practice wherever it is to be found. Operations will be seen as the means of exceeding customer expectations by delighting the customer. Operations will be managed proactively to drive the business strategy of the organization.

A stage 1 organization finds it impossible to manage its operations strategically, as its operations performance objectives are continually changing between low cost, increased flexibility, improved quality, etc. Because operations managers never have the time to focus on a consistent set of objectives, a stage 1 organization is characterized by a reactive approach to operations management. In such an organization, operations can never provide a source of competitive advantage.

A stage 2 organization manages its operations by seeking to emulate those of its competitors. It is likely to copy the prevailing best practices of its industry, such as JIT (just-in-time), TQM (total quality management), BPO (business process outsourcing) etc. However, as they always adopt these techniques in the wake of industry leaders, they are never likely to have developed the same level of expertise in their application. The best that such an approach can achieve is to match the operations performance of its competitors. Although the combination of operations practices adopted by a stage 2 organization may be considered by some as amounting to an operations strategy in that they are consistent, they will not be overtly linked to business strategy. Indeed, it may be that such an operations strategy is inappropriate for the organization's business strategy. In any event, a stage 2 organization's operations can not provide the basis for competitive advantage.

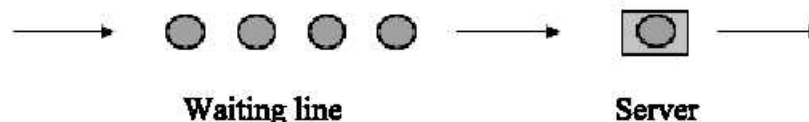
A stage 3 organization has an operations strategy that is linked to and derived from its business strategy. This means that its operations performance objectives are aligned with, and supportive of, its business objectives, offering the possibility that operations can provide the means of achieving a competitive advantage. The chances of achieving competitive advantage will be considerably increased if the organization has adopted industry best practice in its operations.

A stage 4 organization is radically different to one at any of the other stages. A stage 4 organization uses its operations excellence as the basis for its business strategy – an operations-based strategy. The operations of a stage 4 organization are at the forefront of developments in best practice in that they set industry standards in ways that delight customers. Thus, the organization's operations enable it to retain its existing customers and attract new ones. For an operations-based competitive advantage to be sustainable, the organization must continually develop its operations, as any source of advantage is liable to be imitated by competitors. To remain at stage 4, an organization needs to learn how to make the most of its existing resources and competences to learn how to develop new capabilities. Recent advances in the understanding of organizational performance have emphasized the importance of path dependency

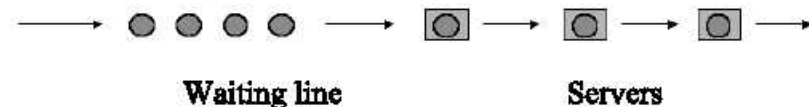
(i.e. how organizations got to their present position), the dynamic nature of the capabilities on which organizational success ultimately depends and the role of organizational learning. (See for example Teece and Pisano, 1994; Cohen and Levinthal, 1990.)

Single-Channel Structures

Single-server, single-stage



Single-server, multiple stages



PROBLEM

- The teller facility of a bank has a one-man operation at present. Customers arrive at the bank at the rate of one every 4 minutes to use the teller facility. The service time varies randomly across customers on account of some parameters. However, based on the observations in the past, it has been found that the teller takes on an average 3 minutes to serve an arriving customer. The arrivals follow Poisson distribution and the service times follow exponential distribution.
 - What is the probability that there are at most three customers in front of the teller counter?
 - Assess the various operational performance measures for the teller facility.
 - Of late the bank officials notice that the arrival rate has increased to one every three and a half minutes. What is the

impact of this change in the arrival rate? Do you have any observation to make?

Solution to Problem

- Arrival rate at the bank: = 15 per hour
- Service rate at the teller: = 20 per hour
- Utilisation of teller facility: $\rho = \frac{\lambda}{\mu} = \frac{15}{20} = 0.75$
- Probability of at most three customers in the system = $\sum_{n=0}^3 P_n$
- Using equation, we compute P_n for values of $n = 0$ to 3
 $P_0 = (1 - \rho) = 0.25$; $P_1 = 0.25 \cdot 0.75 = 0.1875$;
 $P_2 = 0.25 \cdot 0.75^2 = 0.1406$; $P_3 = 0.25 \cdot 0.75^3 = 0.1055$.
- Probability of at most 3 customers =
 $0.25 + 0.1875 + 0.1406 + 0.1055 = 0.6836$

Operational Performance Measures

Avg. No. of customers in the waiting line: $L_q = \frac{\lambda^2}{\mu(\mu - \lambda)}$

Avg. No. of customers in the system: $L_s = L_q + \frac{\lambda}{\mu}$

Avg. time a customer spends waiting in line: $W_q = \frac{L_q}{\lambda}$

Avg. time a customer spends in the system: $W_s = \frac{L_s}{\lambda}$

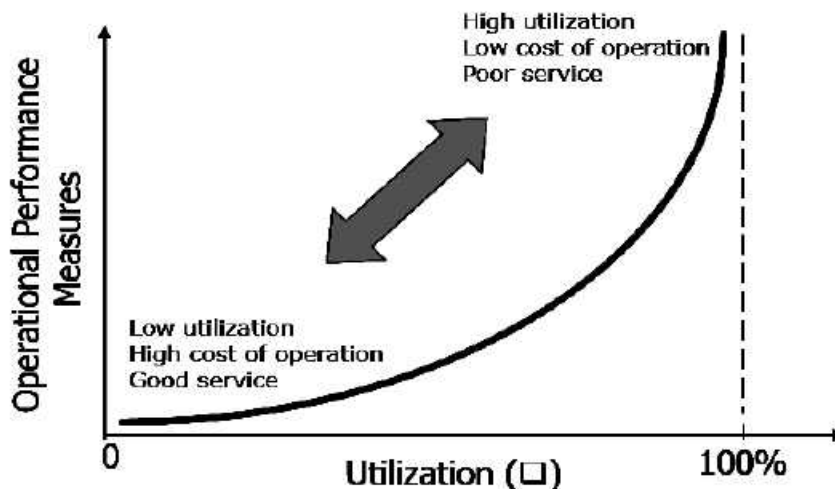
Avg. No. of customers in the waiting line: $L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{15^2}{20(20 - 15)} = 2.25$

Avg. No. of customers in the system: $L_s = L_q + \frac{\lambda}{\mu} = 2.25 + \frac{15}{20} = 3.00$

Avg. time a customer spends waiting in line: $W_q = \frac{L_q}{\lambda} = \frac{2.25}{15} = 0.15 \text{ Hr} = 9 \text{ min}$

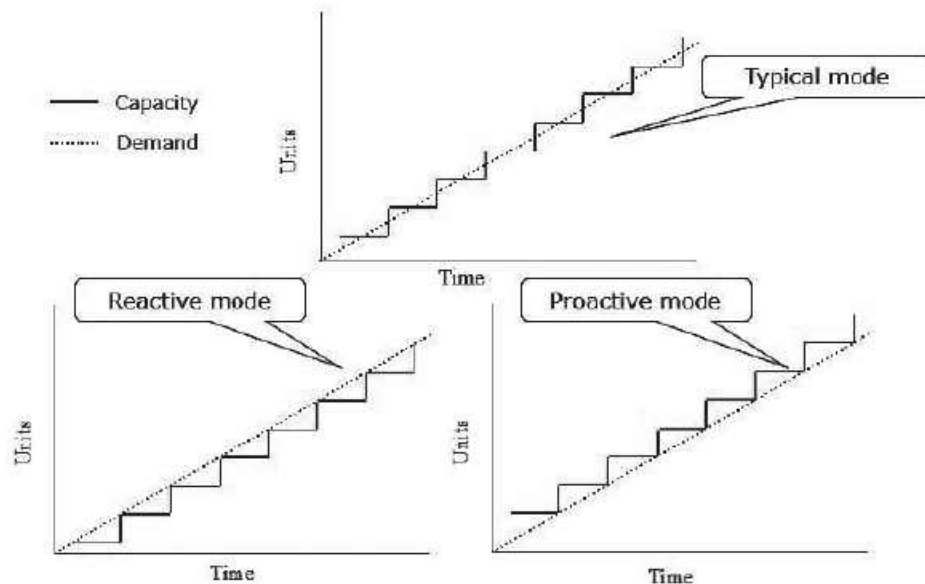
Avg. time a customer spends in the system: $W_s = \frac{L_s}{\lambda} = \frac{3.00}{15} = 0.20 \text{ Hr} = 12 \text{ min}$

Capacity Design issue Flexibility/Utilization Trade-off



10.5 EVALUATION OF ALTERNATIVE PLANT SIZE

Capacity build up (Alternative modes)



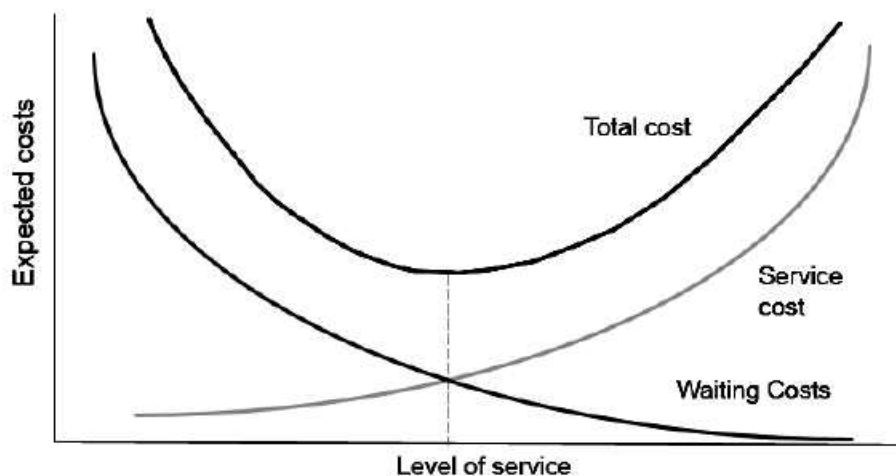
Evaluating Alternatives

- **Cost-volume analysis: Break-even point**
 - One product is involved
 - Everything produced can be sold
 - Variable cost per unit is the same regardless of volume
 - Fixed costs do not change with volume
 - Revenue per unit constant with volume
 - Revenue per unit exceeds variable cost per unit
- **Financial analysis**
 - **Cash Flow** - the difference between cash received from sales and other sources, and cash outflow for labor, material, overhead, and taxes.
 - **Present Value** - the sum, in current value, of all future cash flows of an investment proposal.
- **Decision theory**
 - Helpful tool for financial comparison of alternatives under conditions of risk or uncertainty
 - Suited to capacity decisions
- **Waiting-line analysis**
 - Useful for designing or modifying service systems

- Waiting-lines occur across a wide variety of service systems
- Waiting-lines are caused by bottlenecks in the process
- Helps managers plan capacity level that will be cost-effective by balancing the cost of having customers wait in line with the cost of additional capacity
- **Strategy Driven Investment**
 - Select investments as part of a coordinated strategic plan
 - Choose investments yielding competitive advantage
 - Consider product life cycles
 - Include a variety of operating factors in the financial return analysis
 - Test investments in light of several revenue projections

10.6 Traditional Economic Requirements for a Single Production Stage

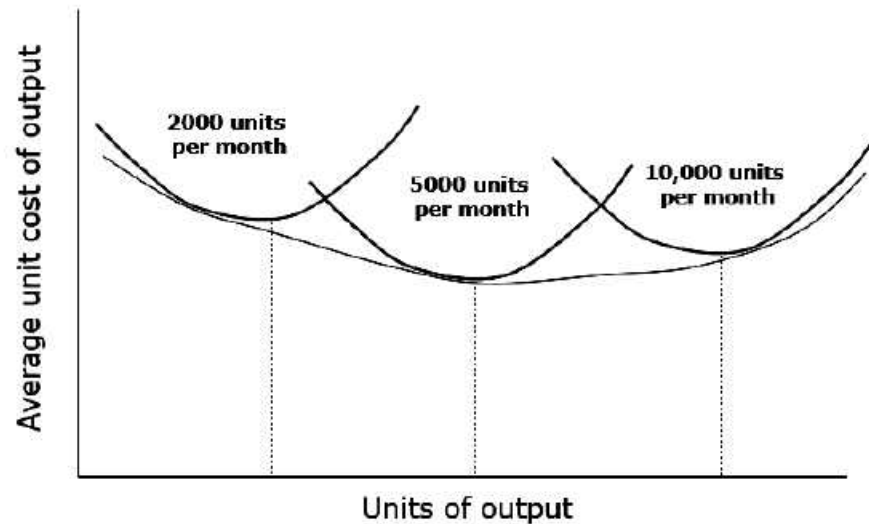
Cost Relationship in Queuing



- Capacity denotes in general the extent of availability of these resources for use by various processes
- It also denotes the maximum output of products and services one can achieve using these resources
- Capacity planning is a systematic approach to
 - Estimate the amount of capacity required,
 - Evaluation of alternative methods of augmenting capacity
 - Devise methods to use capacity effectively

- Capacity planning is important
 - It has a significant impact on the cost of operation of the system due to large fixed costs associated with capacity
- Economies of scale is a concept in economics related to capacity

Economies of Scale An illustration



10.7 DETERMINATION OF THE STAGE EFFICIENCY STAGE

- Facilities
- Product and Service Factors
- Process Factors
- Human Factors
- Policy Factors
- Operational Factors
- Supply Chain Factors
- External Factors

Strategy in a business organization is essentially about how the organization seeks to survive and prosper within its environment over the long-term. The decisions and actions taken within its operations have a direct impact on the basis on which an organization is able to do this. The way in which an organization secures, deploys and utilizes its resources will determine the extent to which it can successfully pursue specific performance objectives.

Slack et al. (2004) argue that there are five operations performance objectives:

1. Cost: The ability to produce at low cost.

2. **Quality:** The ability to produce in accordance with specification and without error.
3. **Speed:** The ability to do things quickly in response to customer demands and thereby offer short lead times between when a customer orders a product or service and when they receive it.
4. **Dependability:** The ability to deliver products and services in accordance with promises made to customers (e.g. in a quotation or other published information).
5. **Flexibility:** The ability to change operations. Flexibility can comprise up to four aspects:
 - i. The ability to change the volume of production.
 - ii. The ability to change the time taken to produce.
 - iii. The ability to change the mix of different products or services produced.
 - iv. The ability to innovate and introduce new products and services.

10.8 Summary

Management of capacity basically involves capacity planning, balance between various issues against economic advantages and disadvantages and its proper utilization, before discussing the planning and management of capacity let understand the process of measurement of capacity. Capacity planning is classified in long term, medium term and short term planning. It is planned with well-defined objectives in step wise step processing. There are several determination of capacity requirement: Facilities, Product and Service Factors, Process Factors, Human Factors, Policy Factors, Operational Factors, Supply Chain Factors, External Factors. Capacity decisions are very important in organizations. Capacity planning may be planned in single stage and multi stage format. Stages may be applied on single-server or on multi-server.

Self assessment questions

- Explain various aspects of Capacity Planning?
- Explain the process of Determination of Capacity Requirement?
- What are Traditional Economic Requirements for a Single Production Stage?
- Explain Determination of the Stage Efficiency Stage?

UNIT - 11

FACILITY PLANNING

STRUCTURE

- 11.0 What Is Facility Planning?
- 11.1 Need for Facility Planning,
- 11.2 Facility Planning Objectives,
- 11.3 Types of Layouts,
 - 11.3.1 Product on Live Layout,
 - 11.3.2 Fixed Position Layout,
 - 11.3.3 Combination Layout, Combination Approach for Developing Process Layout.
- 11.4 Summary

11.0 WHAT IS FACILITY PLANNING?

Facility layout decisions are based on criteria aimed at creating an effective and efficient workflow and high standard production. Facilities is defined as the workspace and equipment needed to carry out the operations of the organization. This includes offices, factories, computers, and trucks. The location, design, and layout of an organizations' Facility Planning is aka: Master Planning and Facility Design.

There are 5 Phases of Facility Planning

1. *Site Selection*
 - ❖ New Construction
 - ❖ Existing Building Retrofit
 - ❖ Existing Laundry Renovation/Expansion
2. *Preliminary Design*
 - ❖ Project Kick-off
 - ❖ Define Facility Requirements
 - ❖ As-built Drawings
 - ❖ Alternative Preliminary Designs
 - ❖ Project Cost Estimate

3. *Final Design*

- ❖ Work Out the Details
- ❖ Final Design Review / Approval
- ❖ Freeze the Design

4. *Project Bid*

- ❖ Building Construction / Modifications
- ❖ Process Utility Installation
- ❖ Equipment Purchase / Installation
- ❖ Design/Build contractor
- ❖ Process Utilities – Local vs. Laundry
- ❖ Details, Details, Details! The more details the better the price.
- ❖ Best Value vs. Lowest Price

5. *Project Management*

- ❖ Building Construction
- ❖ Equipment Installation
- ❖ Equipment Commissioning
- ❖ Project Follow-up

11.1 Need for Facility Planning

There are many factors that can determine where an organization will locate its facilities. For any given situation, some factors become more important than others in how facility location affects an organization's efficiency and effectiveness. There are several reasons why Facility planning is needed is as below:

1. **Proximity to sources of supply:** Firms that process bulk raw materials usually locate close to the source of supply to reduce transportation costs. Paper mills locate close to forests, canneries are built close to farming areas, and fish processing plants are located close to the labours where the fishing vessels dock.
2. **Proximity to customers:** There are several reasons why an organization would locate close to end customers. Service firms need to be close to customers to be convenient, as is the case for grocery stores, gas stations, fast food restaurants, and hospitals. Transportation costs can also require proximity to customers, as in the case of concrete manufacturing. Perishable products often require that they be produced close to the final market, as is the case for bakeries and fresh flowers.

3. **Community factors:** Communities may offer a number of incentives to entice companies, including waiving or reducing taxes, and providing access roads, water and sewer connections, and utilities. Community attitudes can also play a role in an organization's location decision. Some communities may actively discourage companies that might bring more pollution, noise, and traffic to the area. Some communities may not want a prison to be located in their community. Other communities may welcome such firms because of the jobs, tax revenues, and economic diversity they promise.
4. **Labour factors:** Research shows that the majority of location decisions are largely based on labor factors, since labour is a critical variable for many firms. Labour factors include the prevailing wage rate in a community for similar jobs, the supply of qualified workers, and the average education level of the local population (percentage of high school graduates, etc.). Other labour factors can include the degree of union organizing and the general work ethic of a community, as well as other measures of absenteeism, and worker longevity in a job can play a strong role when a firm makes a location decision.
5. **Other factors:** Many other factors can play a role in the location decision, including quality of life (crime rates, good schools, climate, and recreation options), access to major transportation arteries, construction costs, proximity of the competition, and opportunities for future expansion.

As mentioned earlier, the importance of any location factor can vary greatly, depending on the circumstances of the decision.

11.2 FACILITY PLANNING OBJECTIVES

Facilities are central to maximizing the efficiency of the overall operations system. Its objectives is to:

Maximize

- Plant efficiency/output
- Production flexibility
- Quality

Minimize

- Production costs
- Work in process (WIP)
- Project costs

LAYOUT

Plant layout refers to the physical arrangement of production facilities. It is the configuration of departments, work canters and equipment in the

conversion process. It is a floor plan of the physical facilities, which are used in production.

According to Moore *“Plant layout is a plan of an optimum arrangement of facilities including personnel, operating equipment, storage space, material handling equipment and all other supporting services along with the design of best structure to contain all these facilities”*.

Objectives of Plant Layout

The primary goal of the plant layout is to maximize the profit by arrangement of all the plant facilities to the best advantage of total manufacturing of the product. The objectives of plant layout are:

1. Streamline the flow of materials through the plant.
2. Facilitate the manufacturing process.
3. Maintain high turnover of in-process inventory.
4. Minimize materials handling and cost.
5. Effective utilization of men, equipment and space.
6. Make effective utilization of cubic space.
7. Flexibility of manufacturing operations and arrangements.
8. Provide for employee convenience, safety and comfort.
9. Minimize investment in equipment.
10. Minimize overall production time.
11. Maintain flexibility of arrangement and operation.
12. Facilitate the organizational structure.

Principles of Plant Layout

1. **Principle of integration:** A good layout is one that integrates men, materials, machines and supporting services and others in order to get the optimum utilization of resources and maximum effectiveness.
2. **Principle of minimum distance:** This principle is concerned with the minimum travel (or movement) of man and materials. The facilities should be arranged such that, the total distance travelled by the men and materials should be minimum and as far as possible straight line movement should be preferred.
3. **Principle of cubic space utilization:** The good layout is one that utilize both horizontal and vertical space. It is not only enough if only the floor space is utilized optimally but the third dimension, i.e., the height is also to be utilized effectively.
4. **Principle of flow:** A good layout is one that makes the materials to move in forward direction towards the completion stage, i.e., there should not be any backtracking.

5. **Principle of maximum flexibility:** The good layout is one that can be altered without much cost and time, i.e., future requirements should be taken into account while designing the present layout.
6. **Principle of safety, security and satisfaction:** A good layout is one that gives due consideration to workers safety and satisfaction and safeguards the plant and machinery against fire, theft, etc.
7. **Principle of minimum handling:** A good layout is one that reduces the material handling to the minimum.

11.4 TYPES OF LAYOUTS

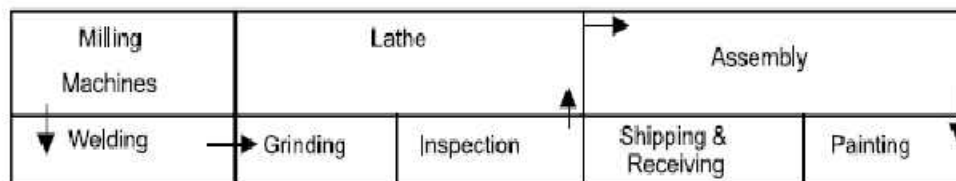
Layouts can be classified into the following five categories:

1. Process layout
2. Product layout
3. Combination layout
4. Fixed position layout
5. Group layout

Process Layout

Process layout is recommended for batch production. All machines performing similar type of operations are grouped at one location in the process layout e.g., all lathes, milling machines, etc. are grouped in the shop will be clustered in like groups.

Thus, in process layout the arrangement of facilities are grouped together according to their functions. A typical process layout is shown in Fig. The flow paths of material through the facilities from one functional area to another vary from product to product. Usually the paths are long and there will be possibility of backtracking. Process layout is normally used when the production volume is not sufficient to justify a product layout. Typically, job shops employ process layouts due to the variety of products manufactured and their low production volumes.



Advantages

1. In process layout machines are better utilized and fewer machines are required.
2. Flexibility of equipment and personnel is possible in process layout.
3. Lower investment on account of comparatively less number of machines and lower cost of general purpose machines.

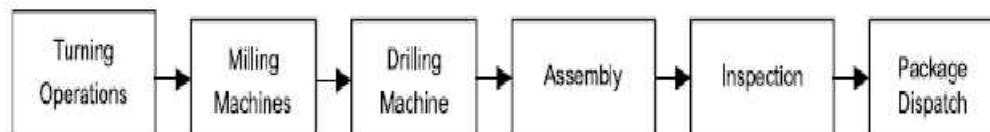
4. Higher utilization of production facilities.
5. A high degree of flexibility with regards to work distribution to machineries and workers.
6. The diversity of tasks and variety of job makes the job challenging and interesting.
7. Supervisors will become highly knowledgeable about the functions under their department.

Limitations

1. Backtracking and long movements may occur in the handling of materials thus, reducing material handling efficiency.
2. Material handling cannot be mechanized which adds to cost.
3. Process time is prolonged which reduce the inventory turnover and increases the in process inventory.
4. Lowered productivity due to number of set-ups.
5. Throughput (time gap between in and out in the process) time is longer.
6. Space and capital are tied up by work-in-process.

11.3.1 PRODUCT LAYOUT

In this type of layout, machines and auxiliary services are located according to the processing sequence of the product. If the volume of production of one or more products is large, the facilities can be arranged to achieve efficient flow of materials and lower cost per unit. Special purpose machines are used which perform the required function quickly and reliably. The product layout is selected when the volume of production of a product is high such that a separate production line to manufacture it can be justified. In a strict product layout, machines are not shared by different products. Therefore, the production volume must be sufficient to achieve satisfactory utilization of the equipment. A typical product layout is shown in Fig.



Advantages

1. The flow of product will be smooth and logical in flow lines.
2. In-process inventory is less.
3. Throughput time is less.
4. Minimum material handling cost.

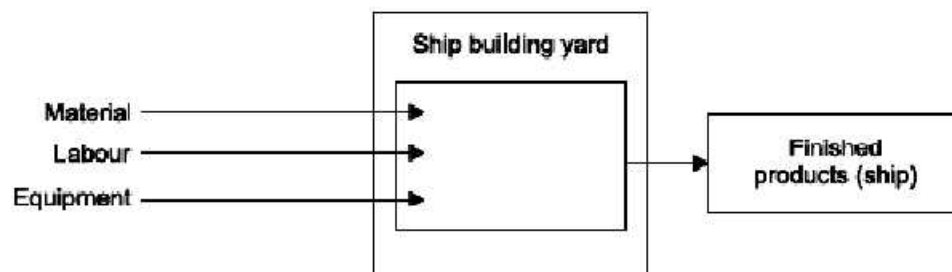
5. Simplified production, planning and control systems are possible.
6. Less space is occupied by work transit and for temporary storage.
7. Reduced material handling cost due to mechanised handling systems and straight flow.
8. Perfect line balancing which eliminates bottlenecks and idle capacity.
9. Manufacturing cycle is short due to uninterrupted flow of materials.
10. Small amount of work-in-process inventory.
11. Unskilled workers can learn and manage the production.

Limitations

1. A breakdown of one machine in a product line may cause stoppages of machines in the downstream of the line.
2. A change in product design may require major alterations in the layout.
3. The line output is decided by the bottleneck machine.
4. Comparatively high investment in equipment is required.
5. Lack of flexibility. A change in product may require the facility modification.

11.3.2 FIXED POSITION LAYOUT

This is also called the **project type** of layout. In this type of layout, the material, or major components remain in a fixed location and tools, machinery, men and other materials are brought to this location. This type of layout is suitable when one or a few pieces of identical heavy products are to be manufactured and when the assembly consists of large number of heavy parts, the cost of transportation of these parts is very high.



Advantages

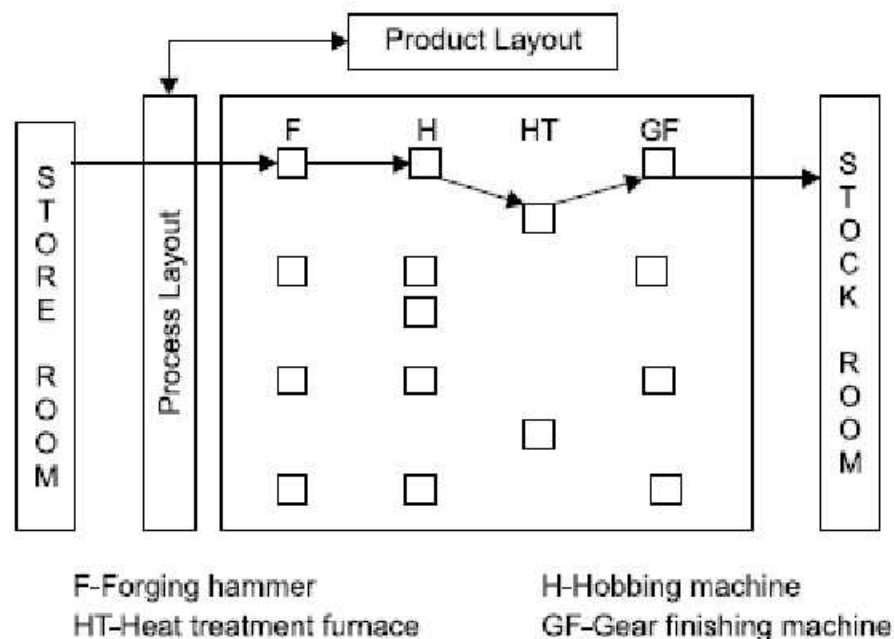
The major advantages of this type of layout are:

1. Helps in job enlargement and upgrades the skills of the operators.
2. The workers identify themselves with a product in which they take interest and pride in doing the job.

3. Greater flexibility with this type of layout.
4. Layout capital investment is lower.

11.3.3 Combination Layout

A combination of process and product layouts combines the advantages of both types of layouts. A combination layout is possible where an item is being made in different types and sizes. Here machinery is arranged in a process layout but the process grouping is then arranged in a sequence to manufacture various types and sizes of products. It is to be noted that the sequence of operations remains same with the variety of products and sizes. Figure shows a combination type of layout for manufacturing different sized gears.



Group Layout (or Cellular Layout)

There is a trend now to bring an element of flexibility into manufacturing system as regards to variation in batch sizes and sequence of operations. A grouping of equipment for performing a sequence of operations on family of similar components or products has become all the important.

Group technology (GT) is the analysis and comparisons of items to group them into families with similar characteristics. GT can be used to develop a hybrid between pure process layout and pure flow line (product) layout. This technique is very useful for companies that produce variety of parts in small batches to enable them to take advantage and economics of flow line layout.

The application of group technology involves two basic steps; first step is to determine component families or groups. The second step in applying group technology is to arrange the plants equipment used to process a particular family of components. This represents small plants

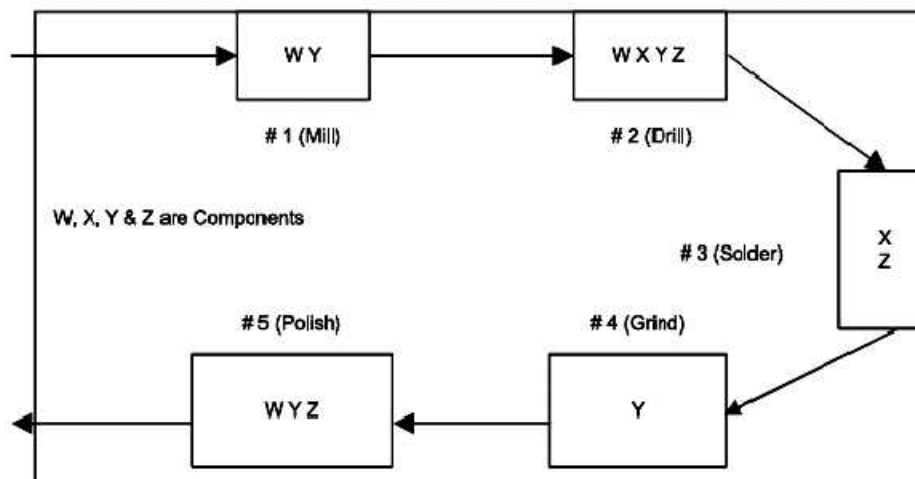
within the plants. The group technology reduces production planning time for jobs. It reduces the set-up time.

Thus **group layout** is a combination of the product layout and process layout. It combines the advantages of both layout systems. If there are m -machines and n -components, in a group layout (Group-Technology Layout), the m -machines and n -components will be divided into distinct number of machine-component cells (group) such that all the components assigned to a cell are almost processed within that cell itself. Here, the objective is to minimize the intercell movements.

The basic aim of a group technology layout is to identify families of components that require similar of satisfying all the requirements of the machines are grouped into cells. Each cell is capable of satisfying all the requirements of the component family assigned to it.

The layout design process considers mostly a single objective while designing layouts. In process layout, the objective is to minimize the total cost of materials handling. Because of the nature of the layout, the cost of equipments will be the minimum in this type of layout. In product layout, the cost of materials handling will be at the absolute minimum. But the cost of equipments would not be at the minimum if the equipments are not fully utilized.

In-group technology layout, the objective is to minimize the sum of the cost of transportation and the cost of equipments. So, this is called as multi-objective layout. A typical process layout is shown in Fig.



Advantages of Group Technology Layout

Group Technology layout can increase—

1. Component standardization and rationalization.
2. Reliability of estimates.
3. Effective machine operation and productivity.
4. Customer service.

11.4 Summary

Facilities is defined as the workspace and equipment needed to carry out the operations of the organization. There are 5 Phases of Facility Planning: Site Selection, Preliminary Design, Final Design, Project Bid and Project Management. There is huge requirement of facility planning. Facilities are central to maximizing the efficiency of the overall operations system. Plant layout refers to the physical arrangement of production facilities. Layouts can be classified into the following five categories: Process layout, Product layout, Combination layout, fixed position layout and Group layout.

Self assessment question

1. What Is Facility Planning?
2. What is Needed for Facility Planning?
3. Explain various types of Layouts?

UNIT - 12

AGGREGATE PRODUCTION PLANNING

STRUCTURE

- 12.0 Introduction;
- 12.1 Linkage between Long Term and Short Term Planning,
- 12.2 The Purpose of Aggregate Planning,
- 12.3 Steps in Aggregate Planning,
- 12.4 Dimension of Production Capacity,
- 12.5 Managerial Importance of Aggregate Planning
- 12.6 Summary

12.0 INTRODUCTION

Production planning and Control is the organization and planning of the manufacturing processes, it coordinates supply and movements of materials and labour; ensures economic and balanced utilization of machines and equipments as well as other activities related with production to achieve the desired manufacturing results in terms of quantity, quality, time and place. Production planning implies formulation, coordination and determination of activities in a manufacturing system necessary for the accomplishment of desired objectives whereas production control is the process of maintaining a balance between various activities evolved during production planning providing most effective and efficient utilization of resources.

Objectives of production planning and control;

- *Determining the nature and magnitude of various inputs factors to manufacture the desired output*
- *To coordinate labour , machines and equipment in the most effective and economic manner,*
- *Establishing targets and checking these against performance.*
- *Ensuring smooth flow of material by eliminating bottlenecks, if any, in production.*
- *Utilization of under employed resources.*
- *To manufacture the desired output of right quality and quantity at right time.*

12.1 LINKAGE BETWEEN LONG TERM AND SHORT TERM PLANNING

Marketing relies on short-term and long-term planning to ensure that company resources are effectively aligned to drive consumer demand at a profit. A short-term plan, sometimes called an operational or tactical marketing plan, is a detailed picture of planned activities, usually over the next 12-month period. Long-term plans, or strategic marketing plans, give the "big picture" of longer-term goals for growth opportunities over five- to 10-year timelines.

Marketing plans are directly related to and evolve out of corporate or company strategic plans. Corporate strategic plans establish broad company goals that are usually expressed in quantifiable terms, such as "to increase operating profit by 5 percent annually over the next five years." These plans look to the future in terms of desired outcomes based on company-wide audits of strengths and weaknesses. In effect, company strategic plans state "where we want to be." In contrast, both tactical and strategic marketing plans are statements of "how to get there." They start with a company's current position and define the pathways to meet the desired outcomes established in the company strategic plan.

Short-Term Plans

Tactical marketing plans are detailed accounts of how the marketing mix — product, distribution, price and promotions — will be managed over the defined period of time, which most commonly is a year, but could be a quarter or even a month, in some cases. If a price increase is required to compensate for increased production costs, the timing of the price increase along with marketing initiatives to mitigate anticipated trade and consumer pushback against the price increase are included in the marketing plan. In effect, tactical plans are "calendars of events" that detail marketing activities on a monthly basis over the next 12 months. They also include supporting monthly sales forecasts and marketing budgets.

Long-Term Plans

Strategic marketing plans establish longer-term marketing strategies against a backdrop of uncertainties relating to future economic, consumer, industry and competitive trends. Many industries need strategic marketing plans because of prolonged lead-times to develop and introduce new products. Such is the case for new product development in the pharmaceutical and defense industries, where products can be in development up to 10 years before market introduction. All companies can benefit from strategic marketing planning because marketing is about creating the future. You need a vision to create the future. Long-term planning opens the window, the vision, into the future.

Integrating Short-Term and Long-Term Planning

Many experienced marketers believe that both tactical and strategic planning responsibilities belong to the marketing department, rather than

leaving marketing strategy to corporate strategists. For instance, Michael Baker, Marketing Professor Emeritus at the University of Strathclyde in Scotland and editor of "The Marketing Book," expressed fear that marketing manager's risk losing the ability to think strategically when removed from the strategic planning process. This can produce narrow-minded, disconnected tactical plans, because they fail to incorporate long-term initiatives that safeguard the future. Short and long-term marketing plans are essential roadmaps that guide the future prosperity of your SMALL BUSINESS. If you are unfamiliar with marketing planning, tap into an abundance of free resources. Visit the Small Business Administration website, or the SCORE website, formerly Service Corp of Retired Executives, for more information on marketing plans.

12.2 AGGREGATE PLANNING

Managing companies for success across a range of time frames - a requisite for achieving both performance and health - is one of the toughest challenges in business. The fact that 10 of the largest 15 bankruptcies in history have occurred since 2001 is playing up its inherent risks. Managements need to build confidence in their ability to realize longer-term strategies and good short-term results. Planning, for any period including aggregate planning, is possible only when management has information available on tap. This is especially true for batch-based manufacturing planning.

Aggregate planning consists of the resource management planning activities that are done after the long-term capacity and capability planning decisions have been made. These planning activities are designed to help the firm achieve its long-term strategic initiatives. The nature of these activities is influenced by the structure of the product delivery systems.

What Is Aggregate Planning?

Firms make the strategic long-term resource commitments that will enable its operations function to achieve its corporate objective. Most of the decisions needed to create these capabilities involve strategic commitments, i.e., where to site and how to site facilities; how to acquire plant and equipment; what type of information systems to be implemented and executed; and how to create an organization with a culture that serves the corporate strategy well.

Aggregate planning is the "big picture" approach to planning for the intermediate term. While strategic planning deals with long range operations of facilities and resources, aggregate planning deals with developing ways to utilize those facilities and resources.

In other words, the aggregate plan links strategic goals and objectives of the organization with the plans for individual products, services and their various components.

Factors Affecting Aggregate Planning

Aggregate planning is an operational activity critical to the organization as it looks to balance long-term strategic planning with short term production success. Following factors are critical before an aggregate planning process can actually start;

- A complete information is required about available production facility and raw materials.
- A solid demand forecast covering the medium-range period
- Financial planning surrounding the production cost which includes raw material, labor, inventory planning, etc.
- Organization policy around labor management, quality management, etc.

For aggregate planning to be a success, following inputs are required;

- An aggregate demand forecast for the relevant period
- Evaluation of all the available means to manage capacity planning like sub-contracting, outsourcing, etc.
- Existing operational status of workforce (number, skill set, etc.), inventory level and production efficiency

12.3 STEPS IN AGGREGATE PLANNING

The process consists of four basic considerations as follows:

- **Concept of Aggregation** starts with a meaningful measure of output. In a single product output organization there is no problem with the output measure. Many organizations have multiple products and it is difficult to find a common factor of measure of output.

For e.g. steel producer can plan in terms of tons of steel, gallons of paint in case of paint industry. Service organizations such as transport system may use passenger miles as a common measure, health care facilities may use patient visits, and educational institutes may use student to faculty contact ratio in terms of hours as a reasonable measure.

A group of products or services that have similar demand requirements and common processing, labor and materials requirements is called a Product Family. Therefore a firm can aggregate its products or services into a set of relatively broad families, avoiding too much detail at the planning stage. For example consider the Bicycle manufacture that has aggregated all products into two families: mountain bikes and road bikes. This

approach aids production planning for the assembly lines in the plants.

- **Goals for aggregate planning** there are number of goals to be satisfied. It has to provide the overall levels of output, inventory and backlogs dictated by the business plan. Proper utilization of the plant capacity. It should not be under-utilized because it is waste of resources. It is better to operate at a near full capacity. The aggregate plan should be consistent with the company's goals and policies regarding its employees. A firm may like to have employee stability or hire and layoff strategy. Other firms change employees freely as the output level is varied throughout the aggregate planning horizon.
- **Aggregate Demand Forecasts** The benefits of aggregate planning depends on the accurate forecasting. Any suitable forecasting model can be used to forecast demand for product groups as well as individual products.
- **Interrelationships among decisions:** Here the managers must consider the future consequence of current decisions. This is important mainly due to the fact that output plans are developed for a long period of time.

Strategies for Aggregate Planning:

There are three pure strategies that the planner could use for the Aggregate Planning.

- Strategy 1.** Vary the number of Productive employees in Response to Varying output Requirements (also known as Chase 1 plan). Here, the average productivity per employee is first calculated which determines the number of employees needed to meet the monthly required output demand. The employees are laid off when the output demand falls. As a result there is always Hiring and laying of employees.
- Strategy 2.** Maintain a Constant Work Force Size but Vary the Utilization of the Work Force (also known as Level # 1).

Suppose, for example, we chose the strategy of employing 70 workers per month throughout the year. On an average, this work force would be capable of producing 700 wagons each day. During the lean months (January, February, March, July, October, November, December), the work force would be scheduled to produce only the amount forecasted, resulting in scheduled to produce only the amount forecasted, resulting in same idle working hours. During high demand months (April, May, June, August, September), overtime operations would be needed to meet demand. The work force would therefore be intensely utilized during some months and underutilized in other months.

Strategy 3. Vary the Size of Inventory in Response to Varying Demand (also known as Chase # 2 plan). Finished goods inventories in make-to-stock companies can be used as a cushion against fluctuating demand. A fixed number of employees, selected to that little or no overtime or idle time is incurred, can be maintained throughout the planning horizon. Producing at a constant rate, output will exceed demand during slack demand periods, and finished goods inventories will accumulate. During peak periods, when demand is greater than capacity, the demand can be supplied from inventory. This planning strategy results in fluctuating inventory levels throughout the planning horizon.

12.5 MANAGERIAL IMPORTANCE OF AGGREGATE PLANNING

Aggregate planning plays an important part in achieving long-term objectives of the organization. Aggregate planning helps in:

- Achieving financial goals by reducing overall variable cost and improving the bottom line
- Maximum utilization of the available production facility
- Provide customer delight by matching demand and reducing wait time for customers
- Reduce INVESTMENT in inventory stocking
- Able to meet scheduling goals there by creating a happy and satisfied work force
- Laying off/hiring excess/inadequate excess/inadequate excess/inadequate workforce until demand decrease/increase.
- Including overtime as part of scheduling there by creating additional capacity.
- Hiring a temporary workforce for a fix period or outsourcing activity to a sub-contractor.

12.6 Summary

Production planning implies formulation, coordination and determination of activities in a manufacturing system necessary for the accomplishment of desired objectives whereas production control is the process of maintaining a balance between various activities evolved during production planning providing most effective and efficient utilization of resources. Marketing plans are directly related to and evolve out of corporate or company strategic plans. Plans may be short term or long term. Aggregate planning activities are designed to help the firm achieve its long-term strategic initiatives. Aggregate planning process consists of four

basic considerations: Concept of Aggregation, Goals for aggregate planning, Aggregate Demand Forecasts, Interrelationships among decisions. There are three pure strategies that the planner could use for the Aggregate Planning. There is very much managerial planning.

Self Assessment questions

1. Explain the Linkage between Long Term and Short Term Planning?
2. What is The Purpose of Aggregate Planning?
3. Explain the Steps in Aggregate Planning?
4. What are the Dimension of Production Capacity?



॥ सरस्वती के सुपात्र मयस्कल ॥
**Uttar Pradesh Rajarshi Tandon
Open University**

Master of Business

M.B.A.-2.2 Production Management

BLOCK

4

WORK SYSTEM DESIGN

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WORK SYSTEM DESIGN	
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MANAGEMENT INFORMATION FOR PRODUCTION SYSTEM	
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JUST IN TIME	
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LOGISTICS MANAGEMENT	
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परिशिष्ट-4
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परिभाषक

अनुवाद की स्थिति में

मूल लेखक

अनुवाद

मूल सम्पादक

भाषा सम्पादक

मूल परिभाषक

सहयोगी टीम

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प्रूफ रीडर

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UNIT - 13

WORK SYSTEM DESIGN

12.1 Introduction

In development, work design is the application of Socio-Technical Systems principles and techniques to the humanization of work. The aims of work design are to improve job satisfaction, to improve through-put, to improve quality and to reduce employee problems (e.g., grievances, absenteeism). Job design is concerned with structuring jobs in order to improve organizational efficiency and employee job satisfaction. The design of a job should reflect both technological and human considerations. It should facilitate the achievement of organizational objectives and the performance of the work that the job was established to accomplish. At the same time, the design should recognize the capacities and needs of those who are to perform it. Over the last two decades, one of the most influential theories of job design is the Job Characteristics Model (JCM) put forward by Hackman and Oldman (1980). This extensively studied model has been used to explain important work outcomes for workers in a wide variety of blue and white-collar jobs. Fundamental to JCM is the notion that there are two kinds of job motivation: external motivation and internal motivation. External job motivation includes salary, benefits, and bonuses. Internal job motivation derives from the sense of self-satisfaction that one receives from a job well done. Therefore, it is important that they maximize internal job motivation. Internal job motivation occurs when three key conditions are met.

□ First, the person must experience **responsibility** for the results of the work, believing that he or she is personally accountable for work outcomes. If one views the quality of the completed work as depending more on external factors than upon one's own initiative or efforts, then he or she will feel less personally satisfied when one does well or dissatisfied when one does not do well.

□ Second, the person must have **knowledge of the results** of his or her work. If the person who does the work never receives knowledge of the results, then that individual has no basis for feeling satisfied about doing well or dissatisfied about doing poorly.

□ Third, the person must experience the work as **meaningful**—as something that “counts” in one's own system of values. If the work being done is seen as trivial, then internal work motivation is unlikely to develop—even when the person has sole responsibility for the work and receives ample information about how well he or she is performing. Hackman and Oldman (1980) believe that jobs have certain characteristics that determine how well the key conditions named above will be met. A sense of responsibility, the first key condition, is facilitated by giving staff

a high degree of autonomy. Knowledge of the results, the second key condition, is facilitated by giving staff feedback on their performance effectiveness. And a sense of meaningfulness, the third key condition, is facilitated by skill variety, task identity, and task significance.

13.2 JOB DESIGN

A job can be defined as the set of tasks and responsibilities of a worker. These tasks and responsibilities, along with performance expectations, work conditions (time and place of work), general skills, and possibly methods to be used, are normally contained in a written job description. There is no set formula for designing jobs that will best fit a production system. Job design is the consciously planned structuring of work effort performed by an individual or a team of persons. There is increasing evidence that poorly designed jobs are a pervasive social problem affecting the mental and physical health of the worker both on and off the job.

Job design helps to determine: What tasks are done, how the tasks are done, how many tasks are done, and in what order the tasks are done. It takes into account all factors which affect the work, and organizes the content and tasks so that the whole job is less likely to be a risk to the employee. The objective of job design is therefore, to develop work assignments that meet the requirements of the organization and the technology, and at the same time also satisfy the personal and individual requirements of the job holder.

Various techniques of job design are

1. Simplification of Job
 2. Job Enlargement
 3. Job Enrichment
 4. Job Rotation
- **Simplification of Job:**

In job simplification jobs are broken in to very small parts as in assembly line operations and work can be done by same individual repeatedly and it will increase productivity and proficiency of individual. However it produces boredom and monotony in worked.

- **Job Enlargement:**

Job enlargement expands job horizontally. It increases job scope; that is, it increases the number of different operations required in a job and the frequency with which the job cycle is repeated. By increasing the number of tasks an individual performs, job enlargement, increases the job scope, or job diversity. Instead of only sorting the incoming mail by department, for instance, a mail sorter's job could be enlarged to include physically delivering the mail to the various departments or running outgoing letters through the postage meter. Job enlargement decreases

some boredom but it is not enough to motivate as nature of work remain same.

Job enlargement means expanding the scope of the job. Many tasks and duties are aggregated and assigned to a single job. It is opposite to job simplification. Job enlargement is an extension of Job rotation, exposing the people to several jobs without changing the job duties to be performed. He is taken off the boring job for a while & is allowed to take up a related task & so on. Monotony is relieved temporarily. Critics are of the opinion that this approach involves nothing more than having to perform several boring jobs rather than one. Job enlargement is to expand in several tasks than just to do one single task. It is also the horizontal expansion of a job. It involves the addition of tasks at the same level of skill and responsibility. It is done to keep workers from getting bored. This would also be considered multi tasking by which one person would do several persons jobs, saving the company money and man hours that normally would be paid to additional workers. Small companies may not have as many opportunities for promotions, so they try to motivate employees through job enlargement. For example when I worked at a restaurant. I would bus the tables, wash the dishes, and run food upstairs. If they had just one person doing each job on the same night, it would cost the management three times the money. This adds more functions; increases variety of tasks and this is short lived. It cannot enrich the human content of job. The ultimate answer is Job Enrichment.

- **Job Rotation:**

Job rotation is the systematic and planned rotation of individuals in pre-determined jobs (other than their own) so they can gain additional knowledge or skills. It is done quite a bit for developing managers (because they need to be familiar with operations overall) and also used with others who want to advance to a new role or become more knowledgeable in their current job role. Job rotation implies systematic movement of employees from one job to the other. Job remains unchanged but employees performing them shift from one job to the other. With job rotation, an employee is given an opportunity to perform different jobs, which enriches his skills, experience and ability to perform different jobs. It is the process of preparing employees at a lower level to replace someone at the next higher level. It is generally done for the designations that are crucial for the effective and efficient functioning of the organization. By this to some extent boredom is reduced. However for this people interest is primary importance. By this they can also learn new things, new techniques, and new ways of doing better work. It may also happen that over a period of time they will be finding a job for which they are better suitable. They can also contribute in a better way to achieve the goals of the organization.

This aspect of job rotation can be seen widely applied in Retail scenario, where end user or consumer is in direct presence all through. This has for large extent reduced boredom, reduced irregularities due to familiarity, acquired new skills & assuming new and varied responsibilities. In other

words it will lead to better job satisfaction, which is the ultimate goal for better contribution. Some of the major benefits of job rotation are:

- It provides the employees with opportunities to broaden the horizon of knowledge, skills, and abilities by working in different departments, business units, functions, and countries
- Identification of Knowledge, skills, and attitudes required
- It determines the areas where improvement is required
- Assessment of the employees who have the potential and caliber for filling the position

• **Job Enrichment:**

Job enrichment is an approach to job design. The focus is to increase the depth of the job (by the amount of discretion and responsibility the job holder has). It is different from job enlargement (which focuses on increasing the number of tasks a job holder is responsible for performing. In job enrichment, additional tasks are not the focus for the goal, but an increase in tasks could be a result of giving the job holder more authority, discretion, and responsibility for decision making in their current role. It is the most effectively motivating tool used by the organizations which enhances the decision making skills of the managers and helps in their overall development. Job enrichment means making the job rich in its contents so that an employee will get more satisfaction while performing that job. It upgrades the responsibility, scope and challenge. A vast majority of the jobs are repetitive and monotonous in nature. This results in reducing the motivational content and human element of the job with repercussions on performance. The central focus of job enrichment is giving people more control over their work (lack of control is a key cause of stress, and therefore of unhappiness.) Where possible, allow them to take on tasks that are typically done by supervisors. This means that they have more influence over planning, executing, and evaluating the jobs they do. In enriched jobs, people complete activities with increased freedom, independence, and responsibility. They also receive plenty of feedback, so that they can assess and correct their own performance.

Job Enrichment tries to embellish the job with factors of motivation: Achievement – Recognition – Increased Responsibilities – Self Involvement – Opportunities for Growth – Advancement – Increased Competence. Job Enrichment is concerned with redesigning the job to include a variety of work content; that gives the person more autonomy & responsibility for planning, directing & controlling his own performance & provide opportunity for personal growth & meaningful work experience. Job Enrichment also for decentralization of decision making rights to individual over areas that directly affect his task functions.

The emphasis is on the result of efforts rather than the procedure to carry out the work, thus making the job result oriented. This also results in motivation, satisfaction in believing oneself to be personally accountable for results & being able to know how satisfactory ones efforts are. By Job

Enrichment, condition or state of human capabilities which were not fully utilized & creation of frustration among the individual is removed to the extent possible.

Work Measurement

Work measurement is also called by the name 'time study'. Work measurement is absolutely essential for both the planning and control of operations. Without measurement data, we cannot determine the capacity of facilities or it is not possible to quote delivery dates or costs. We are not in a position to determine the rate of production and also labor utilization and efficiency. It may not be possible to introduce incentive schemes and standard costs for budget control.

Objectives of Work Measurement

The use of work measurement as a basis for incentives is only a small part of its total application.

The objectives of work measurement are to provide a sound basis for:

1. Comparing alternative methods.
2. Assessing the correct initial manning (manpower requirement planning).
3. Planning and control.
4. Realistic costing.
5. Financial incentive schemes.
6. Delivery date of goods.
7. Cost reduction and cost control.
8. Identifying substandard workers.
9. Training new employees.

Techniques of Work Measurement

For the purpose of work measurement, work can be regarded as:

1. **Repetitive work:** The type of work in which the main operation or group of operations repeat continuously during the time spent at the job. These apply to work cycles of extremely short duration.
2. **Non-repetitive work:** It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

Various techniques of work measurement are:

1. Time study (stop watch technique),
2. Synthesis,
3. Work sampling,
4. Predetermined motion and time study,
5. Analytical estimating.

Time study and work sampling involve direct observation and the remaining are data based and analytical in nature.

1. **Time study:** A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analyzing the data so as to determine the time necessary for carrying out the job at the defined level of performance. In other words measuring the time through stop watch is called time study.
2. **Synthetic data:** A work measurement technique for building up the time for a job or parts of the job at a defined level of performance by totaling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.
3. **Work sampling:** A technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.
4. **Predetermined motion time study (PMTS):** A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as **Methods Time Measurement (MTM)**.
5. **Analytical estimating:** A work measurement technique, being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.

The work measurement techniques and their applications are shown in Table

TABLE: Work measurement techniques and their application

<i>Techniques</i>	<i>Applications</i>	<i>Unit of measurement</i>
1. Time study	Short cycle repetitive jobs. Widely used for direct work.	Centiminute (0.01 min)
2. Synthetic Data	Short cycle repetitive jobs.	Centi minutes
3. Working sampling	Long cycle jobs/ heterogeneous operations.	Minutes
4. MTM	Manual operations confined to one work centre	TMU (1 TMU = 0.006 min)
5. Analytical estimation	Short cycle non-repetitive job.	Minutes

TIME STUDY

Time study is also called work measurement. It is essential for both planning and control of operations. According to British Standard Institute time study has been defined as *"The application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."*

Steps in Making Time Study

Stop watch time is the basic technique for determining accurate time standards. They are economical for repetitive type of work. Steps in taking the time study are:

1. Select the work to be studied.
2. Obtain and record all the information available about the job, the operator and the working conditions likely to affect the time study work.
3. Breakdown the operation into elements. An element is a distinct part of a specified activity composed of one or more fundamental motions selected for convenience of observation and timing.
4. Measure the time by means of a stop watch taken by the operator to perform each element of the operation. Either continuous method or snap back method of timing could be used.
5. At the same time, assess the operator's effective speed of work relative to the observer's concept of 'normal' speed. This is called performance rating.
6. Adjust the observed time by rating factor to obtain normal time for each element

$$\text{Normal} = \text{Observed time} \times \text{Rating}$$

7. Add the suitable allowances to compensate for fatigue, personal needs, and contingencies etc. to give standard time for each element.
8. Compute allowed time for the entire job by adding elemental standard times considering frequency of occurrence of each element.
9. Make a detailed job description describing the method for which the standard time is established.
10. Test and review standards wherever necessary.

Computation of Standard Time

Standard time is the time allowed to an operator to carry out the specified task under specified conditions and defined level of performance. The various allowances are added to the normal time as applicable to get the standard time. Standard time may be defined as the amount of time required to complete a unit of work:

(a) under existing working conditions, (b) using the specified method and machinery, (c) by an operator, able to the work in a proper manner, and (d) at a standard pace.

Thus basic constituents of standard time are:

1. Elemental (observed time).
2. Performance rating to compensate for difference in pace of working.
3. Relaxation allowance.
4. Interference and contingency allowance.
5. Policy allowance.

OT – Observed Time

PRF – Performance Rating Factor

NT – Normal Time

PA – Process Allowances

RPA – Rest and Personal Allowances

SA – Special Allowances

PoA – Policy Allowances

Allowances

The normal time for an operation does not contain any allowances for the worker. It is impossible to work throughout the day even though the most practicable, effective method has been developed.

Even under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation.

Allowances must also be made to enable the worker to attend to his personal needs. The allowances are categorized as:

- (1) Relaxation allowance,
- (2) Interference allowance, and
- (3) Contingency allowance.

1. Relaxation Allowance

Relaxation allowances are calculated so as to allow the worker to recover from fatigue. Relaxation allowance is a addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on nature of the job.

Relaxation allowances are of two types: fixed allowances and variable allowances.

Fixed allowances constitute:

- (a) **Personal needs allowance:** It is intended to compensate the operator for the time necessary to leave the workplace to attend to personal needs like drinking water, smoking, washing hands. Women require longer personal allowance than men. A fair personal allowance is 5% for men, and 7% for women.
- (b) **Allowances for basic fatigue:** This allowance is given to compensate for energy expended during working. A common figure considered as allowance is 4% of the basic time.

2. Variable Allowance

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job. The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organization to organization.

3. Interference Allowance

It is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him. This allowance is applicable for machine or process controlled jobs. Interference allowance varies in proportion to number of machines assigned to the operator. The interference of the machine increases the work content.

4. Contingency Allowance

A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays. The precise measurement of which is uneconomical because of their infrequent or irregular occurrence.

This allowance provides for small unavoidable delays as well as for occasional minor extra work:

Some of the examples calling for contingency allowance are:

- _ Tool breakage involving removal of tool from the holder and all other activities to insert new tool into the tool holder.
 - _ Power failures of small duration.
 - _ Obtaining the necessary tools and gauges from central tool store.
- Contingency allowance should not exceed 5%.

5. Policy Allowance

Policy allowances are not the genuine part of the time study and should be used with utmost care and only in clearly defined circumstances.

The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions.

The policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, e.g., work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances. Policy allowances are sometimes made as imperfect functioning of a division or part of a plant.

Compensation

Compensation refers to a wide range of financial & non-financial rewards to employees for their services rendered to the organization. OR Employee Compensation refers to all forms of pay going to employees & arising from their employment. It has 2 main components, Direct Financial payments (Wages, salaries, incentives, conveyance, HRA, LTA, commissions & bonus), & Indirect Financial payments (Financial benefits like employer paid insurance, Car Policy, Holiday Homes, Hospitalization, Leave Policy, Retirement Policy etc).

Elements of Compensation:-

- Monthly wage & Salary or total pay including basic wage, house rent allowance, Dearness Allowance & city compensatory allowance;
- bonus at the end of the year;
- Economic benefits such as paid holidays, LTA concession;
- Contribution towards insurance premium;
- Contribution towards retirement benefits such as employee provident fund;
- Transport & Medical Facilities.

Compensation Objectives:-

- To reward employees' past performance fairly, in line with efforts, skills and competencies;
- To attract and retain competitive high performing employees;
- To remain competitive in the labor market;
- To align employees' future performance with organizational goals;
- To communicate the employees their worth to the organization;
- To motivate the high performing employees;
- To provide employee social status.

Theories of Remuneration:

- **Reinforcement & Expectancy Theory:** - The Reinforcement theory postulates that a behavior which has a rewarding experience is likely to be repeated. The implication for remuneration is that high employee performance followed by a monetary reward will make future employee performance more likely. In same way, a high performance not followed by a reward will make its recurrence unlikely in future. Vroom's Expectancy theory focuses on the link between rewards & behavior.
- **Equity Theory:** - Adam's equity theory posit that employee's perceptions of how they are treated by their firm is of prime importance to them. The dictum 'a fair day work for fair day pay' denotes a sense of equity felt by employees. When employees perceive inequity, it can result in lower productivity, higher absenteeism or increase in turnover. The remuneration system needs to meet 3 types of equity-internal, external & individual.
 1. **Internal Equity:** - Involves the perceived fairness of pay differentials among different jobs within an organization. Employees should feel that the pay differentials among jobs are fair, given the corresponding differences in job responsibilities;
 2. **External Equity:** Involves employees' perception of the fairness of their remuneration relative to those outside the organization. What competitors pay to similar jobs will have its impact on employee motivation, commitment & Performance.
 3. **Individual Equity:** Considers employee perception of pay differentials among individuals who hold identical jobs in the same organization. Seniority contributes to differences in remuneration received by 2 individuals in the same cadre.
- **Agency Theory:** - The Agency Theory focuses on the divergent interests & goals of the organization's stakeholders & the way the employee remuneration can be used to align these interests & goals. Employers & Employees are the 2 main stakeholders in an organization. Employers assume the role of principals & employees play the role of agents. It is natural that the employees expect high agency costs while the employers seek to minimize it. The agency theory says that the principal must choose a contracting scheme that helps align the interest of the agents with the principal's own interests. It can be behavior oriented (Merit Pay) OR

Outcome oriented (e.g. Profit Sharing, ESOP, and Commissions etc.)

Factors Affecting Wage/Compensation:

External Factors:-

1. **Demand & Supply of Labor:** Demand & Supply of Labor influence wage & salary fixation. A low wage may be fixed when the supply of labor exceeds the demand for it. A higher wage will have to be paid when the demand exceeds supply, as in the case of skilled worker. High remuneration to skilled labor is necessary to attract & retain it.
2. **Productivity of Workers:** Productivity of labor also influences wage fixation. Productivity can arise due to increased effort of the worker or as a result of the factors beyond the control of the worker such as improved technology, machines, equipment & better management. Higher productivity will automatically fetch more profit to the firm, where in turn workers will be paid high wages in comparison to other firms with low productivity.
3. **Cost of Living:** This criteria matters during periods of rising prices, & is forgotten when prices are stable or falling. The justification for cost of living as a criterion for wage fixation is that the real wages of workers should not be allowed to be reduced down by price increases. A rise in the cost of living is sought to be compensated by payment of dearness allowance, basic pay to remain undisturbed.
4. **Labor Unions:** The presence & absence of labor organizations often determine the quantum of wages paid to employees. Employers in non-unionized factories enjoy the freedom to fix wages & salaries as they please. Because of large-scale unemployment, these employers hire workers at little or even less than legal minimum wages. The employees of strongly unionized companies too, have no freedom in wage & salary fixation, as they are forced by the pressure of labor representatives in determining & revising pay scales.
5. **Government:** To protect the working class from the exploitation of powerful employers, the Government has enacted several laws. Laws on minimum wages, hours of work, equal pay for equal work, payment of dearness allowances, payment of bonus etc have been enacted & enforced to bring about a measure of fairness in compensating the working class.
6. **Society:** Remuneration paid to employees is reflected in the prices fixed by an organization for its goods & services. For this reason the consuming public is interested in remuneration decision.
7. **The Economy:** The last external factor that has its impact on wage & salary fixation is the state of the economy. For E.g. A Depressed

Economy will probably increase the labor supply, which in turn should serve to lowering the going wage rate.

Internal Factors:

1. **Business Strategy:** The overall strategy which a company pursues should determine the remuneration to its employees. Where the strategy of the enterprise is to achieve rapid growth, remuneration should be higher than what competitors pay. Where the strategy is to maintain & protect current earnings, because of the declining fortunes of the company, remuneration level needs to be average or even below average.
2. **Job Evaluation & Performance Appraisal:** Job evaluation helps establish satisfactory wage differentials among jobs. Performance Appraisal helps award pay increases to employees who show improved performance.
3. **The Employee:** Several employees related factors interact to determine his or her remuneration. These are Performance, Seniority, experience, potential & Luck.

Challenges of Remuneration:

- **Skill based pay:** In the traditional job based pay employees are paid on the basis of job they do. In the skill based system workers are paid on the basis of number of jobs they are capable of doing, or on the depth of knowledge. The purpose of this system is to motivate employees to acquire additional skills so that they become more useful to the organization. (Pay for performance/ Pay for seniority);
- **Pay Reviews:** Pay once determined should not remain constant. It must be reviewed & changed often, but how often becomes a relevant question. Pay reviews may be made on predetermined dates, anniversary dates or there could be flexible reviews.
- **Pay Secrecy:** Just how much & what types of information about pay should be provided to employees is a question that troubles HR managers. The tendency among most firms is to maintain pay secrecy as this would help avoid pay comparisons likely to be made by employees.
- **Monetary versus Non-monetary Rewards:**
- The issue relating to monetary & non-monetary rewards has primarily tax implications. Many non-monetary rewards such as medical benefits & housing are fully or partially exempted from taxes. Employees & even employers prefer non-monetary benefits than monetary rewards.
- **Eliticism & Egalitarianism:** Firms become egalitarian when they place most of their employees under the same remuneration plan. The plan becomes elitist when the organizations establish different remuneration schemes. E.g. In some firms only the CEO is eligible

for stock options. In others, even the lowest paid workers are offered stock options.

- **Salary compression:** A salary inequity problem, generally caused by inflation, resulting in longer-term employees in a position earning less than workers entering the firm today.
- The pay cycle, Salary increases and promotions, Overtime and shift pay, Probationary pay, Paid and unpaid leaves, Geography, Equity & its impact on Pay Rates.

Methods to Address Equity Issues/ Establishing Pay Rates:

- **Salary Survey:** It is difficult to set pay rates if you don't know what others are paying, so salary surveys- surveys of what others are paying play a big role in pricing jobs. It is aimed at determining prevailing wage rates. Virtually every employer conducts at least an informal telephone, newspaper, or Internet Salary survey. Many Employers use surveys published by Consulting Firms, Governmental Agencies, etc. Employers use survey data to price benchmark jobs. Salary surveys can be formal or informal way. It is mostly to get information of employees, overtime policies, starting salaries, sick leave, insurance & paid vacations.
- **Job Evaluation:** Job Evaluation is a systematic process of analyzing & evaluating jobs to determine the relative worth of each job in an organization. Once the worth of jobs is determined, it becomes easier to fix the wage structure that will be fair & equitable. The basic procedure is to compare the jobs in relation to one another- For E.g. in terms of required effort, responsibility, & skills.

Objectives

1. Maintenance of consistent wage policy.
2. Enable management to gauge & control its payroll costs more accurately.
3. Provide a framework for periodic review of wage & salaries.
4. To manage internal & external consistency in the compensation.
5. Reduce grievances & labor turnover & thereby, increase employee morale & improve management-employee relationship.
6. Serve as a basis for negotiation with the union.

Techniques of Job Evaluation:

1. **Ranking Method:** Ranking is one of the simplest & the oldest job evaluation methods. In this method, the jobs in an organization are assessed based on the knowledge, skills, effort & other job dimensions associated with each job. Jobs also can be arranged according to the relative difficulty in performing them.

Ranking involves preparation of brief job descriptions & assigning ranks to the jobs in accordance with their worth in the organization.

2. **Job classification/ Job Grading:** In this method the jobs are classified & graded based on their significance & their worth to the organization. The jobs at various levels in an organization are placed under different grades, which are clearly defined. Grades are formulated on the basis of the nature of tasks & responsibilities of the jobs, the authority associated with them & the knowledge & skill required for the jobs.
3. **Point rating Method:** The point method or point rating method is one of the most widely used methods of job evaluation. In this method, a point scale is developed to evaluate the jobs. However, different scales might be required to evaluate different jobs. For E.g. all the managerial jobs might be evaluated on one scale, all the operational on another & the clerical jobs on one scale etc.
4. **Factor Comparison Method:** Here they determine & define the specific factors like mental requirements, skills, physical requirements, responsibilities, working conditions etc. Next they will identify the key jobs or benchmark jobs, which are well known & have an established pay rate in the organization. The factors in each benchmark job are compared & ranked based on their relative importance.

Process of Job Evaluation:

- **Preparation of a Job Evaluation Plan:** The need for job evaluation is determined & detailed plan of how to go about the whole exercise, including the method to be adopted, is prepared;
- **Job Analysis:** Job Analysis provides the basic information for job evaluation. Job Analysis helps in understanding the tasks & responsibilities associated with a job.
- **Job Description & Job Specification:**
 - ❖ **Selection of Job Dimensions:** The different factors which will be the basis for evaluating each job, have to be determined. Once these dimensions are selected, monetary values have to be attached to each of these jobs, as it is a reflection of its contribution to the organization & its significance.
 - ❖ **Implementation of the evaluation:** The employees should be educated about the program to make them understand the basis & the procedure of job evaluation.
 - **Maintenance:** The results of job evaluation have to

be updated from time to time to match the changing organizational needs.

- ❖ **Group Similar Jobs into Pay Grades:** Once the committee has used job evaluation to determine the relative worth of each job, it can turn to the task of assigning pay rates to each job; however, it will usually want to first group jobs into pay grades. The committees will probably group similar jobs into grades for pay purposes. So, instead of having to deal with hundreds of pay rates, it might only have to focus on e.g. 10 or 12. A pay grade is comprised of jobs of approximately equal difficulty or importance as established by job evaluation.
- ❖ **Price Each Pay Grade– Wage Curves:** The next step is to assign pay rates to your pay grades. Wage curve can be used to help assign pay rates to each pay grade or to each job. The wage curve shows the pay rates currently paid for jobs in each pay grade, relative to the points or rankings assigned to each job or grade by the job evaluation. The purpose of wage curve is to show the relationships between (1) the value of the job as determined by one of the job evaluation methods & (2) the current average pay rates for your grades.

– **Fine tune Pay Rates:-**

It Involves (1) Developing Pay rates & (2) Correcting out of line rates.

1. **1. Developing Pay Rates:** Most employers do not pay just one pay rate for all jobs in a particular grade. For E.g. GE Medical won't want to pay all its accounting clerks, from beginners to long tenure, at the same rate. Instead, employers develop vertical pay ranges for each of the pay grades. These pay ranges are a series of steps or levels within a pay grade, usually based upon years of service. These pay ranges lets the employer take a more flexible stance in the labor market. It also let companies provide for performance differences between employees within the same grade or between those with different seniorities.
2. **Correcting Out-of-Line Rates:** The wage rate for a particular job may now fall well off the wage line or well outside the rate range for its grade. This means that the average pay for that job is currently too high or too low, relative to other jobs in the firm. For underpaid jobs, the solution is clear, raise the wage of underpaid employees to the minimum of the rate range for their pay grade.

Pricing Managerial & Professional Jobs:

Developing compensation plans for managers or professionals is similar in many respects to developing plans for any employee. The basic aim is the same i.e. to attract & keep good employees, & in job evaluation-classifying jobs, ranking them or assigning points to them is applicable to managerial & professional jobs. Compensation for a company's top executives usually consists of 4 main elements. **Base Pay**- Includes the person's fixed salary as well as often guaranteed bonuses such as 10% of pay at the end of quarter, regardless of whether or not the company makes profit.

Short term incentives- Are usually cash or stock bonuses for achieving short-term goals, such as year-to-year increases in sales revenue. **Long term incentives** aim to encourage the executive to take actions that drive up the value of the company's stock. **Executive benefits & perks** might include supplemental executive pension plans, supplemental life insurance & health insurance without a deductible.

What Determines Executive Pay?

- Company Size;
- Company Performance;
- Business Strategy;
- Corporate Trends;
- Complexity & Unpredictability of the decisions they make.

Elements of Executive Pay:

Salary is traditionally the cornerstone of executive compensation; it is the element on which employer's layer benefits, incentives, & perquisites- all normally conferred in proportion to base pay. Executive compensation emphasizes performance incentives more than do other employees pay plans, since organizational results are likely to reflect executives' contributions more directly than lower-level employees. Boards are boosting the emphasis on performance based pay.

Compensating Professional Employees:

Professional Employees are those whose work involves the application of learned knowledge to the solution of the employer's problems. Compensating Professional employees like engineers & scientists presents unique problems. Analytical jobs like these emphasize creativity, problem solving, & compensable factors not easily compared or measured. Employers can also use job evaluation for professional jobs. Compensable factors here tend to focus on problem solving, creativity, technical knowledge & expertise.

Competency Based Pay:

Competency Based Pay means the company pays for the employee's range, depth, & types of skills & knowledge, rather than for the job title he or she holds. Experts variously call this competence- knowledge or skill-based pay. With competency based pay, an employee in a class-I job who could do class II work gets paid as a class II worker, not a class I. Competencies are demonstrable characteristics of a person, including knowledge, skills, and behaviors, that enable performance. Pay for knowledge pay plans reward employees for learning organizationally relevant knowledge- for instance Microsoft pays new programmers more as they learn the intricacies of Windows Vista. Skill-based pay tends to be used more for workers with manual jobs- thus carpenters earn more as they become more proficient at finishing cabinets.

Why Use Competency Based Pay?

- **Support High-Performance Work system:** (Encourage employees to work self-motivated way, organizing work around teams, pushing more responsibility for things etc)
- **Support Strategic Aims:** (Paying for skills, knowledge & competencies is more strategic)
- Support Performance Management:** Performance management means aligning employees goals, training, appraisals & rewards so that they support the company's strategic goals. There is not much a manager can do to "manage" the employee's job duties. So, paying for competencies rather than duties gives the employer more control over managing the employee's performance.

Competency Based Pay in Practice:

In practice, skill/competency/knowledge-based pay programs generally contain 4 main elements:-

- A system that defines specific skills, and a *process* for tying the person's pay to his or her skill
- A *training system* that lets employees seek and acquire skills
- A formal competency *testing* system
- A *work design* that lets employees move among jobs to permit work assignment *flexibility*.

Competency Based Pay:

Pros:-

- Higher quality;
- High productivity;
- Higher Growth;
- High Motivations;
- Higher job Satisfaction;
- Healthy Competition.

Cons:-

- Implementation problems;

- The cost implications of paying employees for knowledge, skills & behaviours even if they are not used;
- Complexity of program –systems and evaluations and assessment;
- Uncertainty that the program improves productivity.

Concepts of Wages:

Various forms of wage & salary policies have been developed, differing according to such factors as the nature of the business its location, needs of the workers, capacity of the employee to pay, & general economic conditions prevailing in a country.

- **Minimum Wage:** - “A minimum wage is that wage which is sufficient to cover the bare physical needs of a worker and his family”. It was observed that the minimum wage must provide for the preservation of the efficiency of the worker (education, medical requirements & amenities). It is the wage which has to be paid to the workers irrespective of the capacity of the industry to pay.
- **Fair Wage:** - Fair Wage is understood in 2 ways. In a narrow sense, wage is fair if it is equal to the rate prevailing in the same trade & in the neighborhood for similar work. In a wider sense, it will be fair if it is equal to the predominant rate for similar work throughout the country & for the trades in general.
- **Living Wage:-** Living Wage is a step higher than fair wage. Living Wage may be described as one which should enable the wage earner to provide for himself/herself & his/her family not only the bare essentials of like food, clothing, & shelter, but a measure of frugal comforts including education for children, protection against ill health, requirements of essential social needs, & measure of insurance against the more important misfortunes including old age.

Principles of Wage Administration:

- Wage Policies should be carefully developed, having in mind the interests of (a) Management as the representative of the owners (b) the employees, (c) the consumers (d) the community;
- Wage Policies should be clearly expressed in writing to ensure Uniformity & Stability;
- Management should see to it that the employees know & understand the wage policies;
- Wage policies should be evaluated from time to time to make certain that they are adequate for current needs;
- Matching Employee Expectations;

- Reinforcing positive employee behavior & contribution to the organization;
- Eliminating any discrepancies in wage administration in the organization.

Basic Wage Plans:

- **Time Wage Plan:** Under this system, the worker is paid for the amount of time spent on the job. This is the oldest & most common system & the wages are based on a certain period of time during the course of work. The period of time may be an hour, a day, a week etc & the wage rate will depend upon time fixed for work is completed irrespective of output or completion of the work.
- **Piece Wage Plan:** Under this system, the output of work is the basis of wage payment. A worker is paid according to the amount of work completed or the number of units turned out irrespective of time taken. Though the time is not essence in this system, it is assumed that the worker will not take more than average time to complete the job. The earnings of a worker depend upon the speed of his work & his own skill & efficiency.
- **Skill base pay:** Under this system, employees are compensated for their job related skills. This is also called knowledge based pay. Under a typical skill based system, companies hire employees at below-market rates. Once they gain extensive knowledge & new skills, they are promoted & rewarded with an increased pay.
- **Competency based pay:** Competency can be defined as the knowledge, skills & behavior of an individual that contribute to a worker's performance. The competencies of the best performing employee are identified & the employee is compensated for these competencies that he/she brings to the job.

CASELET

PRODUCTIVITY GAINS AT WHIRLPOOL

Workers and management at Whirlpool Appliance's Benton Harbor plant in Michigan have set an example of how to achieve productivity gains, which has benefited not only the company and its stockholders, but also Whirlpool customers, and the workers themselves. Things weren't always rosy at the plant. Productivity and quality weren't good. Neither were labor-management relations. Workers hid defective parts so management wouldn't find them, and when machines broke down, workers would simply sit down until sooner or later someone came to fix it. All that changed in the late 1980s. Faced with the possibility that the plant would be shut down, management and labor worked together to find a way to keep the plant open. The way was to increase productivity-producing more without using more resources.

Interestingly, the improvement in productivity didn't come by spending money on fancy machines. Rather, it was accomplished by placing more emphasis on quality. That was a shift from the old way, which emphasized volume, often at the expense of quality. To motivate workers, the company agreed to gain sharing, a plan that rewarded workers by increasing their pay for productivity increases.

The company overhauled the manufacturing process, and taught its workers how to improve quality. As quality improved, productivity went up because more of the output was good, and costs went down because of fewer defective parts that had to be scrapped or reworked. Costs of inventory also decreased, because fewer spare parts were needed to replace defective output, both at the factory and for warranty repairs. And workers have been able to see the connection between their efforts to improve quality and productivity.

Not only was Whirlpool able to use the productivity gains to increase workers' pay, it was also able to hold that lid on price increases and to funnel some of the savings into research.

Questions

1. What were the two key things that Whirlpool management did to achieve productivity gains?
2. Who has benefited from the productivity gains?
3. How are productivity and quality related?
4. How can a company afford to pay its workers for productivity gains?
5. Explain compensation management. Describe how in an organization any compensation plan can keep motivated its employees?

Self Assessment Questions

3. What do you mean by work measurement?
2. Discuss the various techniques of work measurement.
3. Discuss the different types of allowances.
4. How any compensation plan helps to keep motivated to their employees?

UNIT - 14

MANAGEMENT INFORMATION FOR PRODUCTION SYSTEM

14.1 CROSS-FUNCTIONAL SYSTEM

A **cross-functional system** is a group of people with different functional expertise working toward a common goal. It may include people from finance, marketing, operations, and human resources departments. Typically, it includes employees from all levels of an organization. Members may also come from outside an organization (in particular, from suppliers, key customers, or consultants).

Cross-functional teams often function as self-directed teams responding to broad, but not specific directives. Decision making within a team may depend on consensus, but often is led by a manager/coach/team leader.

A cross-functional information system is the third era of information systems, after calculations systems and functional systems. Cross-functional systems were designed to integrate the activities of the entire business process, and are called so because they 'cross' departmental boundaries. Changing over to a cross-functional system from a functional one can be problematic at times, as it involves the coordination of activities across multiple departments, with the users changing the way that they work. There is no clear line of authority, and fierce peer competition can often lead to interdepartmental rivalries that hinder the development of the new system.

Example Of Cross Functional System

1. Enterprise Resource Planning (ERP) is an integrated computer-based system used to manage internal and external resources, including tangible assets, financial resources, materials, and human resources. Its purpose is to facilitate the flow of information between all business functions inside the boundaries of the organization and manage the connections to outside stakeholders. Built on a centralized database and normally utilizing a common computing platform, ERP systems consolidate all business operations into a uniform and enterprise-wide system environment. An ERP system can either reside on a centralized server or be distributed across modular hardware and software units that provide "services" and communicate on a local area network. The distributed design allows a business to assemble modules from different vendors without the need for the placement of multiple copies of complex and expensive computer systems in areas which will not use their full capacity.

Cross-Functional Teams

The simplest definition of cross-functional teams (or CFTs) is groups that are made up of people from different functional areas within a

company—marketing, engineering, sales, and human resources, for example. These teams take many forms, but they are most often set up as working groups that are designed to make decisions at a lower level than is customary in a given company. They can be either a company's primary form of organizational structure, or they can exist in addition to the company's main hierarchical structure.

Cross-functional teams have become more popular in recent years for three primary reasons: they improve coordination and integration, span organizational boundaries, and reduce the production cycle time in new product development. Bringing people together from different disciplines can improve problem solving and lead to more thorough decision making. The teams foster a spirit of cooperation that can make it easier to achieve customer satisfaction and corporate goals at the same time.

Cross-functional teams are not new. Northwestern Mutual Life insurance company pioneered their use in the 1950s when the CEO of the company brought together people from the financial, investment, actuarial, and other departments to study the impact that computers would have on the business world. As a result of that first CFT, Northwestern was among the first companies in the country to create an information systems department that gave the company a large competitive advantage as computers gained in popularity. The company now relies on cross-functional teams in almost every facet of its organization. Based on success stories like this one, CFTs slowly grew in popularity throughout the 1960s and 1970s before exploding in popularity in the 1980s when faster production time and increased organizational performance became critical in almost every industry.

Cross-functional teams are similar to conventional work teams, but they differ in several important ways. First, they are usually composed of members who have competing loyalties and obligations to their primary subunit within the company (for example, a marketing person serving on a cross-functional team has strong ties to his or her home department that may conflict with the role he or she is being asked to play on the CFT). Second, in companies where CFTs are being used on a part-time basis as opposed to a permanent organizational structure, they are often temporary groups organized for one important purpose, which means group members are often under considerable pressure. On these temporary teams, the early development of stable and effective group interaction is imperative. Finally, CFTs are often held to higher performance standards than conventional teams. Not only are they expected to perform a task or produce a product, they are also expected to reduce cycle time, create knowledge about the CFT process, and disseminate that knowledge throughout the organization.

For cross-functional teams to succeed, several factors have been identified that are imperative:

- Team members must be open-minded and highly motivated.
- Team members must come from the correct functional areas.

- A strong team leader with excellent communication skills and a position of authority is needed.
- The team must have both the authority and the accountability to accomplish the mission it has been given.
- Management must provide adequate resources and support for the team, both moral and financial.
- Adequate communications must exist.

Without any one of these elements, any cross-functional team will be fighting an uphill battle to succeed.

Cross-Functional Teams and New Product Development

Many businesses have been able to use cross-functional teams to reduce the cycle time in new product development. As a result, CFTs have become a common tool in new product development at many companies, especially those in industries in which rapid change and innovation is the norm. CFTs have shown the flexibility to adapt to changing market needs and the ability to more quickly develop innovative products.

In the past, new product development invariably meant gathering data sequentially from a number of departments before a new product was given the green light. First, the idea would be conceptualized. Then, it would be handed off to the marketing department, which would conduct market research to see if the product was viable. The product might then be passed on to the sales department, which would be asked to create a sales estimate. From there, the idea would move on to engineering or manufacturing, which would determine the costs to produce the product. Finally, with all those numbers gathered over the course of months, or even years, the product would move to an executive committee which would either approve or kill the project. By that time, market conditions sometimes had shifted sufficiently to render the product obsolete.

Cross-functional teams eliminate the "throw it over the wall" mentality that passes a product off from department to department. Instead, a member of each of the above functional areas would have a representative on the new product team. Team members would learn of the new product at the same time and would begin working on estimates together. If part of the product simply could not be manufactured cheaply enough, the team member from that area could immediately sit down with the engineering rep and come up with a new production method. The two of them could then meet with the marketing and sales team members and discuss new ways to position the product on the market. The result, say

proponents, is a vastly improved product that is manufactured and released to the market in far less time than was achieved using traditional methods.

Establishing a Cross-Functional Team

Set Goals

When CFTs are first convened, conflict may be the result. There is a good chance that some of the members of the new team have bumped heads in the past when their functional areas clashed over a project. Additionally, some CFT members may think that their area of specialty is the most important on the team and thus assume an inflated sense of value to the team. Finally, since CFTs often bring together people who have vastly different ranks in the organizational hierarchy, there can be power plays by members who are high-ranking employees off the team but are actually less important stakeholders on the team. Those high-ranking team members may try to assert authority over the team in a situation when they should be deferring to lower-ranking team members.

The High Production Volume Information System (HPVIS) is a database that provides access to health and environmental effects information obtained through the High Production Volume (HPV) Challenge. This program "challenges" companies to make this data publicly available on chemicals produced or imported into the United States in quantities of 1 million pounds or more per year.

On this Web site, HPVIS enables users to search for summary information, test plans, and new data on HPV chemicals as they are received by the Agency. Currently, the HPVIS database contains over 340 submissions, representing almost 900 chemical substances, either as a single chemical submission or as a member of a chemical category.

EPA is carefully reviewing HPV chemical data to characterize the hazards and risks associated with HPV chemicals. HPVIS contains HPV Chemical Hazard Characterizations prepared during EPA's ongoing review of the health and environmental effects data contained with each HPV Challenge Program submission. HPVIS also contains Risk-Based Prioritization documents prepared from EPA's examination of HPV Challenge hazard data along with chemical use and exposure information collected from the 2006 Inventory Update Reporting (IUR). These recommendation documents prioritize HPV chemicals for follow-up data collection or management actions based on their potential risks.

Database

A **database** is an organized collection of data. The data is typically organized to model relevant aspects of reality (for example, the availability of rooms in hotels), in a way that supports processes requiring this information (for example, finding a hotel with vacancies).

Database management systems (DBMSs) are specially designed applications that interact with the user, other applications, and the database itself to capture and analyze data. A general-purpose **database management system (DBMS)** is a software system designed to allow the

definition, creation, querying, update, and administration of databases. Well-known DBMSs include MySQL, PostgreSQL, SQLite, Microsoft SQL Server, Microsoft Access, Oracle, SAP, dBASE, FoxPro, IBM DB2 and FilemakerPro. A database is not generally portable across different DBMS, but different DBMSs can inter-operate by using standards such as SQL and ODBC or JDBC to allow a single application to work with more than one database.

Data Collection and HPVIS Content

In the HPV Challenge Program, companies have sponsored more than 2,200 HPV chemicals, with approximately 1,400 chemicals sponsored directly through the HPV Challenge Program and over 860 chemicals sponsored indirectly through international efforts. Only directly sponsored HPV Challenge Program chemicals make it to HPVIS.

Under the program, when companies, such as chemical manufacturers and trade associations, voluntarily sponsor a set of HPV chemicals, they provide existing data or perform tests on the chemicals, and submit their test data to this database. To ensure consistency, sponsors follow the Screening Information Data Set (SIDS), developed by the Organization for Economic Cooperation and Development (OECD). SIDS provides internationally agreed upon tests for screening chemicals for human and environmental hazards.

HPVIS consists of basic hazard (toxicity) and environmental fate information on HPV chemicals that can be used by environmental managers, public decision-makers, and others in their own health and environmental protection activities.

Manufacturing Information System

The information needs were and are always there. Information systems used to exist when computerized environments were not available. Automation has enhanced the availability of information. Every industry has its own departmental structure which gives rise to a different set of sub-systems as part of the information system. Here we would consider the sub-systems of a manufacturing system only.

Following are the sub-systems of an information system

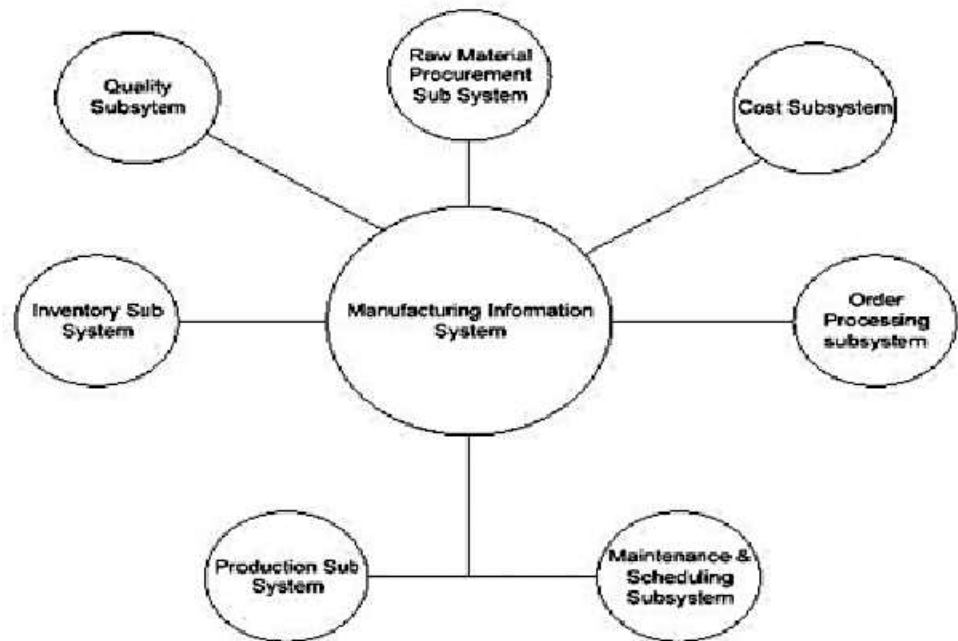
Raw Material Procurement Sub-System

This is the commencement of the manufacturing process. Some might think of procurement as a simple purchasing process like any other commodity but the spirit of having an all-embracing raw material procurement sub-system is simply more than that

Parameters of Raw-material Procurement

Like with every system, there has to be a list of minimum specifications which every system or subsystem has to cover. Purchasing logistics of an entity critically affect time to market and other quality related issues. Issues like selection of suppliers, choice between local purchase or import and delivery time taken by the supplier. All these

concerns are met and dealt with in the purchase subsystem. The complexity of the purchase subsystem should depend on types of raw materials required, number of suppliers to deal with and complexity of the terms of purchase agreements for long term. With higher customer expectations, every organization wants to efficiently manage its suppliers and other internal processes. Supply chain management spans all movement and storage of raw materials, work-in- process inventory, and finished goods from point-of-origin to point-of-consumption. A procurement system should help in improving the supply chain of the organization.



Inventory Sub System

Inventory subsystem focuses on maintaining records and movements on inventory levels and usage. This control of inventory is critical to the organization since money lock-in of raw materials purchase represent substantial investment. Timely production of finished goods require availability of right quantity of material, maintenance of right stock levels, determination of lead times and flex times and exchange of information with supplier at the right time. An inventory subsystem helps us to address these issues. Inventory subsystems are critical where the organization is following Just in Time approach a philosophy which encourages zero tolerance for stock levels and placing orders exactly when they are needed for manufacturing.

Proper logistic management is important for the timely and quality production.

Various factors which can play critical role are

- Who to purchase from supplier selection

- When to purchase time of delivery or raw materials
- How much to purchase Ideal stock levels
- An efficient inventory subsystem helps us to deal with these issues in a time saving manner.

Production Sub System

It can be seen as the most critical part of the entire manufacturing sub system. Basically it tracks the flow of the job through the entire production process. It also records change in form of goods or transfer of goods from one place to the other

Maintenance & Scheduling Sub System

For efficient production, the machines should be timely available. Many a times, the machine is under repair and is not available to be used for production. Without this subsystem, there is a possibility of customer's orders not being met on time. Certain issues that can be very important are

- Deciding delivery time in accordance with availability of machines.
- Any foreseen machine-down-time.
- Any major overhauling / tuning / replacement expected may result in unavailability of machine. An overhauling schedule should be kept so that the production of finished goods is not halted.
- Avoiding duplication of jobs for the same machine.

Quality Sub system

This subsystem ensures the production made and end product being delivered to the customer are conforming the quality standards set by the company. Quality covers aspects for the organization like better quality raw materials and what is being purchased is according to organization's standards and improved finished goods in accordance with the customer specification.

The question now arises is why do we need a quality sub-system? It is defined and demanded by customer, it has to be achieved by management, it is a firm wide responsibility and these subsystem provide the firm's managers with information that reveals the extent to which the firms products are achieving the quality goals.

Total Quality Management (TQM)

TQM is a set of management and control activities which focus on quality assurance. The quality of the products and services is enhanced and then offered to consumers. An organizational undertaking to improve the quality of manufacturing and service, it focuses on obtaining continuous feedback for making improvements and refining existing processes over the long term. There are certain Graphical tools used to implement and promote TQM. For instance

- ◆ Histogram

- ❖ Pareto Analysis
- ❖ Cause & Effect Diagram

Costing Sub System

Costs are incurred more frequently in a manufacturing entity. Monitoring these costs on regular basis requires instituting a formal cost subsystem. Cost sub systems are responsible for generation of cost reports which represent cost break ups on various bases, for instance

- ❖ Machine usage basis
- ❖ Product basis
- ❖ Department wise

Order Processing Sub System

This subsystem deals with following issues.

- Status of orders placed with suppliers
- Status of departmental requisitions
- Quality of materials received
- Any other issues related to suppliers

Order processing subsystem gives a snapshot of statuses of various orders placed, at any given time.

Management Levels in Manufacturing Information Systems

Manufacturing Information System should cater for information requirements at each level, for instance

Strategic level

3. Locating new plant which can save cost
4. Investment in new manufacturing technology

Knowledge Level

3. Distribute knowledge to drive the production process
4. Innovating new forms of manufacturing processes

Management level

2. Monitoring production costs and resources

Operational Level

2. Status of production tasks

Planning Productions/Operations

This function in many firms is supported by IT. The major areas of planning and their computerized support are as follows.

- ❖ Materials Requirement Planning (MRP)
- ❖ Manufacturing Resource Planning (MRP II)
- ❖ Automated Software
- Computer Aided Design (CAD)

Computer Aided Manufacturing (CAM)

Computer Integrated Manufacturing (CIM)

Materials Requirement Planning (MRP)

Material procurement needs to be planned in compliance with the production Schedule. Initially companies used to do plan it manually through a document termed as "Material Requirement Plan". Material

Requirements Planning (MRP) is software based production planning and inventory control system for material procurement and scheduling.

It helps meeting three objectives:

- ❖ Ensure materials and products are available for production and delivery to customers.
- ❖ Maintain the lowest possible level of inventory.
- ❖ Plan manufacturing activities, delivery schedules and purchasing activities.

MRP helps in getting the right material and physical resources together at the right place and at the right time to meet the customer's requirements. This helps in achieving on time delivery, High Quality, at the best price.

Manufacturing Resource Planning (MRP II)

An expanded version of MRP that integrates finance, accounting, accounts payable and other business processes into the MRP system. It also includes production scheduling function, and inventory control functions. It is an integrated computer system that connects the regular MRP to other functional area, especially finance and human resources. It is made up of a variety of functions, each linked together:

- ❖ Business planning
- ❖ Sales and operations planning
- ❖ Production planning
- ❖ Master scheduling
- ❖ Material requirements planning
- ❖ Capacity requirements planning

Automated Tools

IT has been used successfully in cutting the time required for the design of products, services or processes. Some of these applications are

- Computer Aided Design (CAD)
- Computer Aided Manufacturing (CAM)
- Computer Integrated Manufacturing (CIM)

Computer Aided Design (CAD)

"It is a system that enables drawings to be constructed on a computer screen and subsequently stored, manipulated and updated electronically."

The ability to rotate or create movement in the design allows testing for clearances and frequently reduces the cost of prototyping the products. The technology is used for a wide variety of products in such fields as architecture, electronics, and aerospace, naval, and automotive engineering. Although CAD systems originally merely automated drafting, they now usually include three-dimensional modeling and computer-simulated operation of the model. Rather than having to build prototypes and change components to determine the effects of tolerance ranges, engineers can use computers to simulate operation to determine loads and stresses. For example, an automobile manufacturer might use CAD to calculate the wind drag on several new car-body designs without having to build physical models of each one. In microelectronics, as devices have become smaller and more complex, CAD has become an especially important technology. Among the benefits of such systems are lower product-development costs and a greatly shortened design cycle. While less expensive CAD systems running on personal computers have become available for do-it-yourself home remodeling and simple drafting, state-of-the-art CAD systems running on workstations and mainframe computers are increasingly integrated with computer-aided manufacturing system.

Computer Aided Manufacturing (CAM)

Computer-aided manufacturing (CAM) is a form of automation where computers communicate work instructions directly to the manufacturing machinery. The technology evolved from the numerically controlled machines of the 1950s, which were directed by a set of coded instructions contained in a punched paper tape. Today a single computer can control banks of robotic milling machines, lathes, welding machines, and other tools, moving the product from machine to machine as each step in the manufacturing process is completed. Such systems allow easy, fast reprogramming from the computer, permitting quick implementation of design changes. The most advanced systems, which are often integrated with computer-aided design systems, can also manage such tasks as parts ordering, scheduling, and tool replacement.

It is a system that uses computer-aided techniques to control production facility. Some of these techniques are

- ◆ Computer-aided process planning Use of computer to control activities and functions to prepare a detailed set of plans and instructions to produce a machine or part. -- Machines
- ◆ Computerized Numerical control (CNC) refers specifically to the computer control of machine tools for the purpose of (repeatedly)

manufacturing complex parts in metal as well as other materials. e.g. drills, wood routers use this technology.

- ❖ **Robotics programming** The science or study of the technology associated with the design, fabrication, theory, and application of robots. Automobile industry.

Self Assessment Questions

1. What is the importance of management information for production system?
2. How TQM help in production system?

UNIT - 15

JUST IN TIME

15.1

Just-In-Time (JIT) manufacturing is a process by which companies don't keep lots of excess inventory; instead, they manufacture a product as an order comes in. It is a management philosophy of continuous and forced problem solving.

The objective of JIT manufacturing system is to:

- Eliminate waste that is, minimize the amount of equipment, materials, parts, space, and worker's time, which adds a great value to the product
- Increase productivity

JIT means making what the market demands when it is in need. It is the most popular systems that incorporate the generic elements of lean systems. Lean production supplies customers with exactly what the customer wants, when the customer wants, without waste, through continuous improvement.

Deploying JIT results in decrease of inventories and increases the overall efficiencies. Decreasing inventory allows reducing wastes which in turn results in saving lots of money. There are many advantages of JIT:

- Increases the work productivity
- Reduces operating costs
- Improves performance and throughput
- Improves quality
- Improves deliveries
- Increases flexibility and innovativeness

For industrial organizations to remain competitive, cost efficiencies have become compulsory. JIT helps in this process. It is extended to the shop floor and also the inventory systems of the vendors. JIT has been extended to mean continuous improvement. These principles are being applied to the fields of Engineering, Purchasing, Accounting, and Data processing.

However, for organizations to completely implement JIT manufacturing system, they need to have a proper commitment along with the following basic facilities - proper material, quality, equipment, and people involvement.

Characteristics of JIT

In this section, we will study different methods by which inefficiency is reduced and unproductive time is minimized. The consequent savings are to be utilized for reducing cost and rendering better service to the customer. Shigeo Shingo an authority on JIT at Toyota classifies the wastes to be eliminated as follows. (See Figure : *Seven wastes*)

The seven wastes to be eliminated according to JIT are:

1. Over production
2. Inventory
3. Waiting time
4. Movement
5. Effort
6. Defective products
7. Over processing

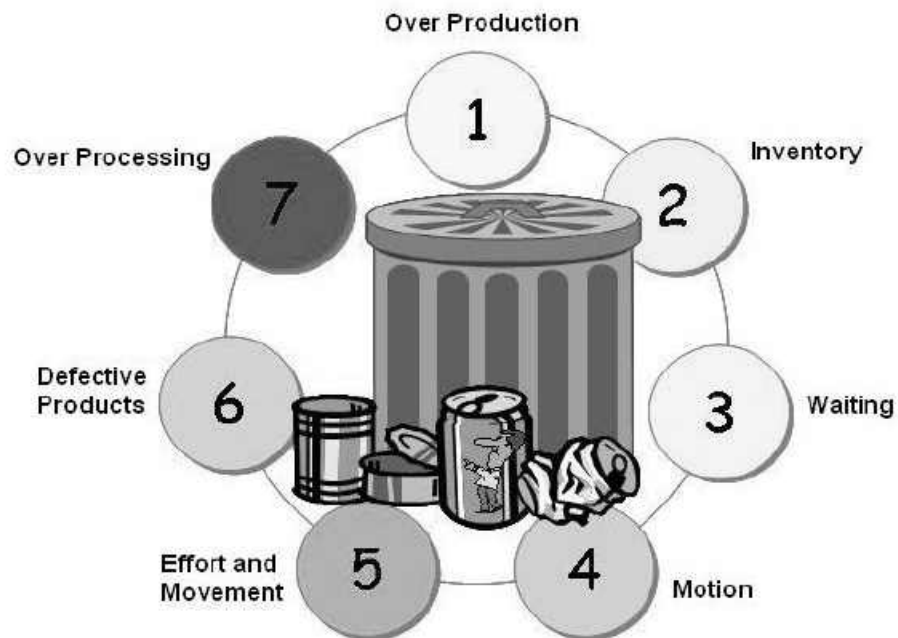


Figure: Seven wastes

1. **Over production:** Over production is to manufacture products before it is actually needed. If the demand for that product decreases, the extra parts or products produced may not be useful or needed. Also over production results in high storage costs and is also difficult to detect defects. So, over production is considered a waste.

2. **Inventory:** Excess procurement or production builds up stock of materials which are not immediately used, thus locking space and funds carrying heavy costs. The figure 13.2, illustrates the inventories at different levels of an organization – Supplier distribution, Production, and Customer distribution.

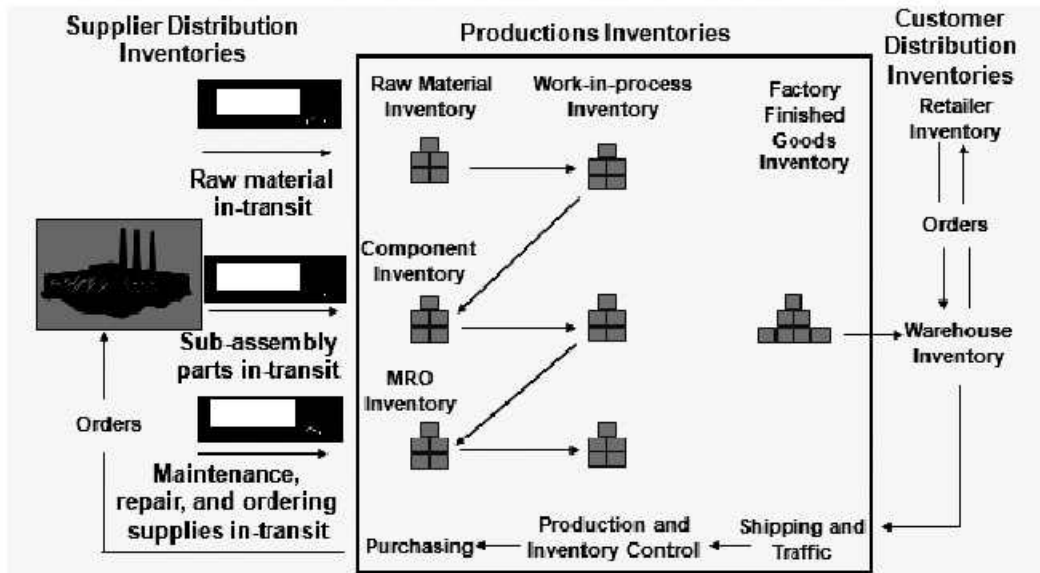


Figure: Inventories in an organization

3. **Waiting time:** Waste of time happens when goods are not moving or being processed. The operator, the machine or the part will either be not working or be worked upon. The duration of waiting is can be said to be unproductive and may create more serious consequences.
4. **Movement:** Any unnecessary movement is a waste of energy; it causes blockages, disrupting movements and delaying the flow of other items creating delays.
5. **Effort:** The people, who work, do not make a study as to how the products on which they are making are utilized and do not realize the purpose for which they are made. This lack of education will lead to waste of resources. Finally, they end up in shortage of resources when needed.
6. **Defective products:** The defective products lead to a tremendous loss to the company. This is because they use up the same equipments, workmen and the time that would be used to make good products. Thus defective products use up resources and result in losses.
7. **Over Processing:** Some steps like unnecessary processing or production do not add value to the final output. As a result, it is waste of all the inputs that go into the process.

Since these wastes have to be eliminated, a thorough study of how they occur and what steps would result in their elimination is of paramount importance.

Philosophy of JIT

The philosophy of JIT is simple: the storage of unused inventory is a waste of resources. JIT inventory systems expose hidden cost of keeping inventory, and are therefore not a simple solution for a company to adopt. The company must follow an array of new methods to manage the consequences of the change. The ideas in this way of working come from many different disciplines including statistics, industrial engineering, production management, and behavioral science. The JIT inventory philosophy defines how inventory is viewed and how it relates to management.

Inventory is seen as incurring costs, or waste, instead of adding and storing value, contrary to traditional accounting. This does not mean to say JIT is implemented without awareness that removing inventory exposes pre-existing manufacturing issues. This way of working encourages businesses to eliminate inventory that does not compensate for manufacturing process issues, and to constantly improve those processes to require less inventory. Secondly, allowing any stock habituates management to stock keeping. Management may be tempted to keep stock to hide production problems. These problems include backups at work centers, machine reliability, and process variability, lack of flexibility of employees and equipment, and inadequate capacity.

In short, the Just-in-Time inventory system focus is having "the right material, at the right time, at the right place, and in the exact amount", without the safety net of inventory. The JIT system has broad implications for implementers.

Implementation of JIT

JIT, Total Quality Management (TQM) and other developmental measures, are possible only with top management commitment and a learning culture in the organization. The main handicap to any programme is the resistance by the organizational members, even at the top, to make changes. This resistance may take the form of non-cooperation and may enlarge to become sabotage. These usually show up at the implementation stage. So, communication of the goals is to be realized and the objectives of each team are to be framed effectively. Initially, a milestone chart helps in establishing various steps to be taken and correcting the activities as the process is on. This is the best way of ensuring success. It is well to remind you at this stage that JIT is not a destination, but an ongoing continuous improvement programme in the process of achieving TQM.

- **Pre-requisites of JIT**

Like any advanced method of production and quality improvement, some pre-requisites are needed to be in place so that, implementation is easy and the results are identifiable. The following table gives the requirements from the design process to the measurement of performance.

Table: Prerequisites for measurement of performance	Design Flow Process	1. Link operations 2. Balance workstation capacities 3. Relay-out for flow 4. Emphasis preventive maintenance 5. Reduce lot sizes 6. Reduce set-up and changeover times
b	Total Quality Control	1. Worker responsibility for quality 2. Measure – SQC 3. Enforce compliance 4. Fail-safe methods 5. Automatic inspection
c	Stabilize Schedule	1. Level schedule 2. Under utilize capacity
d	Kanban Pull	1. Demand pull 2. Back flush 3. Reduce lot sizes
e	Work with Vendor	1. Reduce lead times 2. Frequent deliveries 3. Project usage requirements 4. Quality expectation
f	Reduce Inventories	1. Look for other areas 2. Stores 3. Transit 4. Carousels 5. Conveyors
g	Improve Product Design	1. Standard product configuration 2. Standardize and reduce number of parts 3. Process design with product design 4. Quality expectations

The above activities lead to:

a. Solving problems concurrently

1. Root cause

2. Solve permanently
3. Team approach
4. Line and specialist responsibility
5. Continual education
- b. Measuring performance*
 1. Emphasize improvement
 2. Track trends

You will observe that when above requirements are met, we achieve JIT to a very close extent.

- **Shop floor control**

Realistic planning and scheduling takes the frequency with which setups have to be changed to manage material flow without building up inventories into consideration, and leads to JIT manufacturing.

SMED (Single Minute Exchange of Dies) gives flexibility for production process. Advocated by Shigeo Shingo, SMED method calls for designing, making fixtures, and tooling which are instrumental in changing setups so that, changes are to be effected within a minute. The de-clamping and clamping elements should be made for this purpose.

Application of Kanban, wherever suitable is another mechanism for controlling flow of material. Maintenance of machines and periodic shop floor inspection is necessary. Verifying whether the processes are delivering components within the tolerances specified is needed.

- **JIT Purchasing**

The essence of JIT purchasing, lies in treating the purchaser as a participant in your activities. Cooperative relationship leads to the development of the supplier who understands company's requirements and in situations where he confronts any difficulty, he should be in a position to approach the company for its solution. Being open and trusting helps the organizations to identify the problems and go to the source which is like implementing TQM.

Every problem or discovery of a defect is considered an opportunity, which the supplier and the company together get a deeper understanding of the problem, and the solutions will not only solve that problem, but also ones that were hidden. It is also the practice of many companies who procure a large number of parts manufactured from their vendors to have supplies made to the assembly in specific quantities to meet the needs just in time.

Self certification by the vendor is resorted to ensure quality of the material. The actual users are given autonomy to demand from the supplier, the quantities required as well as the time of its need. Any change in demand is conveyed and complied. This requires cooperation and trust between the supplier and the customer. This is how JIT

purchases work. The JIT purchasing concept attempts to reduce replenishment lead time by utilizing suppliers located close to the using plant and by ordering small quantities, which in turn reduces a supplier's workload per period. The most important aspects of the JIT purchasing concept focus on new ways of dealing with suppliers and a clear-cut recognition of the appropriate purchasing role in the development of corporate strategy. Suppliers should be viewed as outside partners who can contribute to the long-run welfare of the buying firm rather than as outside adversaries. The major actions focus on attempts to reduce the ordering cost and replenishment lead time values. Hahn et al noted that more systematic empirical research is needed to assess the costs and benefits of JIT purchasing systems. Such research should provide new dimensions and opportunities for refining existing purchasing and materials management theory.

- **Vendor managed inventory**

The very purpose of JIT is to reduce inventory at all places in the supply chain. Inventory is considered a waste because inventory is created by using materials, machines and efforts of persons. All of these are resources which have already been used up and that portion of it which is not consumed and sent up the value chain causes a drag on the system. However, inventories are inevitable because uncertainties exist at every stage, making it necessary to provide a buffer so that demands do not go unfilled. The challenge is to keep it to the minimum. To make this happen, the calculations involving the following are necessary.

- ☐ Forecasts of the market demand
- ☐ Capacities of the equipments
- ☐ Worker absenteeism
- ☐ Suppliers' lead times
- ☐ Quality of the produced components

Each of these will have many factors which affect them. JIT depends upon accurate assessment of them and based on the decisions taken, activities are initiated. These should result in holding materials as small as the number of components or products as feasible to maintain flow of material without disruption. Many companies make their suppliers hold their inventories and request them to make timely supplies. This may be done at a cost.

CASELET

Anode Electronics produces different kinds of electronic products like TVs and tape recorders. Since the world market of electronics was moving towards high variety of products and the delivery of the orders was getting shorter, the top managers of Anode Electronics were under a great pressure to increase the competitive position of the company in the market. One of the executive managers of Anode Electronics suggested implementing a system called JIT with the hope that inventory levels would be reduced and quality production would increase.

The main aspect in introducing JIT manufacturing system in a company is to educate the staff about JIT. Four middle level managers were asked to attend a seminar conducted by a company called Electrode Combinations who have already implemented this system, so that they could explain the whole company about JIT manufacturing system. A group of managers, one from each department were a part of the team who discussed what is to be done and how to implement JIT in their company. According to their discussions, the following 5 activities were called the 5 JIT principles.

- ☐ Classify materials on the shop floor based on its usefulness
- ☐ Place the value-added materials in handy positions
- ☐ Clean up the non-value-added materials
- ☐ Maintain the factory in a good looking shape
- ☐ Let the employees in the company have good habits and follow the rules

With these activities, the working environment in Anode Electronics was improved and the safety, quality, and productivity were increased. As the JIT system was newly implemented in Anode Electronics, the company started continuously improving the quality of the products. The managers of each department formed an improvement committee to look after the implementation of JIT in different areas of the company, especially the shop floor. All necessary materials were posted with a 'red card' and deposited for further rework. Thus all materials have been identified in terms of their names, places, quantities, and so on. The concept of visual management, which is management simply by eye sight, has been strongly motivated and encouraged.

Tremendous resistance from suppliers and workers was faced during the early stage of developing the JIT system. High level commitments of top manager, determination of pushing JIT system and suppliers' involvement have helped to achieve JIT material flow. With

this, the Anode Electronics Company has laid down a solid foundation for the JIT system so that the production system can be operated smoothly to improve safety, quality, and productivity over the years. The quality and productivity problems 'under the water' have shown up and have been solved.

A major success in the implementation of JIT system showed the reduction in the amount of inventory and workers. Inventory level has reduced by 63%, parts inventory has reduced by 50%, and the number of workers has reduced from 1020 to 865 during the past four years. The growth rate of the company has increased by 5% every year.

Key Processes to Eliminate Waste

The key processes to eliminate the wastes are listed below:

1. Kanban for material flow
2. High quality productions
3. Small and uniform workloads
4. Suppliers as partners
5. Flexible workforce and training
6. Total productive maintenance

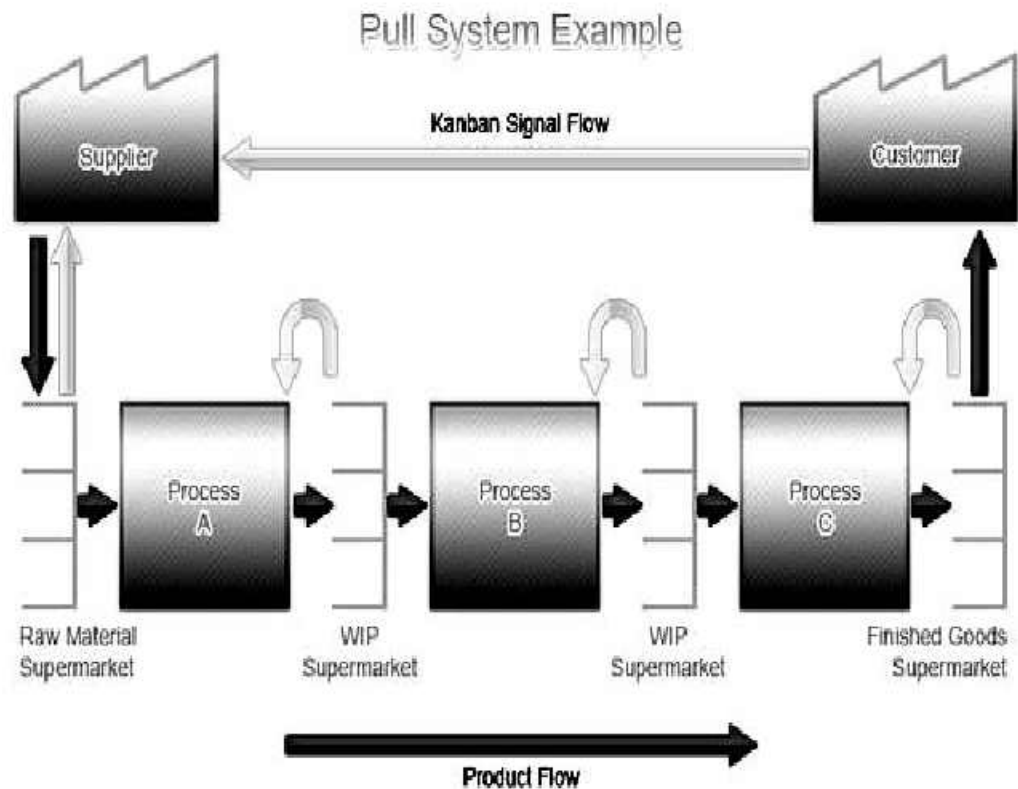
Let us discuss in brief about each processes in this section.

Kanban for material flow

Controlling material flow using cards through the manufacturing system implementing JIT is called Kanban. These cards are used to tell a work station to perform a certain function on materials.

Kanban means a 'Visible Card' and also 'Signal' in Japanese language. These cards are used for communicating the quantities required at the 'customers' point for his use. This means that the operator next in line, who is the customer, decides how many units he needs and asks for them. The operator who receives the card should make only that many and supply. Similarly, the operator makes a demand on his predecessor by a 'kanban' and receives only the required quantity. This is called the pull system.

See figure for the operation of the Pull/Kanban system. It controls the flow of resources in a production process when and where a customer order is placed. This system helps to eliminate waste in handling, storing, and delivering the product to the customer.



Example of a Kanban signal flow

The containers used in the material flow are designed to hold specific components in certain numbers. Kanban system is a physical control system which uses cards and containers, that is, materials must not be removed without posting a card at the receiving post.

Advantages of Kanban processes are listed below.

- ☐ The orders are controlled and triggered from defined locations
- ☐ Inventory costs and Work in Progress (WIP) are reduced
- ☐ The control of stock in the inventory will be improved
- ☐ The lead time to deliver is reduced
- ☐ The process demand can be visualized
- ☐ The process of deviation escalation and rectification of root cause of the deviations in production can be improved

High quality production

JIT production is meant for products which are repetitive in nature. The system has its origin in providing a solution to a manufacturing process, where the finished product has a number of parts that get assembled. The problems in such situations will be to keep the arrival of parts, components, and sub-assemblies so that no shortages will occur while holding up production. Therefore, it becomes vital that all parts that form

the flow in many streams are of high quality, so that the assembly does not get held up.

For JIT to be successful inventories have to be kept to the minimum and every component produced must represent highest quality. It is relevant to mention Taguchi's insistence on achieving the target value to realize quality. The permitted tolerances do not ensure high quality. Controlling variability by strict adherence to best processes with built-in robustness to achieve Six Sigma standards ensures high quality. These help in realizing JIT, which has economy in focus and provide an additional factor for competitiveness. So, high quality production helps in reducing the waste of inventory space to the maximum extent.

Small and uniform workloads

Manufacturing facilities have to produce a number of parts to meet the requirements of a number of products. Offering variety in terms of products is a strategy that most businesses practice.

Manufacturing all the products in large volumes and maintaining stocks at various distribution centers is highly uneconomical and no organization would contemplate such a plan. The input resources like the raw materials, bought-out-items, transportation, storage and funds, lay a heavy burden on the system. Added to that, the costs and the operations involved in the transformation process become unthinkable.

The solution is to be able to produce a variety of products in small numbers and plan the production schedules in such a way that the production facilities become more adept in meeting the market demands. The aim is to reduce inventories, but at the same time not to lose business. So, a small load on various work centre's, both at in-house facilities as well as those of sub-contractors, is the answer.

Achieving uniformity of loading is important to avoid piling up of work in process. Soft wares are specially developed to tackle these problems which help in achieving the desired result. However, any decision will have a trade off. The frequent changes in set ups, increased transportation, production hold ups owing to mismatch of the production of different parts. The costs involved on both counts have to be weighed and then decisions are to be taken.

Suppliers as partners

Suppliers are those companies which undertake supplying the manufactured products of an organization. Suppliers can be the dealers for organizations or conduct some transformation activity on the materials delivered by organizations to them. In all cases, since organizations do business with them, they will have a profit for the service rendered by them.

If the technology they have is superior, if the equipments they use are optimal and the workforce is efficient, the benefits would increase for them at a cost to the organization.

If there are a number of suppliers, the organizations would exploit the situation and decrease the cost by choosing the one who charges the least. With this exploitative environment, there are some disadvantages to the organization, such as:

- ☐ Commitment to meet the organization needs is less
- ☐ Giving the benefit of their learning to the organization has fewer chances
- ☐ Transferring organization knowledge to the suppliers for improved service would be absent
- ☐ Likelihood of quality suffers

As explained earlier, to be able to implement JIT, we need to change schedules quite often either delaying or hastening the production of some items almost on a daily basis, if not hourly. The main concern in such situations will be a build up of inventory or stock out positions. Problems of communication add to the difficulties. The following ways will ensure cooperation of the suppliers and timely delivery of supplies with good quality.

- ☐ Treating suppliers as a part of the organization's business and sharing information
- ☐ Providing technical and financial assistance
- ☐ Seeking supplier's help in improving process
- ☐ Building up rapport between the employees of the supplier organization
- ☐ Assuring business

Many times, the supplier, owing to his specialized operations, may contribute to the organization's productivity. Quality enhancement programs can be implemented simultaneously for faster and better results.

Flexible workforce and training

Flexible workforce consists of workmen who are capable of performing many tasks. It may be at their specified workstations, or at other workstations, where the skills required may be quite different from those which they use regularly.

The operational managers can look for personnel's who have an attitude for learning other skills. They should give the personnel training so that when shortages occur, they can be utilized to get over stoppages of work and disruption in workflow. This flexibility ensures reliable customer service and overcomes bottlenecks.

Part time and temporary employees also enable the company to overcome surges in demand. In such cases specially trained regular workers can be asked to take over tasks which require high skills and the non-regular employees can be given jobs which are simple and can be handled by them without causing any disturbance in the production.

Total productive maintenance

Maintenance of equipment is a fundamental requirement to increase the productivity in required quantities with high quality. The presumption that machines deliver these is the basis to JIT philosophy.

Generally, periodic and preventive maintenance is conducted by the operator, sometimes with the help of the supervisor. These activities help them to understand the machine better and give an opportunity to sense when the equipment may need a major repair or reconditioning. This is to be done to bring back the machine to give the required quantities and not have any impermissible variations.

Break downs generally occur as the symptoms are neglected. In total productivity maintenance, the worker is trained to:

- ☐ Maintain the machine
- ☐ Keep record of the parts to be replaced on periodic basis
- ☐ Make arrangements to procure them or make them

This helps the worker to maintain his machine in a perfect order without breakdown. It will be his responsibility to maintain the machine and his assistance to others should be available. With these responsibilities, the worker will also have the autonomy to undertake measures to ensure productivity and quality.

Benefits of JIT

Main benefits of JIT include:

- *Reduced setup time.* Cutting setup time allows the company to reduce or eliminate inventory for "changeover" time. The tool used here is SMED (single-minute exchange of dies).
- *The flow of goods from warehouse to shelves improves.* Small or individual piece lot sizes reduce lot delay inventories, which simplifies inventory flow and its management.
- *Employees with multiple skills are used more efficiently.* Having employees trained to work on different parts of the process allows companies to move workers where they are needed.
- *Production scheduling and work hour consistency synchronized with demand.* If there is no demand for a product at the time, it is not made. This saves the company money, either by not having to pay workers overtime or by having them focus on other work or participate in training.
- *Increased emphasis on supplier relationships.* A company without inventory does not want a supply system problem that creates a part shortage. This makes supplier relationships extremely important.
- *Supplies come in at regular intervals throughout the production day.* Supply is synchronized with production demand and the

optimal amount of inventory is on hand at any time. When parts move directly from the truck to the point of assembly, the need for storage facilities is reduced.

- *Minimizes storage space needed.*
- *Smaller chance of inventory breaking/expiring.*

Case Study

Flexibility helps JIT at L'Oréal

L'Oréal cosmetics are now the world's largest toiletries and cosmetics group, with a presence in over 140 different countries. In the UK, the 45 000 square meter purpose-built facility in mid-Wales produces 1300 product types in a spotlessly clean environment, which is akin to a pharmaceutical plant in terms of hygiene, safety and quality. The plant has 55 production lines and 45 different production processes, and the manufacturing systems employed are of a flexibility that allows them to run each of the 1300 product types every two months – that means over 150 different products each week. But the plant was not always as flexible as this. It has been forced to enhance its flexibility by the requirement to ship over 80 million items each year. The sheer logistics involved in purchasing, producing, storing and distributing the volume and variety of goods has led to its current focus on introducing JIT principles into the manufacturing process.

To help achieve its drive for flexibility and for JIT production, L'Oreal organized the site into three production centers', each autonomous and focused within technical families of products. Their processes and production lines are then further focused within product sub-divisions. Responsible for all the activities within his area, from pre-weighing to dispatch, is the Production Centre Manager, whose role also encompasses staff development, training and motivation. Within the focused production centers, improvement groups have been working on improving shop-floor flexibility, quality and efficiency. One of the projects reduced the setup times on the line which produces hair colorants from 2.5 hours to only eight minutes. These new changeover times mean that the company can now justify even smaller batches, and may give the company the flexibility to meet market needs just-in-time. Prior to the change in setup time, batch size was 30 000 units; now batches as small as 2000– 3000 units can be produced cost-effectively.

Questions

- 1 What did L'Oréal do to help it organize the process of setup reduction?
- 2 What do you think L'Oréal gained from doing each of these things?
- 3 If we could halve all changeover times in the factory, what effect would this have on inventory?

Self Assessment Questions

1. What are the characteristics of JIT?
2. What are the conditions for implementation of the JIT system with success?
3. What do you understand by Vendor Managed Inventory (VMI)?

UNIT - 16

LOGISTICS MANAGEMENT

16.1

Logistics is concerned with getting the products and services where they are needed and when they are desired. It is difficult to accomplish any marketing or manufacturing without logistical support. It involves the integration of information, transportation, inventory, warehousing, material handling, and packaging.

The operating responsibility of logistics is the geographical repositioning of raw materials, work in process, and finished inventories where required at the lowest cost possible.

The formal definition of the word 'logistics' as per the perception of Council of Logistics Management is the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements.

Mission of logistics is providing a means by which customer satisfaction is achieved. Art of moving, lodging and supplying troops, supplies and equipment is logistics. Concept of logistics has moved into business to move, lodge and supply inputs and outputs.

Logistics is practiced for ages since organized activity began. Without logistics support no activity can be performed to meet defined goal. The current challenge is to perform logistics scientifically in order to optimize benefits to the organization.

Logistics is a planning function of management. Logistics function is concerned with taking products and services where they are needed and when they are needed.

Logistics ensures that the required inputs [what] to a value adding process are made available, where they are needed, when they are needed and in the quantities [how much] they are needed. It also ensures that the outputs of the value adding process are made available where they are needed when they are needed and in the quantities [how much?] they are needed.

There are many ways of defining logistics but the underlying concept might be defined as follows: 'Logistics is the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory through the organization and its

marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfillment of orders.'

Genesis of Modern Logistics

Several Modern Management concepts are born or refined in the crucible of II World War. You may remember several OR techniques like Value Analysis & PERT/CPM have their origin in the II World War. Resources come under pressure in a war, like no other time and one is expected to deliver results in spite of all odds. These trying situations forced the military planners to evolve solutions to their problems. After the war these concepts traveled to business where resource crunch is usual. In business there is no enemy, but there are competitors who pose threat to the organizations survival.

Field Marshall Rommel's words that 'before they are fought, battles are won or lost by quartermasters' speak about the importance of logistics.

There are several examples where battles are lost due to long & ineffective supply lines.

Logistics received great importance in military planning and subsequently became a very important management function in the course of last 40 years.

Logistical management includes the design and administration of systems to control the flow of material, work in process and finished inventory to support business unit strategy.

Overview of logistics function

Logistical History of India: India was a maritime power since about 300 BC, trading with several countries of the world bringing prosperity home. Traders of Surat brought riches to the country by extensive maritime trade. Like many of our excellent practices, logistical efficiency also faded away over a period of time.

Some important logistical feats in history:

1. **Berlin Airlift – 1945: A study in logistics.** When the city of Berlin was blockaded by Soviets and all supply lines were cut off, Americans planned and executed a major logistics operation to feed the city from air.
2. **Indians in the Gulf countries – 1991:**
In 1991, when gulf war broke out, Indian Government evacuated thousands of Indians from the gulf countries and brought them home in a massive exercise employing Indian airlines planes.
3. **Operation Overlord-1945:** Allies' invasion of Europe and subsequent victory In II World War.
4. **American war of Independence**
Keeping 12,000 soldiers armed and fed from England was a big task; British lost the American war of independence due to bad logistics.

Objectives of logistics management

1. Rapid response

F-flexibility objective of an organization: Some companies measure this as response time to customer's order. On an average how much time do we need to fulfill one particular type of customer's order in a year? This is a measure of **Rapid response**

Logistics should ensure that the supplier is able to respond to the change in the demand very fast. Entire production should change from traditional **push system** to **pull system** to facilitate rapid response. Instead of stocking the goods and supplying on demand, orders are executed on shipment to shipment basis. Information Technology plays an important role here as an **enabler**. IT helps management in producing and delivering goods when the consumer needs them. This results into reduction of inventory and exposes all operational deficiencies. Now the management resolves these deficiencies and slashes down costs. [Concept of SMED and KANBAN as practiced by JIT companies in Japan or elsewhere]

2. Minimum variance

D-delivery objective of an organization, this can be measured as 'On Time Delivery' or **OTD**. If 100 deliveries are made in a month/quarter/year how many reached as per the commitment made to the customer? This percentage is **OTD**.

Any event that disrupts a system is variance. Logistics operations are disrupted by events like delays due to obstacles in information flow, traffic snarls, acts of god, wrong dispatches, damage in transit. Traditional approach is to keep safety stocks and transport the goods by high cost mode. The cost of this approach is huge. Logistics is expected to minimize these events, thereby minimize and improve on On Time Delivery.

3. Minimum inventory

This is component of **cost** objective of a company. **Inventory** is associated with a huge baggage of costs. It is termed as a necessary evil. Objective of minimum inventory is measured as Inventory Turns or Inventory Turnover Ratio. Americans call this measure as **turn velocity**. Logistics management reduces these turns without sacrificing customer satisfaction. Lower turns ensure effective utilization of assets devoted to stock. [Concept of single piece flow as practiced by JIT companies in Japan or elsewhere]. Logistical management should keep the overall well being of a company in view and fix a minimum inventory level without trying to minimize the inventory level as an isolated objective

4. Movement consolidation

Transportation is the biggest contributor to logistics cost. Transportation cost depends on product type, size, weight, distance to be transported etc. for transporting small shipments just in time

[reduction in inventory costs] expensive transport modes are used which again tend to hike the costs. **Movement consolidation** is planning several such small shipments together [of different types of shipments] by integrating interests of several players in the supply chain. Generally, large shipment size and long distances reduce transportation cost per unit. Movement consolidation shall result into reduction in transportation costs.

5. Quality

If the quality of product fails logistics will have to ship the product out of customers' premises and repeat the logistics operation again. This adds to costs and customer dissatisfaction. Hence logistics should contribute to TQM initiative of management. In fact, commitment to TQM has made the management's world over wake up to the significance of logistics function. Logistics can play a significant role in total quality improvement by improving the quality of logistics performance continuously and continually.

6. Life cycle support Logistics function is expected to provide life cycle support to the product after sale. This includes

- a. **After sales service:** the service support needed by the product once it is sold during its life cycle.
- b. **Reverse logistics** or Product recall as a result of
 - rigid quality standards [critical in case of contaminated products which can cause environmental hazard]
 - transit damage [leaking containers containing hazardous material]
 - product expiration dating
 - rigid laws prohibiting unscientific disposal of items associated with product [packaging]
 - Rigid laws making recycling mandatory
 - Erroneous order processing by supplier
 - Reverse logistics is an important component of logistics planning

Activities of the Logistics Functions

Logistics function consists of following sets of activities:

- (1) **Order processing.** Though this activity does not contribute much to total costs, yet it is treated important because of its contribution to lead time.
- (2) **Transportation Management.** Transportation involves-
 - Firm's own transport (if goods are to be collected)

- Hiring of transport (if services of external firm are to be used)
 - Routing and load planning.
 - Selection of the most suitable of transport (i.e. rail, road, sea or air).
 - Packaging needed (i.e. loose, pallets or special).
 - Documentation required (especially if goods are arriving from overseas.)
- (3) **Inventory management.** Inventories require to be maintained to take care of needs between the time of demand and time of supply. Inventory management involved decisions concerning.
- Buffer stocks.
 - Lead time.
 - Replenishment of stocks.
- (4) **Warehousing.** Is concerned with management of space to hold inventories and it involves such problems as:
- Site selection.
 - Space determination.
 - Layout and design.
 - Receipts and issues and storage.
 - Preservation.
- (5) **Materials handling** is concerned with movement of product at the stocking point and it involves such decision as :
- Smoothening of materials flow.
 - Selection of materials handling equipment.
 - Maintenance of materials handling equipment.
- (6) **Packaging** is concerned with design of packing of the product that ensures damage free movement of the product and is conducive to efficient handling and storage.
- (7) **Acquisition** is concerned with sourcing, planning and ordering of the product in order to ensure its availability in the right quantity, at the right time, at the right place and at the right cost. Acquisition, however, dose not includes other purchasing activities such as price negotiation, vendor rating etc.

- (8) **Product scheduling** is concerned with preparation of aggregate quantities to be produced in accordance with demands, actual as well as projected. Product scheduling, however, does not include day-to-day detailed scheduling carried out by production planner.
- (9) **Information system** is a must for the successful implementation of logistics function. Database on customer location, sales volume, inventory levels, lead times etc. must be maintained.

Improving Effectiveness of Logistics Management

Five pillars to the effective logistics are: (i) Logistical network, (ii) Transport (iii) information, (iv) Inventory and (v) Warehousing, materials handling and packaging.

- (1) **Logistical network** include facilities such as manufacturing, warehouse, dealers and retail stores. The larger the geographical spread, the more complex the firm's logistical network. Superior logistical network, based on systematic analysis and determination of number of each type of facilities, their geographical location, specific work allocations etc. can be a very big competitive tool.
- (2) **Information.** Accurate forecasting and good order management are essential for the systematic inventory management JIT and Contingency Replenishment (CR) and quick response (QR) to the customer. Timely information thus is the key to the logistical performance. Modern information technology, in the form of both hardware (faxes, mobile phones, e-mail) and software (Enterprise Resource Planning) have removed the deficiencies in information.
- (3) **Transport.** Cost, speed and reliability are key determinants of the effectiveness, whether it is a war or business. Since time is the essence, quality of transport performance becomes the critical factor. Further, as speed and cost of transport are inter-related, careful selection of the transport becomes essential for optimum cost. For example, faster transport costs mean more money but reduce inventories and improve customer service.
- (4) **Inventory management.** Good inventory management system must be put into place to achieve desired customer service with minimum inventory investment. Inventory policies must be carefully devised. Excessive inventories hide deficiencies (e.g. deficiencies of logistics network, poor quality of suppliers, interior purchase order management etc.) while too low inventories cause delay in order execution, slow response and deficient customer service. Selective treatment based on following principles generally lead to effective inventory management:
 - Enough quantity of high profit high volume products, demanded by the core customer, may be carried in stock while or negligible inventory may be kept of low-profit-low volume products purchased by a fringe of customers.

- Core customers may be serviced by fast reliable air service while orders of other customers may be dispatched by surface transport.
 - Commitment to deliver product rapidly and timely (say within the declared period) must be preceded by enhanced capabilities of logistic network.
 - Commitment of rapid and consistent delivery should be intended to gain customer service advantage and to neutralize the strength that a competitor enjoys.
- (5) **Warehousing, materials handling and packaging.** The choice and location of the warehouse should be with a view to get closer to the core customers. Materials handling within the warehouse should be planned to ensure safe and speedy receipt, movement, storage and packaging of customer's requirements.

Key issues in logistics

Logistics is a process which interfaces and interacts with the entire company and with external companies, vendors, customers, carriers and more. Logistics is responsible for the movement of products from your vendor's right through to the delivery at your customer's door, including moves through manufacturing facilities, warehouses, and third-parties, such as repackagers or distributors. It is not shipping and receiving, nor is it traffic or warehousing. It is more.

Logistics must make work effectively. This is required by your customers and, in turn, by your company. For effective logistics, there are five key issues--

- **Movement of product.** This is often the way that logistics is viewed in many companies. Rush ship an order. Expedite in a component. But there is more. Products moves should complement the corporate strategy. If the emphasis is on cost reduction, lower inventories, customer service or whatever, then products must move in a way that is consistent with the emphasis. Product must also flow, not just move, from, to, between and among vendors, manufacturing sites, warehouses and customers. If it does not flow, then there is not a supply pipeline. Instead there are imbalances in inventories with components and finished goods not being where they should be.

The movement may be extremely broad in geographical scope. Raw materials and completed units can move between and among all regions of the world. While other departments in the company may focus on select geographical regions for sourcing, manufacturing or sales, logistics must deal with all of these. Everything must move.

The movement plan must be flexible. Forecasting may be the weak link in all corporate planning and execution. So the movement

must be able to adjust and deal with the swings in business activity. This may require a multi-mode, and/or a multi-carrier and/or multi-level service program to keep the global supply chain moving smoothly. For example, it may require a mix of ocean and air modes to keep a smooth pipeline, especially if there are significant swings in volumes and requirements. Or a mix of fast-boat and slow-boat transit time ocean carriers, trading off transit time and freight costs for sea freight service. Or, if the destination is on the East Coast, a mix of MLB service and all-water, similar to the multi-carrier approach but staying, perhaps, with the same steamship line.

- **Movement of information.** It is not enough to move product and materials. You must know where they are. You must know what inventories are where and if critical action is required. You must know what orders are coming in and when they must be delivered. Information—timely and accurate-- is vital for sound decision-making.

The information must flow between the company and its suppliers, carriers, forwarders, warehouses and customers. It must also move internally among purchasing, customer service, logistics, manufacturing, sales, marketing and accounting. And doing this goes beyond Email, faxes and phone calls. Investment in information technology is not an alternative anymore; it is a requirement for logistics and corporate effectiveness.

Systems should exist at the macro or corporate level and view. Since logistics is a process which interacts with many other groups in the company, it is fundamental that a corporate system be in place. It has to be dynamic for handling customer orders, production planning, material requirements planning, distribution requirements planning, finance and sales forecasting. It must be able to receive orders via EDI, transmit Advance Ship Notices, accommodate multiple warehouse and plant locations in both a single site and aggregated views, track inventories at various levels, such as eaches and cases, and more.

There must also be systems at the micro, or logistics level and view. Programs are needed for warehouse management, cross-docking, shipment tracking for example. Each in turn takes technology, with bar-coding and scanning. These satisfy the operations/reactive and the planning/anticipatory needs.

- **Time/service.** The ability to respond to the dynamics of the global marketplace—changing forecasts, customer requirements, new product introductions, new sourcing, and how to manage all these changes—must be done quickly. Raw materials and components must be ordered and arrive completely, accurately and quickly. Orders must be filled completely, accurately and quickly. It is no longer months or weeks for lead times. It may not even be days. Hours may decide customer service, competitiveness and value-

added. Back orders are not tolerated. If your company cannot properly respond, your customers will look for those who can.

Service is more than having to expedite a shipment. Time/service is a factor of competition, customer requirements, your company's position in the industry, your corporate culture, how well everyone in the global supply chain works together, and how well everyone works together in your company. Logistics is the link among all this. And the more diverse the geographical scope of vendors, manufacturing, warehouses and customers, the more critical is time. Distance means time. Yet time delays are not acceptable. Movement of product and movement of information show their impact here.

- **Cost.** Cost is the key measure by which logistics effectiveness is often measured. Freight, warehouse labor, public warehouse charges and other items on the P&L. Or inventory, a balance sheet item. Cost control, containment, and management is important for corporate profitability. Fiscal stewardship is a duty of all managers. The highest price does not mean the best service, and it may not be the service you need. Nor does the lowest price necessarily meet your needs.

There is no doubt about how important costs are. But the company must be careful. Minimizing the cost of the various logistics elements, such as freight and warehousing, can sub optimize the effectiveness of the logistics group and of the company in satisfying its customers.

Cost has a relation to service. They go hand in hand. As you define your service against your costs or costs against service, the give and take develops into your operating costs and budgets. Then you have to make sure that the cost can be managed. Otherwise costs can go out of control, or seem to.

However, there is no ready mechanism which really makes proper recognition in costs for time/service or for adjustments in any part of the company plan. There is no item in the P&L or balance sheet for Time/Service, which is the driver of a company's logistics efforts. Logistics cost measurement is a shortcoming in the present accounting systems. There were designed when the Model A was being built and are not adequate in today's competitive business world. They make discreet cost buckets in a weak attempt to measure a dynamic, global logistics process.

In addition there may be other issues such as currency conversion and fluctuations. Air freight is quoted in the currency of the origin country. Ocean terminal and other accessorial origin charges are also in origin country currency. Warehouses in other countries will invoice in origin currencies. Currency conversion and dynamics can create unfavorable or favorable cost variances which have nothing to do with logistics performance.

- **Integration**--within your company, between you and your customers and between you and your vendors. Integration--

bringing it all together--within your company is vital. Logistics is a process. Effectiveness requires that each relevant element of the organization do its part. However there is a problem with doing this. The organization chart. The traditional organization with its boxes and defined responsibilities is a collection of functional silos. Each silo segments and collects different parts of the vendor purchase/manufacturing/sales activity and stores it. Hence there is no process. There is a compartmentalization, a fragmenting of the process. This creates an anti-process effect.

In addition to internal integration, you must bring together and work with the external players. Your vendors, including your carriers and warehouses, must understand what you are doing and why. You must share your logistics vision and plan with them. This sharing and understanding will better enable them to cooperate with and assist you. They may be able to offer ideas and gain sharing to further improve the logistics effectiveness and the key issues with it.

Integration with customers is important. You and everyone in your company must be working and satisfy your customers. You should review written customer requirements with everyone in the logistics department and with everyone in the company. It is not enough to a company to tear apart the written requirements and hand them to various departments. That is not integration. That is functional silos.

Meeting with key customers is very good. A face-to-face discussion with him about his requirements and how you will meet them is important. This shows how much you value him and want to work with him. What does he need? How does he need it? Why does he need it? When does he need it? The more you know about your customer and his needs, the more valued of a supplier you are to him. This is a competitive advantage. Partnerships and alliances can be developed or enhanced.

Caselet

The management of Yummy Noodles Company was contemplating on introducing 200 grams pack of savory noodles into the Indian market at Rs. 10 per pack. This was only for one month which was construed to be as a test marketing period. During this period, the Company wanted to have a “blitz” strategy of flooding the market with their product.

In the subsequent month, the management of Yummy Noodles Company had planned to raise the price of the pack to Rs. 15, while the weight of the pack was to be fixed at 250 grams. A free gift in the form of a plastic bowl with a spoon was also planned.

Two months before the launch of the actual production, the marketing department of the company brought out advertisements regarding the savory noodles. The advertisements were displayed on bill-boards, TV, radio, print media.

Schools and colleges were also targeted to rope in students and children to buy the product. Production of the noodles was planned to be started along with the marketing program. The forecast of the number of expected packets that could be sold for the first month was around 75,000, and 1,25,000 for the second month. The production was required to be started earlier to meet the target of projected demand as well as to account for the changeover in the pack-size in the second month.

You are appointed as a logistics consultant by the Company. You are required to guide the Company regarding the following

- a) The Company is very keen that its product must be well-received in the market. What coordination is required between the production, marketing and other departments of the Company? (Note: You are required to **spell-out** the various departments (namely, warehousing, production, quality control, packaging, etc.) that are expected to be required in the Company)
- b) Explain the role of the Logistics Department in the introductory phase.

Self Assessment Questions

1. Explain Logistics management.
2. What are the advantages of logistics?
3. What are the objectives of logistics management?
4. What are the issues with logistic management?



॥ सात्यमेव जयते ॥
**Uttar Pradesh Rajarshi Tandon
Open University**

Master of Business

M.B.A.-2.2 Production Management

BLOCK

5

WORK SYSTEM DESIGN

UNIT 17	253-280
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ISSUES IN MATERIALS MANAGEMENT

UNIT 18	281-288
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INDEPENDENT DEMAND INVENTORY SYSTEMS

UNIT 19	289-300
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DEPENDENT DEMAND INVENTORY SYSTEM

UNIT 20	301-312
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SCHEDULING

परिशिष्ट-4
आन्तरिक कवर-दो का प्रारूप
Format of the II Inner Covers

विशेषज्ञ समिति

1. Dr. Omji Gupta, Director SoMS UPRTOU Allahabad.
 2. Prof. Arvind Kumar, Professor, Department of Commerce, Lucknow University, Lucknow.
 3. Prof. Geetika, HOD, SoMS, MNNIT Allahabad
 4. Prof. H.K. Singh, Professor, Department of Commerce, BHU Varanasi
-

लेखक Dr. Hemant Yadav, Director, PPGIT M & M, Bareilly.

सम्पादक Prof. H.K. Singh, Professor, Department of Commerce, BHU Varanasi.

परिभाषक

अनुवाद की स्थिति में

मूल लेखक

अनुवाद

मूल सम्पादक

भाषा सम्पादक

मूल परिभाषक

परिभाषक

सहयोगी टीम

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UNIT - 17

ISSUES IN MATERIALS MANAGEMENT

17.1

Materials Management is simply the process by which an organization is supplied with the goods and services that it needs to achieve its objectives of buying, storage and movement of materials. Materials Management is related to planning, procuring, storing and providing the appropriate material of right quality, right quantity at right place in right time so as to co-ordinate and schedule the production activity in an integrative way for an industrial undertaking. Most industries buy materials, transport them in to the plant, change the materials in to parts, assemble parts in to finished products, sell and transport the product to the customer. All these activities of purchase of materials, flow of materials, manufacture them in to the product, supply and sell the product at the market requires various types of materials to manage and control their storage, flow and supply at various places. It is only possible by efficient materials management. The materials requirements planning, purchasing, inventory planning, storage, inventory control, materials supply, transportation and materials handling are the activities of materials management. About 20-25 years ago, there was no cut-throat competition in the market to sell the various consumer items manufactured by different industrial undertakings and the availability of materials to manufacture these items was not scarce. Therefore, materials management was not thought to be so important and its separate identity in the organization was not felt. But today it has become an important management activity to streamline production. Actually before the production begins it is necessary to ensure availability of all the types of materials needed for production and its supply at the various production centers. Planning, purchasing and scheduling are the main functions of materials management. It aims at improved productivity. It is used to reduce the cost, which increases profitability and streamlines the production. Apart from management of material cost and its supply it helps in its proper utilization, transportation, storage, handling and distribution.

The market research and forecasting both for sales of company's product and purchasing of various materials required for producing the product are needed at the planning stage. Purchasing, procurement of materials, transportation, storage, inventory control, quality control and inspection of materials and goods supplied at various production centers before production are also managed as routine work. Materials handling, packaging, warehouse planning, accounting, scrap, surplus and obsolete materials disposal, finished goods safety and care are the activities

managed by the materials management department. Selection of personnel for marketing, purchasing, inventory control, stores management and materials handling and their training and placement is also to be seen by the materials management department. This indicates that it is very essential to have a materials management department in any organization to support the management in the production activities. It also helps in the marketing, sales promotion and control of all the types of materials for its quantity, quality and cost.

Objectives of Materials Management

The objectives and functions of materials management can be categorized in two ways as follows:

- (I) Primary objectives**
- (II) Secondary objectives**

They are discussed below:

(I) Primary objectives

This can be classified as:

- (i) Efficient materials planning**
- (ii) Buying or Purchasing**
- (iii) Procuring and receiving**
- (iv) Storing and inventory control**
- (v) Supply and distribution of materials**
- (vi) Quality assurance**
- (vii) Good supplier and customer relationship**
- (viii) Improved departmental efficiency**

(II) Secondary objectives

There can be several secondary objectives of materials management. Some of them are given below:

- (i) Efficient production scheduling**
- (ii) To take make or buy decisions**
- (iii) Prepare specifications and standardization of materials**
- (iv) To assist in product design and development**
- (v) Forecasting demand and quantity of materials requirements**
- (vi) Quality control of materials purchased**
- (vii) Material handling**
- (viii) Use of value analysis and value engineering**
- (ix) Developing skills of workers in materials management**
- (x) Smooth flow of materials in and out of the organization**

Scope or Functions of Materials Management

Materials management is defined as *"the function responsible for the coordination of planning, sourcing, purchasing, moving, storing and controlling materials in an optimum manner so as to provide a pre-decided service to the customer at a minimum cost"*.

From the definition it is clear that the scope of materials management is vast.

The functions of materials management can be categorized in the following ways:

1. Material Planning and Control
2. Purchasing
3. Stores Management
4. Inventory Control or Management
5. Standardization
6. Simplification
7. Value Analysis
8. Ergonomics
9. Just-in-Time (JIT)

All the above mentioned functions of materials management has been discussed in detail

1. Materials planning and control: Based on the sales forecast and production plans, the materials planning and control is done. This involves estimating the individual requirements of parts, preparing materials budget, forecasting the levels of inventories, scheduling the orders and monitoring the performance in relation to production and sales.

2. Purchasing: This includes selection of sources of supply finalization in terms of purchase, placement of purchase orders, follow-up, maintenance of smooth relations with suppliers, approval of payments to suppliers, evaluating and rating suppliers.

3. Stores management or management: This involves physical control of materials, preservation of stores, minimization of obsolescence and damage through timely disposal and efficient handling, maintenance of stores records, proper location and stocking. A store is also responsible for the physical verification of stocks and reconciling them with book figures. A store plays a vital role in the operations of a company.

4. Inventory control or management: Inventory generally refers to the materials in stock. It is also called the idle resource of an enterprise. Inventories represent those items, which are either stocked for sale or they are in the process of manufacturing or they are in the form of materials, which are yet to be utilized. The interval between receiving the purchased parts and transforming them into final products varies from

industries to industries depending upon the cycle time of manufacture. It is, therefore, necessary to hold inventories of various kinds to act as a buffer between supply and demand for efficient operation of the system. Thus, an effective control on inventory is a must for smooth and efficient running of the production cycle with least interruptions.

5. Other related activities

(a) 3S

- (i) **Standardization:** Standardization means producing maximum variety of products from the minimum variety of materials, parts, tools and processes. It is the process of establishing standards or units of measure by which extent, quality, quantity, value; performance etc. may be compared and measured.
- (ii) **Simplification:** The concept of simplification is closely related to standardization. Simplification is the process of reducing the variety of products manufactured. Simplification is concerned with the reduction of product range, assemblies, parts, materials and design.
- (iii) **Specifications:** It refers to a precise statement that formulizes the requirements of the customer. It may relate to a product, process or a service.

Example: Specifications of an axle block are Inside Dia. = 2 ± 0.1 cm, Outside Dia. = 4

± 0.2 cm and Length = 10 ± 0.5 cm.

- (b) **Value analysis:** Value analysis is concerned with the costs added due to inefficient or unnecessary specifications and features. It makes its contribution in the last stage of product cycle, namely, the maturity stage. At this stage research and development no longer make positive contributions in terms of improving the efficiency of the functions of the product or adding new functions to it.
- (c) **Ergonomics (Human Engineering):** The human factors or human engineering is concerned with man-machine system. Ergonomics is "the design of human tasks, man-machine system, and effective accomplishment of the job, including displays for presenting information to human sensors, controls for human operations and complex man-machine systems." Each of the above functions are dealt in detail.

Material planning and Control

Material planning is a scientific technique of determining in advance the requirements of raw materials, ancillary parts and components, spares etc. as directed by the production programme. It is a

sub-system in the overall planning activity. There are many factors, which influence the activity of material planning. These factors can be classified as macro and micro systems.

1. *Macro factors:* Some of the micro factors which affect material planning, are price trends, business cycles Govt. import policy etc.
2. *Micro factors:* Some of the micro factors that affect material planning are plant capacity utilization, rejection rates, lead times, inventory levels, working capital, delegation of powers and communication.

Techniques of material planning

The basis for material planning is the forecast demand for the end products. Forecasting techniques such as weighted average method, exponential smoothening and time series models are used for the same. Once the demand forecast is made, it is possible to go through the excurses of material planning.

Bill of materials is a document which shows list of materials required, unit consumption location code for a given product. An explosive chart is a series of bill of material grouped in a matrix form so that combined requirements for different components can be done requirements of various materials are arrived at from the demand forecast, using bill of materials, through explosion charts. Thus material requirement plan will lead to be the development of delivery schedule of the materials and purchasing of those material requirements.

Purchasing

Purchasing is an important function of materials management. In any industry purchase means buying of equipments, materials, tools, parts etc. required for industry. The importance of the purchase function varies with nature and size of industry. In small industry, this function is performed by works manager and in large manufacturing concern; this function is done by a separate department. The moment a buyer places an order he commits a substantial portion of the finance of the corporation which affects the working capital and cash flow position. He is a highly responsible person who meets various salesmen and thus can be considered to have been contributing to the public relations efforts of the company. Thus, the buyer can make or mar the company's image by his excellent or poor relations with the vendors.

Objectives of Purchasing

The basic objective of the purchasing function is to ensure continuity of supply of raw materials, sub-contracted items and spare parts and to reduce the ultimate cost of the finished goods. In other words, the objective is not only to procure the raw materials at the lowest price but to reduce the cost of the final product.

The objectives of the purchasing department can be outlined as under:

1. **To avail the materials, suppliers and equipments at the minimum possible costs:**

These are the inputs in the manufacturing operations. The minimization of the input cost increases the productivity and resultantly the profitability of the operations.

2. **To ensure the continuous flow of production** through continuous supply of raw materials, components, tools etc. with repair and maintenance service.
3. **To increase the asset turnover:** The investment in the inventories should be kept minimum in relation to the volume of sales. This will increase the turnover of the assets and thus the profitability of the company.
4. **To develop an alternative source of supply:** Exploration of alternative sources of supply of materials increases the bargaining ability of the buyer, minimization of cost of materials and increases the ability to meet the emergencies.
5. **To establish and maintain the good relations with the suppliers:** Maintenance of good relations with the supplier helps in evolving a favorable image in the business circles. Such relations are beneficial to the buyer in terms of changing the reasonable price, preferential allocation of material in case of material shortages, etc.
6. **To achieve maximum integration with other department of the company:** The purchase function is related with production department for specifications and flow of material, engineering department for the purchase of tools, equipments and machines, marketing department for the forecasts of sales and its impact on procurement of materials, financial department for the purpose of maintaining levels of materials and estimating the working capital required, personnel department for the purpose of manning and developing the personnel of purchase department and maintaining good vendor relationship.
7. **To train and develop the personnel:** Purchasing department is manned with varied types of personnel. The company should try to build the imaginative employee force through training and development.
8. **Efficient record keeping and management reporting:** Paper processing is inherent in the purchase function. Such paper processing should be standardized so that record keeping can be facilitated. Periodic reporting to the management about the purchase activities justifies the independent existence of the department.

Parameters of Purchasing

The success of any manufacturing activity is largely dependent on the procurement of raw materials of right quality, in the right quantities, from right source, at the right time and at right price popularly known as ten 'R's' of the art of efficient purchasing. They are described as the basic principles of purchasing. There are other well known parameters such as right contractual terms, right material, right place, right mode of transportation and right attitude are also considered for purchasing.

1. Right Price

It is the primary concern of any manufacturing organization to get an item at the right price. But right price need not be the lowest price. It is very difficult to determine the right price; general guidance can be had from the cost structure of the product. The 'tender system' of buying is normally used in public sector organizations but the objective should be to identify the lowest 'responsible' bidder and not the lowest bidder. The technique of 'learning curve' also helps the purchase agent to determine the price of items with high labor content. The price can be kept low by proper planning and not by rush buying. Price negotiation also helps to determine the right prices.

2. Right Quality

Right quality implies that quality should be available, measurable and understandable as far as practicable. In order to determine the quality of a product sampling schemes will be useful. The right quality is determined by the cost of materials and the technical characteristics as suited to the specific requirements. The quality particulars are normally obtained from the indents. Since the objective of purchasing is to ensure continuity of supply to the user departments, the time at which the material is provided to the user department assumes great importance.

3. Right Time

For determining the right time, the purchase manager should have lead time information for all products and analyze its components for reducing the same. Lead time is the total time elapsed between the recognition of the need of an item till the item arrives and is provided for use. This covers the entire duration of the materials cycle and consists of pre-contractual administrative lead time, manufacturing and transporting lead time and inspection lead time. Since the inventory increases with higher lead time, it is desirable to analyze each component of the lead time so as to reduce the first and third components which are controllable. While determining the purchases, the buyer has to consider emergency situations like floods, strikes, etc. He should have 'contingency plans' when force major clauses become operative, for instance, the material is not available due to strike, lock-out, floods, and earthquakes.

4. Right Source

The source from which the material is procured should be dependable and capable of supplying items of uniform quality. The buyer has to decide which item should be directly obtained from the manufacturer. Source selection, source development and vendor rating play an important role in buyer-seller relationships. In emergencies, open market purchases and bazaar purchases are resorted to.

5. Right Quantity

The right quantity is the most important parameter in buying. Concepts, such as, economic order quantity, economic purchase quantity, fixed period and fixed quantity systems, will serve as broad guidelines. But the buyer has to use his knowledge, experience and common sense to determine the quantity after considering factors such as price structure, discounts, availability of the item, favorable reciprocal relations, and make or buy consideration.

6. Right Attitude

Developing the right attitude, too, is necessary as one often comes across such statement:

'Purchasing knows the price of everything and value of nothing'; 'We buy price and not cost'; 'When will our order placers become purchase managers?'; 'Purchasing acts like a post box'.

Therefore, purchasing should keep 'progress' as its key activity and should be future-oriented.

The purchase manager should be innovative and his long-term objective should be to minimize the cost of the ultimate product. He will be able to achieve this if he aims himself with techniques, such as, value analysis, materials intelligence, purchases research, SWOT analysis, purchase budget lead time analysis, etc.

7. Right Contracts

The buyer has to adopt separate policies and procedures for capital and consumer items. He should be able to distinguish between indigenous and international purchasing procedures. He should be aware of the legal and contractual aspects in international practices.

8. Right Material

Right type of material required for the production is an important parameter in purchasing.

Techniques, such as, value analysis will enable the buyer to locate the right material.

9. Right Transportation

Right mode of transportation has to be identified as this forms a critical segment in the cost profile of an item. It is an established fact that the cost of the shipping of ore, gravel, sand, etc., is normally more than the cost of the item itself.

10. Right Place of Delivery

Specifying the right place of delivery, like head office or works, would often minimize the handling and transportation cost.

PURCHASING PROCEDURE

The procedure describes the sequence of steps leading to the completion of an identified specific task. The purchasing procedure comprises the following steps:

1. Recognition of the need

The initiation of procedure starts with the recognition of the need by the needy section. The demand is lodged with the purchase department in the prescribed Purchase Requisition Form forwarded by the authorized person either directly or through the Stores Department. The purchase requisition clearly specifies the details, such as, specification of materials, quality and quantity, suggested supplier, etc. Generally, the low value sundries and items of common use are purchased for stock while costlier and special items are purchased according to the production programmes. Generally, the corporate level executives are authorized signatories to such demands. Such purchases are approved by the Board of Directors. The reference of the approval is made on requisition and a copy of the requisition is sent to the secretary for the purpose of overall planning and budgeting.

2. The selection of the supplier

The process of selection of supplier involves two basic aspects: searching for all possible sources and short listing out of the identified sources. The complete information about the supplier is available from various sources, such as, trade directories, advertisement in trade journals, direct mailing by the suppliers, interview with suppliers, salesmen, suggestions from business associates, visit to trade fair, participation in industries convention, etc. Identification of more and more sources helps in selecting better and economical supplier. It should be noted that the low bidder is not always the best bidder. When everything except price is equal, the low bidder will be selected. The important considerations in the selection are the price, ability to supply the required quantity, maintenance of quality standards, financial standing etc. It should be noted that it is not necessary to go for

this process for all types of purchases. For the repetitive orders and for the purchases of low-value, small lot items, generally the previous suppliers with good records are preferred.

3. Placing the order

Once the supplier is selected the next step is to place the purchase order. Purchase order is a letter sent to the supplier asking to supply the said material. At least six copies of purchase order are prepared by the purchase section and each copy is separately signed by the purchase officer.

Out these copies, one copy each is sent to store-keeper, supplier, accounts section, inspection department and to the department placing the requisition and one copy is retained by the purchase department for record.

4. Follow-up of the order

Follow-up procedure should be employed wherever the costs and risks resulting from the delayed deliveries of materials are greater than the cost of follow-up procedure, the follow-up procedure tries to see that the purchase order is confirmed by the supplier and the delivery is promised. It is also necessary to review the outstanding orders at regular intervals and to communicate with the supplier in case of need. Generally, a routine urge is made to the supplier by sending a printed post card or a circular letter asking him to confirm that the delivery is on the way or will be made as per agreement. In absence of any reply or unsatisfactory reply, the supplier may be contact through personal letter, phone, telegram and/or even personal visit.

5. Receiving and inspection of the materials

The receiving department receives the materials supplied by the vendor. The quantity are verified and tallied with the purchase order. The receipt of the materials is recorded on the specially designed receiving slips or forms which also specify the name of the vendor and the purchase order number. It also records any discrepancy, damaged condition of the consignment or inferiority of the materials. The purchase department is informed immediately about the receipt of the materials. Usually a copy of the receiving slip is sent to the purchase department.

6. Payment of the invoice

When the goods are received in satisfactory condition, the invoice is checked before it is approved for the payment. The invoice is checked to see that the goods were duly authorized to purchase, they were properly ordered, they are priced as per the agreed terms, the quantity and quality confirm to the order, the calculations are arithmetically correct etc.

7. Maintenance of the records

Maintenance of the records is an important part and parcel of the efficient purchase function.

In the industrial firms, most of the purchases are repeat orders and hence the past records serve as a good guide for the future action. They are very useful for deciding the timings of the purchases and in selecting the best source of the supply.

8. Maintenance of vendor relations

The quantum and frequency of the transactions with the same key suppliers provide a platform for the purchase department to establish and maintain good relations with them. Good relations develop mutual trust and confidence in the course of the time which is beneficial to both the parties. The efficiency of the purchase department can be measured by the amount of the goodwill it has with its suppliers.

Selection of Suppliers

Selection of the right supplier is the responsibility of the purchase department. It can contribute substantially to the fundamental objectives of the business enterprise. Different strategies are required for acquiring different types of materials. The selection of supplier for standardized products will differ from non-standardized products. Following factors are considered for the selection of suppliers:

A. Sources of supplier

The best buying is possible only when the decision maker is familiar with all possible sources of supply and their respective terms and conditions. The purchase department should try to locate the appropriate sources of the supplier of various types of materials. This is known as 'survey stage'. A survey of the following will help in developing the possible sources of supply:

1. Specialized trade directories.
2. Assistance of professional bodies or consultants.
3. The buyer's guide or purchase handbook.
4. The manufacturer's or distributor's catalogue.
5. Advertisements in dailies.
6. Advertisement in specialized trade journals.
7. Trade fair exhibitions.

B. Development of approved list of suppliers

The survey stage highlights the existence of the source. A business inquiry is made with the appropriate supplier. It is known as 'Inquiry Stage'. Here a short listing is made out of the given sources of suppliers in terms of production facilities and capacity, financial standing, product quality, possibility of timely supply, technical competence, manufacturing

efficiency, general business policies followed, standing in the industry, competitive attitude, and interest in buying orders etc.

C. Evaluation and selection of the supplier

The purchase policy and procedure differ according to the type of items to be purchased. Hence, evolution and selection of the supplier differ accordingly. In the 'purchasing handbook' edited by Aljian, it has been described that the following variables to be considered while evaluating the quotations of the suppliers:

1. Cost Factors

Price, transportation cost, installation cost if any, tooling and other operations cost, incidence of sales tax and excise duty, terms of payment and cash discount are considered in cost factor.

2. Delivery

Routing and F.O.B. terms are important in determining the point at which the title to the goods passes from vendor to the buyer and the responsibility for the payment of the payment charges.

3. Design and Specification Factors

Specification compliance, specification deviations, specification advantages, important dimensions and weights are considered in line with the demonstration of sample, experience of other users, after sale services etc.

4. Legal Factors

Legal factors include warranty, cancellation provision, patent protection, public liability, federal laws and reputation compliance.

5. Vendor Rating

The evaluation of supplier or vendor rating provides valuable information which help in improving the quality of the decision. In the vendor rating three basic aspects are considered namely quality, service and price. How much weight should be given to each of these factors is a matter of judgment and is decided according to the specific need of the organization. Quality would be the main consideration in the manufacturing of the electrical equipments while price would be the prime consideration in the product having a tense competitive market and for a company procuring its requirements under the blanket contract with agreed price, the supplier rating would be done on the basis of two variables namely quality and delivery.

The Development Project Committee of the National Association of Purchasing Agents

(U.S.A.) has suggested following methods for evaluating the performance of past suppliers.

- 1. The categorical plan:** Under this method the members of the buying staff related with the supplier like receiving section, quality

control department, manufacturing department etc., are required to assess the performance of each supplier. The rating sheets are provided with the record of the supplier, their product and the list of factors for the evaluation purposes. The members of the buying staff are required to assign the plus or minus notations against each factor. The periodic meetings, usually at the interval of one month, are held by senior man of the buying staff to consider the individual rating of each section. The consolidation of the individual rating is done on the basis of the net plus value and accordingly, the suppliers are assigned the categories such as 'preferred', 'neutral' or 'unsatisfactory'. Such ratings are used for the future guidance. This is a very simple and inexpensive method. However, it is not precise. Its quality heavily depends on the experience and ability of the buyer to judge the situation. As compared to other methods, the degree of subjective judgment is very high as rating is based on personal whim and the vague impressions of the buyer. As the quantitative data supported by the profits do not exist, it is not possible to institute any corrective action with the vendor. The rating is done on the basis of memory, and thus it becomes only a routine exercise without any critical analysis.

2. **The weighted-point method:** The weighted-point method provides the quantitative data for each factor of evaluation. The weights are assigned to each factor of evaluation according to the need of the organization, e.g., a company decides the three factors to be considered—quality, price and timely delivery. It assigns the relative weight to each of these factors as under:

Quality 50 points

Price 30 points

Timely delivery 20 points

The evaluation of each supplier is made in accordance with the aforesaid factors and weights and the composite weighted-points are ascertained for each suppliers—A, B and C—are rated under this method. First of all the specific rating under each factor will be made and then the consolidation of all the factors will be made for the purpose of judgment.

Quality rating: Percentage of quantity accepted among the total quantity is called quality rating. In other words, the quality of the materials is judged on the basis of the degree of acceptance and rejections. For the purpose of comparison, the percentage degree of acceptance will be calculated in relation to the total lots received. **Price rating** is done on the basis of net price charged by the supplier. **Timely delivery** rating will be done comparing with the average delivery schedule of the supplier.

3. **The cost-ratio plan:** Under this method, the vendor rating is done on the basis of various costs incurred for procuring the materials from various suppliers. The cost-ratios are ascertained delivery etc. The cost-ratios are ascertained for the different rating variables such as quality,

price, timely delivery etc. The cost-ratio is calculated in percentage on the basis of total individual cost and total value of purchases. At the end, all such cost-ratios will be adjusted with the quoted price per unit. The plus cost-ratio will increase the unit price while the minus cost-ratio will decrease the unit price. The net adjusted unit price will indicate the vendor rating. The vendor with the lowest net adjusted unit price will be the best supplier and so on. Certain quality costs can be inspection cost, cost of defectives, reworking costs and manufacturing losses on rejected items etc. Certain delivery costs can be postage and telegrams, telephones and extra cost for quick delivery etc.

Special Purchasing Systems

The following are some of the important purchasing systems:

1. Forward Buying

Forward buying or committing an organization far into the future, usually for a year. Depending upon the availability of the item, the financial policies, the economic order quantity, the quantitative discounts, and the staggered delivery, the future commitment is decided. This type of forward buying is different from speculative buying where the motive is to make capital out of the price changes, by selling the purchased items. Manufacturing organizations normally do not indulge in such buying. However, a few organizations do 'Hedge', particularly in the commodity market by selling or buying contracts.

2. Tender Buying

In public, all semblance of favoritism, personal preferences should be avoided. As such, it is common for government departments and public sector undertakings to purchase through tenders. Private sector organizations adopt tender buying if the value of purchases is more than the prescribed limits as Rs. 50000 or Rs. 100000. The steps involved are to establish a bidders' list, solicit bids by comparing quotations and place the order with the lowest bidder. However, care has to be taken that the lowest bidder is responsible party and is capable of meeting the delivery schedule and quality requirements. Open tender system or advertisement in newspapers is common in public sector organizations. As advertising bids is costly and time consuming, most private sector organizations solicit tenders only from the renowned suppliers capable of supplying the materials.

3. Blanket Order System

This system minimizes the administrative expenses and is useful for 'C' type items. It is an agreement to provide a required quantity of specified items, over a period of time, usually for one year, at an agreed price. Deliveries are made depending upon the buyer's needs. The system relieves the buyers from routine work, giving him more time for focusing attention on high value items. It requires fewer purchase orders and thus reduces clerical work. It often achieves lower prices through quantity discounts by grouping the requirements. The supplier, under the system maintains adequate inventory to meet the blanket orders.

4. Zero Stock

Some firms try to operate on the basis of zero stock and the supplier holds the stock for these firms. Usually, the firms of the buyer and seller are close to each other so that the raw materials of one are the finished products of another. Alternatively, the system could work well if the seller holds the inventory and if the two parties work in close coordination. However, the price per item in this system will be slightly higher as the supplier will include the inventory carrying cost in the price. In this system, the buyer need not lock up the capital and so the purchasing routine is reduced. This is also significantly reduces obsolescence of inventory, lead time and clerical efforts in paper work. Thus, the seller can devote his marketing efforts to other customers and production scheduling becomes easy.

5. Rate Contract

The system of rate contract is prevalent in public sector organizations and government departments. It is common for the suppliers to advertise that they are on 'rate contract' for the specific period. After negotiations, the seller and the buyer agree to the rates of items. Application of rate contract has helped many organizations to cut down the internal administrative lead time as individual firms need to go through the central purchasing departments and can place orders directly with the suppliers. However, suppliers always demand higher prices for prompt delivery, as rate difficulty has been avoided by ensuring the delivery of a minimum quantity at the agreed rates. This procedure of fixing a minimum quantity is called the running contract and is being practiced by the railways. The buyer also has an option of increasing the quantity by 25% more than the agreed quantity under this procedure.

6. Reciprocity

Reciprocal buying means purchasing from one's customers in preference to others. It is based on the principle "if you kill my cat, I will kill your dog", and "Do unto your customers as you would have them do unto you". Other things, like soundness from the ethics and economics point of view being equal, the principles of reciprocity can be practiced. However, a purchasing executive should not indulge in reciprocity on his initiative when the terms and conditions are not equal with other suppliers. It is often sound that less efficient manufacturer and distributors gain by reciprocity what they are unable to gain by price and quality. Since this tends to discourage competition and might lead to higher process and fewer suppliers, reciprocity should be practiced on a selective basis.

7. Systems Contract

This is a procedure intended to help the buyer and the sellers to reduce administrative expenses and at the same time ensure suitable controls. In this system, the original indent, duly approved

by competent authorities, is shipped back with the items and avoids the usual documents like purchase orders, materials requisitions, expediting letters and acknowledgements, delivery period price and invoicing

procedure, Carborandum company in the US claims drastic reduction in inventory and elimination of 40000 purchase orders by adopting the system contracting procedure.

It is suitable for low unit price items with high consumption.

Stores Management

Stores play a vital role in the operations of company. It is in direct touch with the user departments in its day-to-day activities. The most important purpose served by the stores is to provide uninterrupted service to the manufacturing divisions. Further, stores are often equated directly with money, as money is locked up in the stores.

Functions of Stores

The functions of stores can be classified as follows:

1. To receive raw materials, components, tools, equipment's and other items and account for them.
2. To provide adequate and proper storage and preservation to the various items.
3. To meet the demands of the consuming departments by proper issues and account for the consumption.
4. To minimize obsolescence, surplus and scrap through proper codification, preservation and handling.
5. To highlight stock accumulation, discrepancies and abnormal consumption and effect control measures.
6. To ensure good house keeping so that material handling, material preservation, stocking, receipt and issue can be done adequately.
7. To assist in verification and provide supporting information for effective purchase action.

Codification

It is one of the functions of stores management. Codification is a process of representing each item by a number, the digit of which indicates the group, the sub-group, the type and the dimension of the item. Many organizations in the public and private sectors, railways have their own system of codification, varying from eight to thirteen digits. The first two digits represents the major groups, such as raw materials, spare parts, sub-contracted items, hardware items, packing material, tools, oil, stationery etc. The next two digits indicate the sub-groups, such as, ferrous, non-ferrous etc. Dimensional characteristics of length, width, head diameter etc. constitute further three digits and the last digit is reserved for minor variations.

Whatever may be the basis, each code should uniquely represent one item. It should be simple and capable of being understood by all. Codification should be compact, concise, consistent and flexible enough to accommodate new items. The groupings should be logical, holding similar

parts near to one another. Each digit must be significant enough to represent some characteristic of the item.

Objectives of Codification

The objectives of a rationalized material coding system are:

1. Bringing all items together.
2. To enable putting up of any future item in its proper place.
3. To classify an item according to its characteristics.
4. To give a unique code number to each item to avoid duplication and ambiguity.
5. To reveal excessive variety and promote standardization and variety reduction.
6. To establish a common language for the identification of an item.
7. To fix essential parameters for specifying an item.
8. To specify item as per national and international standards.
9. To enable data processing and analysis.

Advantages of Codification

As a result of rationalized codification, many firms have reduced the number of items. It enables systematic grouping of similar items and avoids confusion caused by long description of items since standardization of names is achieved through codification, it serves as the starting point of simplification and standardization. It helps in avoiding duplication of items and results in the minimization of the number of items, leading to accurate record. Codification enables easy recognition of an item in stores, thereby reducing clerical efforts to the minimum. If items are coded according to the sources, it is possible to bulk the items while ordering. To maximize the aforesaid advantages, it is necessary to develop the codes as concerned, namely, personnel from design, production, engineering, inspection, maintenance and materials.

Inventory Control or Management

Meaning of Inventory

Inventory generally refers to the materials in stock. It is also called the idle resource of an enterprise. Inventories represent those items which are either stocked for sale or they are in the process of manufacturing or they are in the form of materials, which are yet to be utilized. The interval between receiving the purchased parts and transforming them into final products varies from industries to industries depending upon the cycle time of manufacture. It is, therefore, necessary to hold inventories of various kinds to act as a buffer between supply and demand for efficient operation of the system. Thus, an effective control on inventory is a must

for smooth and efficient running of the production cycle with least interruptions.

Reasons for Keeping Inventories

1. To stabilize production: The demand for an item fluctuates because of the number of factors, *e.g.*, seasonality, production schedule etc. The inventories (raw materials and components) should be made available to the production as per the demand failing which results in stock out and the production stoppage takes place for want of materials. Hence, the inventory is kept to take care of this fluctuation so that the production is smooth.

2. To take advantage of price discounts: Usually the manufacturers offer discount for bulk buying and to gain this price advantage the materials are bought in bulk even though it is not required immediately. Thus, inventory is maintained to gain economy in purchasing.

3. To meet the demand during the replenishment period: The lead time for procurement of materials depends upon many factors like location of the source, demand supply condition, etc.

So inventory is maintained to meet the demand during the procurement (replenishment) period.

4. To prevent loss of orders (sales): In this competitive scenario, one has to meet the delivery schedules at 100 per cent service level, means they cannot afford to miss the delivery schedule which may result in loss of sales. To avoid the organizations have to maintain inventory.

5. To keep pace with changing market conditions: The organizations have to anticipate the changing market sentiments and they have to stock materials in anticipation of non-availability of materials or sudden increase in prices.

6. Sometimes the organizations have to stock materials due to other reasons like suppliers minimum quantity condition, seasonal availability of materials or sudden increase in prices.

Objectives of Inventory Control

- 1. To ensure adequate supply of products to customer and avoid shortages as far as possible.**
- 2. To make sure that the financial investment in inventories is minimum (*i.e.*, to see that the working capital is blocked to the minimum possible extent).**
- 3. Efficient purchasing, storing, consumption and accounting for materials is an important objective.**
- 4. To maintain timely record of inventories of all the items and to maintain the stock within the desired limits.**
- 5. To ensure timely action for replenishment.**

6. To provide a reserve stock for variations in lead times of delivery of materials.
7. To provide a scientific base for both short-term and long-term planning of materials.

Benefits of Inventory Control

It is an established fact that through the practice of scientific inventory control, following are the benefits of inventory control:

1. Improvement in customer's relationship because of the timely delivery of goods and service.
2. Smooth and uninterrupted production and, hence, no stock out.
3. Efficient utilization of working capital. Helps in minimizing losses due to deterioration, obsolescence damage and pilferage.
4. Economy in purchasing.
5. Eliminates the possibility of duplicate ordering.

Techniques of Inventory Control

In any organization, depending on the type of business, inventory is maintained. When the number of items in inventory is large and then large amount of money is needed to create such inventory, it becomes the concern of the management to have a proper control over its ordering, procurement, maintenance and consumption. The control can be for order quality and order frequency.

The different techniques of inventory control are:

- (1) ABC analysis,
- (2) HML analysis,
- (3) VED analysis,
- (4) FSN analysis,
- (5) SDE analysis,
- (6) GOLF analysis and
- (7) SOS analysis.

The most widely used method of inventory control is known as ABC analysis. In this technique, the total inventory is categorised into three sub-heads and then proper exercise is exercised for each sub-heads.

Standardization

Standardization means producing maximum variety of products from the minimum variety of materials, parts, tools and processes. It is the process of establishing standards or units of measure by which extent, quality, quantity, value, performance etc., may be compared and measured.

Advantages of Standardization

All the sections of company will be benefited from standardization as mentioned below.

Benefits to Design Department

1. Fewer specifications, drawings and part list have to prepared and issued.
2. More time is available to develop new design or to improve established design.
3. Better resource allocation.
4. Less qualified personnel can handle routine design work.

Benefits to Manufacturing Department

1. Lower unit cost.
2. Better quality products.
3. Better methods and tooling.
4. Increased interchangeability of parts.
5. Better utilization of manpower and equipment.
6. Accurate delivery dates.
7. Better services of production control, stock control, purchasing, etc.
8. More effective training.

Benefits to Marketing Department

1. Better quality products of proven design at reasonable cost leads to greater sales volume.
2. Increased margin of profit.
3. Better product delivery.
4. Easy availability of sales part.
5. Less sales pressure of after-sales services.

Benefits to Production Planning Department

1. Scope for improved methods, processes and layouts.
2. Opportunities for more efficient tool design.
3. Better resource allocation.
4. Reduction in pre-production activities.

Benefits to Production Control Department

1. Well proven design and methods improve planning and control.
2. Accurate delivery promises.
3. Fewer delays arise from waiting for materials, tools, etc.

4. Follow-up of small batches consumes less time.

Benefits to Purchase and Stock Control Department

1. Holding of stock of standard items leads to less paper work and fewer requisitions and orders.
2. Storage and part location can be improved.
3. Newer techniques can be used for better control of stocks.
4. Because of large purchase quantities involved, favourable purchase contracts can be made.

Benefits to Quality Control Department

1. Better inspection and quality control is possible.
2. Quality standards can be defined more clearly.
3. Operators become familiar with the work and produce jobs of consistent quality.

Other Benefits

1. Work study section is benefited with efficient break down of operations and effective work measurement.
2. Costing can obtain better control by installing standard costing.
3. More time is available to the supervisors to make useful records and preserve statistics.
4. Reduced reductions and scrap.
5. Helps supervisors to run his department efficiently and effectively.

Disadvantages of Standardization

Following are the disadvantages of standardization:

1. Reduction in choice because of reduced variety and consequently loss of business or customer.
2. Standard once set, resist change and thus standardization may become an obstacle to progress.
3. It tends to favor only large companies.
4. It becomes very difficult to introduce new models because of less flexible production facilities and due to high cost of specialized production equipment.

Simplification

The concept of simplification is closely related to standardization. Simplification is the process of reducing the variety of products manufactured. Simplification is concerned with the reduction of product range, assemblies, parts, materials and design.

Advantages of Simplification

Following are the advantages of simplification:

1. Simplification involves fewer, parts, varieties and changes in products; this reduces manufacturing operations and risk of obsolescence.
2. Simplification reduces variety; volume of remaining products may be increased.
3. Simplification provides quick delivery and better after-sales services.
4. Simplification reduces inventory and thus results in better inventory control.
5. Simplification lowers the production costs.
6. Simplification reduces price of a product.
7. Simplification improves product quality.

Value Analysis

Value engineering or value analysis had its birth during the World War II Lawrence D. Miles was responsible for developing the technique and naming it. Value analysis is defined as "an organized creative approach which has its objective, the efficient identification of unnecessary cost-cost which provides neither quality nor use nor life nor appearance nor customer features."

Value analysis focuses engineering, manufacturing and purchasing attention to one objective equivalent performance at a lower cost.

Value analysis is concerned with the costs added due to inefficient or unnecessary specifications and features. It makes its contribution in the last stage of product cycle, namely, the maturity stage. At this stage, research and development no longer make positive contributions in terms of improving the efficiency of the functions of the product or adding new functions to it.

Value is not inherent in a product, it is a relative term, and value can change with time and place. It can be measured only by comparison with other products which perform the same function. Value is the relationship between what someone wants and what he is willing to pay for it. In fact, the heart of value analysis technique is the functional approach. It relates to cost of function whereas others relate cost to product. It is denoted by the ratio between function and cost.

$$\text{Value} = \text{Function/Cost}$$

Value Analysis Framework

The basic framework for value analysis approach is formed by the following questions, as given by Lawrence D. Miles:

1. What is the item?
2. What does it do?
3. What does it cost?

4. What else would do the job?
5. What would the alternative cost be?

Value analysis requires these questions to be answered for the successful implementation of the technique.

Steps in Value Analysis

In order to answer the above questions, three basic steps are necessary:

1. **Identifying the function:** Any useful product has some primary function which must be identified—a bulb to give light, a refrigerator to preserve food, etc. In addition it may have secondary functions such as withstanding shock, etc. These two must be identified.
2. **Evaluation of the function by comparison:** Value being a relative term, the comparison approach must be used to evaluate functions. The basic question is, 'Does the function accomplish reliability at the best cost' and can be answered only comparison.
3. **Develop alternatives:** Realistic situations must be faced, objections should overcome and effective engineering manufacturing and other alternatives must be developed. In order to develop effective alternatives and identify unnecessary cost the following thirteen value analysis principles must be used:
 1. Avoid generalities.
 2. Get all available costs.
 3. Use information only from the best source.
 4. Brain-storming sessions.
 5. Blast, create and refine: In the blast stage, alternative productive products, materials, processes or ideas are generated. In the 'create' stage the ideas generated in the blast stage are used to generate alternatives which accomplish the function almost totally. In the refining stage the alternatives generated are sifted and refined so as to arrive at the final alternative to be implemented.
 6. Identify and overcome road blocks.
 7. Use industry specialists to extend specialized knowledge.
 8. Key tolerance not to be too light.
 9. Utilize the pay for vendors' skills techniques.
 10. Utilize vendors' available functional products.
 11. Utilize specialty processes.
 12. Utilize applicable standards.
 13. Use the criterion 'Would I spend my money this way?'

Ergonomics (Human Engineering)

The word 'Ergonomics' has its origin in two Greek words *Ergon* meaning laws. So it is the study of the man in relation to his work. In USA and other countries it is called by the name 'human engineering or human factors engineering'. ILO defines human engineering as, "The application of human biological sciences along with engineering sciences to achieve optimum mutual adjustment of men and his work, the benefits being measured in terms of human efficiency and well-being."

The human factors or human engineering is concerned with man-machine system. Thus another definition which highlights the man-machine system is: "The design of human tasks, man-machine system, and effective accomplishment of the job, including displays for presenting information to human sensors, controls for human operations and complex man-machine systems."

Human engineering focuses on human beings and their interaction with products, equipment facilities and environments used in the work. Human engineering seeks to change the things people use and the environment in which they use the things to match in a better way the capabilities, limitations and needs of people.

Objectives of Human Engineering

Human engineering (ergonomics) has two broader objectives:

1. To enhance the efficiency and effectiveness with which the activities (work) is carried out so as to increase the convenience of use, reduced errors and increase in productivity.
2. To enhance certain desirable human values including safety reduced stress and fatigue and improved quality of life.

Thus, in general the scope and objective of ergonomics is "designing for human use and optimizing working and living conditions". Thus human factors (ergonomics) discover and apply information about human behavior. Abilities and limitations and other characteristics to the design of tools, machines, systems, tasks, jobs and environment for productive, safe, comfortable and effective human use. Ergonomics aims at providing comfort and improved working conditions so as to channelize the energy, skills of the workers into constructive productive work. This accounts for increased productivity, safety and reduces the fatigue. This helps to increase the plant utilization.

Just-In-Time (JIT) Manufacturing

Introduction

Just-In-Time (JIT) Manufacturing is a philosophy rather than a technique. By eliminating all waste and seeking continuous improvement, it aims at creating manufacturing system that is response to the market needs.

The phase just in time is used to because this system operates with low WIP (Work-In- Process) inventory and often with very low finished goods

inventory. Products are assembled just before they are sold, subassemblies are made just before they are assembled and components are made and fabricated just before subassemblies are made. This leads to lower WIP and reduced lead times. To achieve this organizations have to be excellent in other areas e.g. quality.

According to Voss, JIT is viewed as a *"Production methodology which aims to improve overall productivity through elimination of waste and which leads to improved quality"*. JIT provides an efficient production in an organization and delivery of only the necessary parts in the right quantity, at the right time and place while using the minimum facilities".

Seven Wastes

Shiego Shingo, a Japanese JIT authority and engineer at the Toyota Motor Company identifies seven wastes as being the targets of continuous improvement in production process. By attending to these wastes, the improvement is achieved.

1. Waste of over production eliminate by reducing set-up times, synchronizing quantities and timing between processes, layout problems. Make only what is needed now.
2. Waste of waiting eliminate bottlenecks and balance uneven loads by flexible work force and equipment.
3. Waste of transportation establishes layouts and locations to make handling and transport unnecessary if possible. Minimize transportation and handling if not possible to eliminate.
4. Waste of processing itself question regarding the reasons for existence of the product and then why each process is necessary.
5. Waste of stocks reducing all other wastes reduces stocks.
6. Waste of motion study for economy and consistency. Economy improves productivity and consistency improves quality. First improve the motions, then mechanize or automate otherwise. There is danger of automating the waste.
7. Waste of making defective products develop the production process to prevent defects from being produced, so as to eliminate inspection. At each process, do not accept defects and makes no defects. Make the process fail-safe. A quantify process always yield quality product.

Benefits of JIT

The most significant benefit is to improve the responsiveness of the firm to the changes in the market place thus providing an advantage in competition. Following are the benefits of JIT:

1. *Product cost*—is greatly reduced due to reduction of manufacturing cycle time, reduction of waste and inventories and elimination of non-value added operation.

2. *Quality*—is improved because of continuous quality improvement programs.
3. *Design*—Due to fast response to engineering change, alternative designs can be quickly brought on the shop floor.
4. Productivity improvement.
5. Higher production system flexibility.
6. Administrative ease and simplicity.

Need For Material Management

The costs associated with material management are hidden in other activities or included as overhead costs. Stukhart states that studies from the Construction Industry Cost Effectiveness Project (CICEP) concluded that senior management have not recognized the contribution of material management to cost issues in projects, that personnel involved in material management activities do not receive an adequate training, and that the computer systems used by companies are not good sources of information for materials control. Historically managers had paid more attention to the costs associated with personnel, equipment and plant and little attention has been given to materials. For manufacturing organizations, the costs related to materials have increased and had become the largest expenditure of the organization; therefore more attention has been placed into activities related to materials. The cost of materials has escalated to twice the cost of labor between 1975 and 1980 inducing companies to pay more attention to activities related to materials (Bernold and Treseler, 1991).

Traditionally the responsibilities for activities related to materials flow have been divided between different departments. The activities related to material management are divided between different departments. For example, the finance department is in charge of the purchasing activities while the manufacturing department is in charge of the control of materials during production. This division of responsibilities makes it difficult to coordinate the activities related to materials. In addition, this division can make the control and identification of materials extremely difficult. The integration of the functions related to materials into a single department makes it easier to control and identify all the activities related to material flow and costs. Material Management is designed to coordinate and control the materials needed and activities related to those materials. In a typical organization, the material activities are interrelated.

Issues in Material Management

The major issue that materials managers face is maintaining a consistent flow of materials for production. There are many factors that inhibit the accuracy of inventory which results in production shortages, premium freight, and often inventory adjustments. The major issues that all materials managers face are incorrect bills of materials, inaccurate cycle counts, un-reported scrap, shipping errors, receiving errors, and production reporting errors. Materials managers have striven to determine how to manage these issues in the business sectors of manufacturing since

the beginning of the industrial revolution. Although there are no known methods that eliminate the afore mentioned inventory accuracy inhibitors, there are best methods available to eliminate the impact upon maintaining an interrupted flow of materials for production.

One challenge for materials managers is to provide timely releases to the supply base. On the scale of worst to best practices, sending releases via facsimile or PDF file is the worst practice and transmitting releases to the supplier based web site is the best practice. Why? The flaw in transmitting releases via facsimile or email is that they can get lost or even interpreted incorrectly into the suppliers system resulting in a stock out. The problem with transmitting EDI releases is that not all suppliers have EDI systems capable of receiving the release information. The best practice is to transmit the releases to a common supplier web base site where the suppliers can view (for free) the releases. The other advantage is that the supplier is required to use the carrier listed in the web site, must transmit an ASN (advanced shipping notification), and review the accumulative balances of the order.

Importance of Material Management

Importance of Effective Materials Management:

Materials management addresses the increased integration of the materials management process. Materials management is a process that requires single point responsibility, early planning, and effective communication tools.

Effective materials management involves maximizing material productivity. This requires well coordinated approach towards various problems related to materials. With respect materials it helps in decision making. Effective material management solves many problems and some of important problems are as follow:

1. **Inventory Problem** - It helps in solving problems related to reducing inventories in the context of reducing uncertainties in demand and supply. It helps in projection of demand. The gap between demand and supply is very crucial for any business hence effective materials management is very important.
2. **Pilferage** – Issues of proper planning regarding avoidance of pilferage are also solved by effective materials management,
3. **Improving Materials Productivity** - Problems regarding standardization and reduction methodologies for improving productivity are also solved by effective materials management,
4. **Waste Management** - Effective materials management also helps in developing policies and procedure for managing waste materials.

Issues of proper planning of store or warehouse are also important part of effective management and it involves store layout. Hence for solving above problems an integrated approach of material management must be applied properly.

Self Assessment Questions

1. What is the importance of the materials management?
2. What is the scope of materials management?
3. How will you integrate the various activities of materials management?
4. Explain the objectives of materials management.
5. What are the functions of stores?
6. Explain the reasons for keeping inventories.
7. What are the objectives of inventory control?

Skill Development

Fast Food Restaurant Visit: Get the information for the following questions:

1. Material Requirement Plan for procurements of Raw material.
2. Purchase procedures adopted.
3. Preparation of Bill of Material.
4. The supplier or vendors selection.
5. In process spares and etc.
6. Adaptation of Just In Time Manufacturing Technique.

UNIT - 18

INDEPENDENT DEMAND INVENTORY SYSTEMS

18.1

Inventory is the stock of any item or resource used in an organization. An inventory system is the set of policies and controls that monitor levels of inventory and determine what levels should be maintained, when stock should be replenished, and how large orders should be. By convention, manufacturing inventory generally refers to items that contribute to or become part of a firm's product output. Manufacturing inventory is typically classified into raw materials, finished products, component parts, supplies, and work-in-process. In distribution, inventory is classified as in-transit, meaning that it is being moved in the system, and warehouse, which is inventory in a warehouse or distribution center. Retail sites carry inventory for immediate sale to customers. In services, inventory generally refers to the tangible goods to be sold and the supplies necessary to administer the service.

The basic purpose of inventory analysis, whether in manufacturing, distribution, retail, or services, is to specify (1) when items should be ordered and (2) how large the order should be. Many firms are tending to enter into longer-term relationships with vendors to supply their needs for perhaps the entire year. This changes the "when" and "how many to order" to "when" and "how many to deliver."

PURPOSES OF INVENTORY

All firms (including JIT operations) keep a supply of inventory for the following reasons:

1. 1 .To maintains independence of operations. A supply of materials at a work center allows that center flexibility in operations. For example, because there are costs for making each new production setup, this inventory allows management to reduce the number of setups. Independence of workstations is desirable on assembly lines as well. The time that it takes to do identical operations will naturally vary from one unit to the next. Therefore, it is desirable to have a cushion of several parts within the workstation so that shorter performance times can compensate for longer performance times. This way the average output can be fairly stable.
2. 2 To meet variation in product demand. If the demand for the product is known precisely, it may be possible (though not

necessarily economical) to produce the product to exactly meet the demand. Usually, however, demand is not completely known, and a safety or buffer stock must be maintained to absorb variation.

3. **To allow flexibility in production scheduling.**
4. A stock of inventory relieves the pressure on the production system to get the goods out. This causes longer lead times, which permit production planning for smoother flow and lower-cost operation through larger lot-size production. High setup costs, for example, favor producing a larger number of units once the setup has been made.
5. **To provide a safeguard for variation in raw material delivery time.** When material is ordered from a vendor, delays can occur for a variety of reasons: a normal variation in shipping time, a shortage of material at the vendor's plant causing backlogs, an unexpected strike at the vendor's plant or at one of the shipping companies, a lost order, or a shipment of incorrect or defective material.
6. **To take advantage of economic purchase order size.** There are costs to place an order: labor, phone calls, typing, postage, and so on. Therefore, the larger each order is, the fewer the orders that need be written. Also, shipping costs favor larger orders—the larger the shipment, the lower the per-unit cost.

Many other domain-specific reasons. Depending on the situation, inventory may need to be carried. For example, in-transit inventory is material being moved from the suppliers to customers and depends on the order quantity and the transit lead time.

Another example is inventory that is bought in anticipation of price changes such as fuel for jet planes or semiconductors for computers. There are many other examples. For each of the preceding reasons (especially for items 3, 4, and 5), be aware that inventory is costly and large amounts are generally undesirable. Long cycle times are caused by large amounts of inventory and are undesirable as well.

INVENTORY COSTS

In making any decision that affects inventory size, the following costs must be considered:

1. **Holding (or carrying) costs:** This broad category includes the costs for storage facilities, handling, insurance, pilferage, breakage, obsolescence, depreciation, taxes, and the opportunity cost of capital. Obviously, high holding costs tend to favor low inventory levels and frequent replenishment.
2. **Setup (or production change) costs:** To make each different product involves obtaining the necessary materials, arranging specific equipment setups, filling out the required papers,

appropriately charging time and materials, and moving out the previous stock of material.

3. If there were no costs or loss of time in changing from one product to another, many small lots would be produced. This would reduce inventory levels, with a resulting savings in cost. One challenge today is to try to reduce these setup costs to permit smaller lot sizes. (This is the goal of a JIT system.)
4. **Ordering costs:** These costs refer to the managerial and clerical costs to prepare the purchase or production order. Ordering costs include all the details, such as counting items and calculating order quantities. The costs associated with maintaining the system needed to track orders are also included in ordering costs.
5. **Shortage costs:** When the stock of an item is depleted, an order for that item must either wait until the stock is replenished or be canceled. When the demand is not met and the order is canceled, this is referred to as a stock out. A backorder is when the order is held and filled at a later date when the inventory for the item is replenished.

There is a trade-off between carrying stock to satisfy demand and the costs resulting from stock outs and backorders. This balance is sometimes difficult to obtain because it may not be possible to estimate lost profits, the effects of lost customers, or lateness penalties. Frequently, the assumed shortage cost is little more than a guess, although it is usually possible to specify a range of such costs. Establishing the correct quantity to order from vendors or the size of lots submitted to the firm's productive facilities involves a search for the minimum total cost resulting from the combined effects of four individual costs: holding costs, setup costs, ordering costs, and shortage costs. Of course, the timing of these orders is a critical factor that may impact inventory cost.

ABC INVENTORY PLANNING

Maintaining inventory through counting, placing orders, receiving stock, and so on takes personnel time and costs money. When there are limits on these resources, the logical move is to try to use the available resources to control inventory in the best way. In other words, focus on the most important items in inventory.

In the nineteenth century Vilfredo Pareto, in a study of the distribution of wealth in

Milan, found that 20 percent of the people controlled 80 percent of the wealth. This logic of the few having the greatest importance and the many having little importance has been broadened to include many situations and is termed the Pareto principle.

This is true in our everyday lives (most of our decisions are relatively unimportant, but a few shape our future) and is certainly true in inventory systems (where a few items account for the bulk of our investment).

Any inventory system must specify when an order is to be placed for an item and how many units to order. Most inventory control situations involve so many items that it is not practical to model and give thorough treatment to each item. To get around this problem, the ABC inventory classification scheme divides inventory items into three groupings: high dollar volume (A), moderate dollar volume (B), and low dollar volume (C). Dollar volume is a measure of importance; an item low in cost but high in volume can be more important than a high-cost item with low volume.

ABC CLASSIFICATION

If the annual usage of items in inventory is listed according to dollar volume, generally, the list shows that a small number of items account for a large dollar volume and that a large number of items account for a small dollar volume. Exhibit 11.11A illustrates the relationship.

The ABC approach divides this list into three groupings by value: A items constitute roughly the top 15 percent of the items, B items the next 35 percent, and C items the last 50 percent. From observation, it appears that the list in Exhibit 11.11A can be meaningfully grouped with A including 20 percent (2 of the 10), B including 30 percent, and C including 50 percent. These points show clear delineations between sections. The result of this segmentation is shown in Exhibit 11.11B and plotted in Exhibit 11.11C. Segmentation may not always occur so neatly. The objective, though, is to try to separate the important from the unimportant. Where the lines actually break depends on the particular inventory under question and on how much personnel time is available. (With more time, a firm could define larger A or B categories.)

The purpose of classifying items into groups is to establish the appropriate degree of control over each item. On a periodic basis, for example, class A items may be more clearly controlled with weekly ordering, B items may be ordered biweekly, and C items may be ordered monthly or bimonthly. Note that the unit cost of items is not related to their classification. An A item may have a high dollar volume through a combination of either low cost and high usage or high cost and low usage. Similarly, C items may have a low dollar volume because of either low demand or low cost. In an automobile service station, gasoline would be an A item with daily or weekly replenishment; tires, batteries, oil, grease, and transmission fluid may be B items and ordered every two to four weeks; and C items would consist of valve stems, windshield wiper blades, radiator caps, hoses, fan belts, oil and gas additives, car wax, and so forth. C items may be ordered every two or three months or even be allowed to run out before reordering because the penalty for stock out is not serious.

Sometimes an item may be critical to a system if its absence creates a sizable loss. In this case, regardless of the item's classification, sufficiently large stocks should be kept on hand to prevent run out. One way to ensure closer control is to designate this item an A or a B, forcing

it into the category even if its dollar volume does not warrant such inclusion.

Advantages of ABC Analysis:

1. Better exercise of control over all materials.
2. The capital invested in inventory can be reduced to minimum levels.
3. Warehouse and storage costs can be reduced.

LIMITATIONS OF ABC ANALYSIS

- ABC analysis mainly provides a guideline for inventory management. It need to be supplemented by basic understanding and judgment as there are certain items which may fall into category C or category B due to their low usage value but are otherwise very critical for the production process of the firm. Their inventory levels have to be carefully monitored.
- The ABC analysis, to be effective, needs to be constantly undertaken and periodically reviewed by the management, as the number of items and value of items keep on undergoing changes.
- The practical problem in the usage of ABC analysis is that generally, thousands of items fall in category C, as a result, a lot of time is spent on managing inventory of items of this category (even if it needs simple control). The time left for controlling the inventory stocks of categories A is therefore much shorter than that required for their effective management.

Economic Order Quantity (EOQ)

The Economic Order Quantity (EOQ) is the number of units that a company should add to inventory with each order to minimize the total costs of inventory—such as holding costs, order costs, and shortage costs. The EOQ is used as part of a continuous review inventory system in which the level of inventory is monitored at all times and a fixed quantity is ordered each time the inventory level reaches a specific reorder point. The EOQ provides a model for calculating the appropriate reorder point and the optimal reorder quantity to ensure the instantaneous replenishment of inventory with no shortages. It can be a valuable tool for small business owners who need to make decisions about how much inventory to keep on hand, how many items to order each time, and how often to reorder to incur the lowest possible costs.

The EOQ model assumes that demand is constant, and that inventory is depleted at a fixed rate until it reaches zero. At that point, a specific number of items arrive to return the inventory to its beginning level. Since the model assumes instantaneous replenishment, there are no inventory

shortages or associated costs. Therefore, the cost of inventory under the EOQ model involves a tradeoff between inventory holding costs (the cost of storage, as well as the cost of tying up capital in inventory rather than investing it or using it for other purposes) and order costs (any fees associated with placing orders, such as delivery charges). Ordering a large amount at one time will increase a small business's holding costs, while making more frequent orders of fewer items will reduce holding costs but increase order costs. The EOQ model finds the quantity that minimizes the sum of these costs.

One of the major inventory control problems to be resolved is how much inventory should be added when inventory is replenished. If the firm is buying raw materials, it has to decide lots in which it has to be purchased on each replenishment. These problems are called order quantity problems, and the task of the firm is to determine the optimum or Economic Order Quantity. Determining an optimum inventory level involves 2 types of costs: (a) Ordering Cost and, (b) Carrying Cost. The Economic Order Quantity is that inventory level which minimizes the total of ordering and carrying cost.

- a. **Ordering Cost:** The term ordering cost is used in case of raw material and includes the entire cost of acquiring raw materials. They include cost incurred in the following activities: Requisitions, Purchase Ordering, Transporting, Receiving, inspecting and Storing. Ordering cost includes the number of orders; thus the more frequently inventory is required, the higher the firm's ordering cost. On the other hand, if the firm maintains large inventory levels, there will be few orders placed and ordering cost will be relatively small. Thus ordering cost decreases with increasing size of the inventory.
- b. **Carrying Cost:** Cost incurred on maintaining a given level of inventory are called carrying costs. They include storage, insurance, taxes, deterioration and obsolescence, etc. Carrying cost varies with inventory size. The economic size of inventory would thus depend on trade off between carrying cost and ordering cost.

Formula

Following is the formula for the economic order quantity (EOQ) model:

$$Q^* = \sqrt{\frac{2DS}{H}}$$

Where Q = optimal order quantity

D = units of annual demand

S = cost incurred to place a single order or setup

H = carrying cost per unit

This formula is derived from the following cost function:

Total cost = purchase cost + ordering cost + holding cost

Limitations of the economic order quantity model:

It is necessary for the application of EOQ order that the demands remain constant throughout the year. It is also necessary that the inventory be delivered in full when the inventory levels reach zero.

Underlying assumption of the EOQ model

Following are the underlying assumptions for the EOQ model. Without these assumptions, the EOQ model cannot work to its optimal potential.

- The cost of the ordering remains constant.
- The demand rate for the year is known and evenly spread throughout the year.
- The lead time is not fluctuating (lead time is the latency time it takes a process to initiate and complete).
- No cash or settlement discounts are available, and the purchase price is constant for every item.
- The optimal plan is calculated for only one product.
- There is no delay in the replenishment of the stock, and the order is delivered in the quantity that was demanded, i.e. in whole batch.

These underlying assumptions are the key to the economic order quantity model, and these assumptions help the companies to understand the shortcomings they are incurring in the application of this model.

Limitations of EOQ:

1. The assumptions listed above may not come true in real life situations, thus limiting the use of this model.
2. Price off materials may not remain same throughout the year.
3. Availability of materials is another constraint. Material can only be purchased at the time when it is available.
4. There can be delays in real situation in placing orders since many times the calculated EOQ is an inconvenient number and some time is wasted in taking decision for rounding off this number. In real situations, suppliers receive an irregular stream of orders since the use of EOQ usually leads to orders at random points.
5. If suppliers are allowing discounts after purchasing quantities above a particular level, the discount will also have to be taken into consideration for fixing the ordering quantity. Also purchasing costs are nowadays reduced to a great extent because of computer links between buyer and seller. So in practice purchasing cost and inventory carrying cost are not exactly opposite to each other.

Often the inventory carrying cost and purchasing cost cannot be identified accurately and sometimes cannot be even identified properly.

Exercise

1. Explain different inventory models in manufacturing.
2. How does inventory help in increasing profits & reducing wastage?
3. Differentiate between ABC analysis & EOQ model.

UNIT - 19

DEPENDENT DEMAND INVENTORY SYSTEM

19.1 MATERIAL REQUIREMENT PLANNING (MRP)

MRP refers to the basic calculations used to determine components required from end item requirements. It also refers to a broader information system that uses the dependence relationship to plan and control manufacturing operations.

"Materials Requirement Planning (MRP) is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy master production schedule requirements."

OBJECTIVES OF MRP

1. **Inventory reduction:** MRP determines how many components are required when they are required in order to meet the master schedule. It helps to procure the materials/ components as and when needed and thus avoid excessive build up of inventory.
2. **Reduction in the manufacturing and delivery lead times:** MRP identifies materials and component quantities, timings when they are needed, availabilities and procurements and actions required to meet delivery deadlines. MRP helps to avoid delays in production and priorities production activities by putting due dates on customer job order.
3. **Realistic delivery commitments:** By using MRP, production can give marketing timely information about likely delivery times to prospective customers.
4. **Increased efficiency:** MRP provides a close coordination among various work centres and hence help to achieve uninterrupted flow of materials through the production line. This increases the efficiency of production system.

MRP SYSTEM

The inputs to the MRP system are: (1) A master production schedule, (2) An inventory status file and (3) Bill of materials (BOM).

Using these three information sources, the MRP processing logic (computer programme) provides three kinds of information (output) for

each product component: order release requirements, order rescheduling and planned orders.

1. Master Production Schedule (MPS)

MPS is a series of time phased quantities for each item that a company produces, indicating how many are to be produced and when. MPS is initially developed from firm customer orders or from forecasts of demand before MRP system begins to operate. The MRP system whatever the master schedule demands and translates MPS end items into specific component requirements. Many systems make a simulated trial run to determine whether the proposed master can be satisfied.

2. Inventory Status File

Every inventory item being planned must have an inventory status file which gives complete and up to date information on the on-hand quantities, gross requirements, scheduled receipts and planned order releases for an item. It also includes planning information such as lot sizes, lead times, safety stock levels and scrap allowances.

3. Bill of Materials (BOM)

BOM identifies how each end product is manufactured, specifying all subcomponents items, their sequence of build up, their quantity in each finished unit and the work centers performing the buildup sequence. This information is obtained from product design documents, workflow analysis and other standard manufacturing information.

REORDER POINT

The reorder point ("ROP") is the level of inventory when an order should be made with suppliers to bring the inventory up by the Economic order quantity ("EOQ").

The reorder point for replenishment of stock occurs when the level of inventory drops down to zero. In view of instantaneous replenishment of stock the level of inventory jumps to the original level from zero level.

In real life situations one never encounters a zero lead time. There is always a time lag from the date of placing an order for material and the date on which materials are received. As a result the reorder point is always higher than zero, and if the firm places the order when the inventory reaches the reorder point, the new goods will arrive before the firm runs out of goods to sell. The decision on how much stock to hold is generally referred to as the order point problem, that is, how low should the inventory be depleted before it is reordered.

The two factors that determine the appropriate order point are the delivery time stock which is the Inventory needed during the lead time (i.e., the difference between the order date and the receipt of the inventory ordered)

and the safety stock which is the minimum level of inventory that is held as a protection against shortages due to fluctuations in demand.

Therefore:

Reorder Point = Normal consumption during lead-time + Safety Stock.

Several factors determine how much delivery time stock and safety stock should be held. In summary, the efficiency of a replenishment system affects how much delivery time is needed. Since the delivery time stock is the expected inventory usage between ordering and receiving inventory, efficient replenishment of inventory would reduce the need for delivery time stock. And the determination of level of safety stock involves a basic trade-off between the risk of stock out, resulting in possible customer dissatisfaction and lost sales, and the increased costs associated with carrying additional inventory.

Another method of calculating reorder level involves the calculation of usage rate per day, lead time which is the amount of time between placing an order and receiving the goods and the safety stock level expressed in terms of several days' sales.

Reorder level = Average daily usage rate x lead-time in days.

From the above formula it can be easily deduced that an order for replenishment of materials be made when the level of inventory is just adequate to meet the needs of production during lead-time.

Comparison of Order Point and MRP Models

Feature	MRP	Order Point
Demand	Dependent	Independent
Order philosophy	Requirements	Replenishment
Objectives	Meet manufacturing needs	Meet customer need
Demand pattern	Lumpy and predictive	Random
Type of inventory	Work-in-process and raw material	Finished goods and spare parts
Forecast	Based on MPS	Based on past demand
Control concept	Control all items	ABC analysis
Lot sizing	Discrete	Economic Order Quantity (EOQ)

Three principal functions of MRP:

Inventory

- Order the right part
- Order in the right quantity

- Order at the right time

Priorities

- Order with the right due date
- Keep the due date valid

Capacity

- A complete load
- An accurate (valid) load
- An adequate time span for visibility of future load

MRP Elements

Inputs

1. Master Schedule
2. Bill of Materials (BOM)
3. Inventory Records

Capacity planning (feasibility)

Planned Order Releases (*outputs*)

- Purchasing (buy)
- Shop Floor Control (make)

MRP Inputs

Master schedule

Product structure file (bill of materials or BOM)

- Parts & subassemblies contained in product
- Sequence of operations

Inventory master file

- Item master information
- Balances & ordering information
-

The Function of Material Requirements Planning (MRP)

What is MRP? MRP is a tool to help manage production and purchasing. MRP assumes that there is sufficient capacity to produce the suggestions put forth.

Although MRP is a common term, no two MRP systems look and plan in the same ways. The differences may include the underlying logic, the user interface, and the phrases or jargon used.

MRP has three basic steps. These steps are:

- Identifying requirements for items to be included in an MRP run.
- Running MRP and creating the suggestions.
- Firming the suggestions to release manufacturing orders and purchase orders.

The purpose of this guide is to outline how System 2000's MRP operates, and the data used to develop the plan. In order to fully utilize MRP, several other modules of System 2000 are required to be installed and operational. These required modules include Customer Orders, Purchasing, Inventory Management, Sales Analysis and Manufacturing.

Methodology of a MRP project implementation / alternative techniques

MRP represents an innovation in the manufacturing environment. Thus, its effective implementation requires explicit management action. Steps need to be clearly identified and necessary measures be taken to ensure organizational responsiveness to the technique being implemented.

"Cookbook" like models for implementing MRP does not exist. Each organization poses a unique environment and that means that specific actions need to be taken with due regard to environment specifics.

We approach MRP as an organizational innovation and identify the necessary measure which management should adopt in implementing it. Motivational influences underlying MRP implementation include:

1. *Recognition of business opportunity* for the timely acquisition of MRP.
2. *Recognition of technical opportunity* for the timely acquisition of the technologies supporting MRP implementation.
3. *Recognition of need* for solving manufacturing and/or inventory problems using MRP.

Given the above motivational factors one may readily identify *what* and *how* issues underlying MRP design and implementation.

What refers to a generic process model composed of steps and indicative levels of effort to implement each step? *How* refers to management involvement with respect to the process.

CONDITIONS FOR IMPLEMENTATION

Several requirements have to be met, in order to given an MRP implementation project a chance of success:

- Availability of a computer based manufacturing system is a must. Although it is possible to obtain material requirements plan manually, it would be impossible to keep it up to date because of the highly dynamic nature of manufacturing environments.

- A feasible master production schedule must be drawn up, or else the accumulated planned orders of components might “bump” into the resource restrictions and become infeasible.
- The bills of material should be accurate. It is essential to update them promptly to reflect any engineering changes brought to the product. If a component part is omitted from the bill of material it will never be ordered by the system.
- Inventory records should be a precise representation of reality, or else the netting process and the generation of planned orders become meaningless.
- Lead times for all inventory items should be known and given to the MRP system.
- Shop floor discipline is necessary to ensure that orders are processed in conformity with the established priorities. Otherwise, the lead times passed to MRP will not materialize.

IMPLEMENTATION PROCEDURE OF MRP

Steps / Phases of a MRP project

The material requirements planning portion of manufacturing activities interacts with the master schedule, bill of materials file, inventory records file, and the output reports.

INPUTS TO A STANDARD MRP PROGRAM

Demand for Products: Product demand for end items stems from two main reasons. The first is known customers who have placed specific orders, such as those generated by sales personnel, or from interdepartmental transactions. The second source is forecast demand.

Demand from known customers and demand forecast are combined and become the input to the master production schedule.

Bill of Materials File: The bill of Materials file contains the complete product description, listing materials, parts, and components but also the sequence in which the product is created.

The BOM file is often called the product structure file or product tree because it shows how a product is put together. It contains the information to identify each item and the quantity used per unit of the item of which it is a part.

Inventory Records File: Inventory records file under a computerized system can be quite lengthy. Each item in inventory is carried as a separate file and the range of details carried about an item is almost limitless. The MRP program accesses the status segment of the file according to specific time periods. These files are accessed as needed during the program run.

MRP COMPUTER PROGRAM

The MRP program works as follows:

- ☐ A list of end items needed by time periods is specified by the master production schedule.
- ☐ A description of the materials and parts needed to make each item is specified in the bill of materials file.
- ☐ The number of units of each item and material currently on hand and on order are contained in the inventory file.
- ☐ The MRP program “works” on the inventory file. In addition, it continuously refers to the bill of materials file to compute quantities of each item needed.
- ☐ The number of units of each item required is then corrected for on hand amounts, and the net requirement is “offset” to allow for the lead time needed to obtain the material.

Output Reports

Primary Reports: Primary reports are the main or normal reports used for the inventory and production control. These report consist of

1. *Planned orders* to be released at a future time.
2. *Order release notices* to execute the planned orders.
3. *Changes in due dates* of open orders due to rescheduling.
4. *Cancellations or suspensions* of open orders due to cancellation or suspension of orders on the master production schedule.
5. *Inventory status data.*

Secondary Reports: Additional reports, which are optional under the MRP system, fall into three main categories:

1. *Planning reports* to be used, for example, in forecasting inventory and specifying requirements over some future time horizon.
2. *Performance reports* for purposes of pointing out inactive items and determining the agreement between actual and programmed item lead times and between actual and
3. *Exceptions reports* that point out serious discrepancies, such as errors, out of range situations, late or overdue orders, excessive scrap, or nonexistent parts.

PARTIAL TECHNIQUES AND TOOLS INCLUDED IN EACH STEP

In order to achieve successful results from the use of a MRP system, many variables (e.g. demand of orders) must be taken into

consideration and thorough examination. Statistical tools and forecasting techniques are necessary to predict the unknown demand. In addition to these, many more techniques are used, which are borrowed from the fields of:

- ☐ Production management
- ☐ Control of production
- ☐ Warehouse management

RELATED SOFTWARE

Since the start of MRP in the late 1960s, many systems have been developed and sold by many software and consulting firms. While other competing-type integrated information programs have been and will probably continue to be developed, MRP-based systems will likely stay in the lead. This is because the firms currently in MRP systems are continuing to develop and enhance them. The list also includes MRPII and ERP software, which can be used in order to apply MRP method.

MANUFACTURING RESOURCE PLANNING

Manufacturing resource planning (MRP II) is defined as a method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning, and has a simulation capability to answer "what-if" questions and extension of closed-loop MRP.

This is not exclusively a software function, but management of people skills, dedication to database accuracy, and computer resources. It is a total company management concept for using human resources more productively.

KEY FUNCTIONS AND FEATURES

MRP II is not a proprietary software system and can thus take many forms. It is almost impossible to visualize an MRP II system that does not use a computer, but an MRP II system can be based on either purchased-licensed or in-house software.

Almost every MRP II system is modular in construction. Characteristic basic modules in an MRP II system are:

- Master production schedule (MPS)
- Item master data (technical data)
- Bill of materials (BOM) (technical data)
- Production resources data (manufacturing technical data)
- Inventories and orders (inventory control)

- Purchasing management
- Material requirements planning (MRP)
- Shop floor control (SFC)
- Capacity planning or capacity requirements planning (CRP)
- Standard costing (cost control)
- Cost reporting / management (cost control)

Together with auxiliary systems such as:

- Business planning
- Lot traceability
- Contract management
- Tool management.
- Engineering change control
- Configuration management
- Shop floor data collection
- Sales analysis and forecasting
- Finite capacity scheduling (FCS)

And related systems such as:

- General ledger
- Accounts payable (purchase ledger)
- Accounts receivable (sales ledger)
- Sales order management
- (Distribution requirements planning) (DRP)
- Automated warehouse management
- Project management
- Technical records
- Estimating
- Computer-aided design/computer-aided manufacturing (CAD/CAM)
- CAPP

The MRP II system integrates these modules together so that they use common data and freely exchange information, in a model of how a manufacturing enterprise should and can operate. The MRP II approach is therefore very different from the “point solution” approach, where individual systems are deployed to help a company plan, control or

manage a specific activity. MRP II is by definition fully integrated or at least fully interfaced.

MRP AND MRPII: GENERAL CONCEPTS

Material requirements planning (MRP) and manufacturing resource planning (MRPII) are both incremental information integration business process strategies that are implemented using hardware and modular software applications linked to a central database that stores and delivers business data and information.

MRP is concerned primarily with manufacturing materials while MRPII is concerned with the coordination of the entire manufacturing production, including materials, finance, and human relations. The goal of MRPII is to provide consistent data to all players in the manufacturing process as the product moves through the production line.

Paper-based information systems and non-integrated computer systems that provide paper or disk outputs result in many information errors, including missing data, redundant data, numerical errors that result from being incorrectly keyed into the system, incorrect calculations based on numerical errors, and bad decisions based on incorrect or old data. In addition, some data is unreliable in non-integrated systems because the same data is categorized differently in the individual databases used by different functional areas.

MRPII systems begin with MRP, material requirements planning. MRP allows for the input of sales forecasts from sales and marketing. These forecasts determine the raw materials demand. MRP and MRPII systems draw on a master production schedule, the breakdown of specific plans for each product on a line. While MRP allows for the coordination of raw materials purchasing, MRPII facilitates the development of a detailed production schedule that accounts for machine and labor capacity, scheduling the production runs according to the arrival of materials. An MRPII output is a final labor and machine schedule. Data about the cost of production, including machine time, labor time and materials used, as well as final production numbers, is provided from the MRPII system to accounting and finance (Monk and Wagner).

Benefits

MRP II systems can provide:

- Better control of inventories
- Improved scheduling
- Productive relationships with suppliers

For design / engineering:

- Improved design control
- Better quality and quality control

For financial and costing:

- Reduced working capital for inventory
- Improved cash flow through quicker deliveries
- Accurate inventory records

Self Assessment Questions

1. What are the objectives of material requirement planning? How in a company MRP plays an important role?
2. What is the difference between MRP and MRP II?
3. Explain the key features 7 functions of MRP.

UNIT - 20

SCHEDULING

20.1

Scheduling can be defined as “prescribing of when and where each operation necessary to manufacture the product is to be performed.”

It is also defined as “establishing of times at which to begin and complete each event or operation comprising a procedure”. The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date.

Scheduling is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce costs.

Production scheduling tools greatly outperform older manual scheduling methods. These provide the production scheduler with powerful graphical interfaces which can be used to visually optimize real-time work loads in various stages of production, and pattern recognition allows the software to automatically create scheduling opportunities which might not be apparent without this view into the data. For example, an airline might wish to minimize the number of airport gates required for its aircraft, in order to reduce costs, and scheduling software can allow the planners to see how this can be done, by analyzing time tables, aircraft usage, or the flow of passengers.

Companies use backward and forward scheduling to allocate plant and machinery resources, plan human resources, plan production processes and purchase materials. Forward scheduling is planning the tasks from the date resources become available to determine the shipping date or the due date.

Backward scheduling is planning the tasks from the due date or required-by date to determine the start date and/or any changes in capacity required.

The benefits of production scheduling include:

- Process change-over reduction
- Inventory reduction, leveling
- Reduced scheduling effort
- Increased production efficiency

- Labor load leveling
- Accurate delivery date quotes
- Real time information

PRINCIPLES OF SCHEDULING

1. **The principle of optimum task size:** Scheduling tends to achieve maximum efficiency when the task sizes are small, and all tasks of same order of magnitude.
2. **Principle of optimum production plan:** The planning should be such that it imposes an equal load on all plants.
3. **Principle of optimum sequence:** Scheduling tends to achieve the maximum efficiency when the work is planned so that work hours are normally used in the same sequence.

INPUTS TO SCHEDULING

1. *Performance standards:* The information regarding the performance standards (standard times for operations) helps to know the capacity in order to assign required machine hours to the facility.
2. Units in which loading and scheduling is to be expressed.
3. Effective capacity of the work centre.
4. Demand pattern and extent of flexibility to be provided for rush orders.
5. Overlapping of operations.
6. Individual job schedules.

SCHEDULING STRATEGIES

Scheduling strategies vary widely among firms and range from 'no scheduling' to very sophisticated approaches.

These strategies are grouped into four classes:

1. **Detailed scheduling:** Detailed scheduling for specific jobs that are arrived from customers is impracticable in actual manufacturing situation. Changes in orders, equipment breakdown, and unforeseen events deviate the plans.
2. **Cumulative scheduling:** Cumulative scheduling of total work load is useful especially for long range planning of capacity needs. This may load the current period excessively and under load future periods. It has some means to control the jobs.

3. **Cumulative detailed:** Cumulative detailed combination is both feasible and practical approach. If master schedule has fixed and flexible portions.
4. **Priority decision rules:** Priority decision rules are scheduling guides that are used independently and in conjunction with one of the above strategies, *i.e.*, first come first serve.

These are useful in reducing Work-In-Process (WIP) inventory.

TYPES OF SCHEDULING

Types of scheduling can be categorized as forward scheduling and backward scheduling.

1. **Forward scheduling** is commonly used in job shops where customers place their orders on "needed as soon as possible" basis. Forward scheduling determines start and finish times of next priority job by assigning it the earliest available time slot and from that time, determines when the job will be finished in that work centre. Since the job and its components start as early as possible, they will typically be completed before they are due at the subsequent work centers in the routing. The forward method generates in the process inventory that is needed at subsequent work centers' and higher inventory cost. Forward scheduling is simple to use and it gets jobs done in shorter lead times, compared to backward scheduling.
2. **Backward scheduling** is often used in assembly type industries and commit in advance to specific delivery dates. Backward scheduling determines the start and finish times for waiting jobs by assigning them to the latest available time slot that will enable each job to be completed just when it is due, but done before. By assigning jobs as late as possible, backward scheduling minimizes inventories since a job is not completed until it must go directly to the next work centre on its routing.

SCHEDULING METHODOLOGY

The scheduling methodology depends upon the type of industry, organization, product, and level of sophistication required. They are:

1. Charts and boards,
 2. Priority decision rules, and
 3. Mathematical programming methods.
1. **Gantt Charts and Boards**

Gantt charts and associated scheduling boards have been extensively used scheduling devices in the past, although many of the charts are now drawn by computer. Gantt charts are extremely easy to

understand and can quickly reveal the current or planned situation to all concerned. They are used in several forms, namely,

- (a) Scheduling or progress charts, which depicts the sequential schedule;
- (b) Load charts, which show the work assigned to a group of workers or machines; and
- (c) Record a chart, which are used to record the actual operating times and delays of workers and machines.

2. Priority Decision Rules

Priority decision rules are simplified guidelines for determining the sequence in which jobs will be done. In some firms these rules take the place of priority planning systems such as MRP systems. Following are some of the priority rules followed.

<i>Symbol</i>	<i>Priority rule</i>
FCFS	First come, first served
EDO	Earliest due date
LS	Least slack (that is, time due less processing time)
SPT	Shortest processing time
LPT	Longest processing time
PCO	Preferred customer order
RS	Random selection

3. Mathematical Programming Methods

Scheduling is a complex resource allocation problem. Firms process capacity, labor skills, materials and they seek to allocate their use so as to maximize a profit or service objective, or perhaps meet a demand while minimizing costs.

The following are some of the models used in scheduling and production control.

- a. **Linear programming model:** Here all the constraints and objective functions are formulated as a linear equation and then problem is solved for optimality. *Simplex method*, *transportation methods* and *assignment method* are major methods used here.
- b. **PERT/CPM network model:** PERT/CPM network is the network showing the sequence of operations for a project and the precedence relation between the activities to be completed.

MASTER PRODUCTION SCHEDULE SYSTEM

A master production schedule (MPS) is a plan for individual commodities to produce in each time period such as production, staffing, inventory etc. It is usually linked to manufacturing where the plan indicates

when and how much of each product will be demanded. This plan quantifies significant processes, parts, and other resources in order to optimize production, to identify bottlenecks, and to anticipate needs and completed goods. Since an MPS drives much factory activity, its accuracy and viability dramatically affect profitability. Typical MPS's are created by software with user tweaking.

Due to software limitations, but especially the intense work required by the "master production schedulers", schedules do not include every aspect of production, but only key elements that have proven their control effectively, such as forecast demand, production costs, inventory costs, lead time, working hours, capacity, inventory levels, available storage, and parts supply. The choice of what to model varies among companies and factories. The MPS is a statement of what the company expects to produce and purchase (i.e. quantity to be produced, staffing levels, dates, available to promise, projected balance). The MPS translates the business plan, including forecast demand, into a production plan using planned orders in a true multi-level optional component scheduling environment. Using MPS helps avoid shortages, costly expediting, last minute scheduling, and inefficient allocation of resources. Working with MPS allows businesses to consolidate planned parts, produce master schedules and forecasts for any level of the Bill of Material (BOM) for any type of part.

MASTER PRODUCTION SCHEDULE (MPS)

- Anticipated build schedule for manufacturing end products (or product options).
- A statement of production, not a statement of market demand.
- MPS takes into account capacity limitations, as well as desires to utilize capacity fully.
- Stated in product specifications – in part numbers for which bill of material exist.
- Since it is a build schedule, it must be stated in terms used to determine component part needs and other requirements; not in monetary or other global unit of measure.
- Specific products may be groups of items such as models instead of end items.
 - The exact product mix may be determined with Final Assembly Schedule (FAS), which is not ascertained until the latest possible moment.
 - If the MPS is to be stated in terms of product groups, we must create a special bill of material (planning bill) for these groups.

TASK PERFORMED BY A MASTER PRODUCTION SCHEDULER

Construct and update the MPS.

- Involves processing MPS transactions, maintaining MPS records and reports, having a periodic review and update cycle (rolling through time), processing and responding to exception conditions, and measuring MPS effectiveness on a routine basis.
- On a day-to-day basis, marketing and production are coordinated through the
- MPS in terms of Order Promising
- Order promising is the activity by which customer order requests receive shipment dates.

AN EFFECTIVE MPS PROVIDES

- Basis for making customer delivery promises
- Utilizing plant capacity effectively
- Attaining the firm's strategic objectives as reflected in the production plan and
- Resolving trade-off between manufacturing and marketing
- Since MPS is the basis for manufacturing budgets, the financial budgets should be integrated with production planning/MPS activities
- When MPS is extended over a time horizon, is a better basis for capital budgeting.
- Based on the production output specified in the MPS the day-to-day cash flow can be forecasted.
- The MPS should be realizable and not overstated.
- When scheduled production exceeds capacity, usually some or all of the following occur:
 - Invalid priority
 - Poor customer service (missed deliveries)
 - Excess in-process inventories
 - High expediting costs
 - Lack of accountability

MASS PRODUCTION

Mass production is the production of large amounts of standardized products, including and especially on assembly lines. With job production and batch production it is one of the three main production methods.^[1]

The concepts of mass production are applied to various kinds of products, from fluids and particulates handled in bulk (such as food, fuel, chemicals, and mined minerals) to discrete solid parts (such as fasteners) to assemblies of such parts (such as household appliances and automobiles). Mass production is a diverse field, but it can generally be contrasted with craft production or distributed manufacturing. It has occurred for centuries; there are examples of production methods that can best be defined as mass production that predate the Industrial Revolution. However, it has been widespread in human experience, and central to economics, only since the late 19th century.

Mass Production involves making many copies of products, very quickly, using assembly line techniques to send partially complete products to workers who each work on an individual step, rather than having a worker work on a whole product from start to finish.

Mass production of fluid matter typically involves pipes with centrifugal pumps or screw conveyors (augers) to transfer raw materials or partially complete product between vessels. Fluid flow processes such as oil refining and bulk materials such as wood chips and pulp are automated using a system of process control which uses various instruments to measure variables such as temperature, pressure, volumetric and level, providing feedback. Bulk materials such as coal, ores, grains and wood chips are handled by belt, chain, slat, pneumatic or screw conveyors, bucket elevators and mobile equipment such as front-end loaders. Materials on pallets are handled with forklifts. Also used for handling heavy items like reels of paper, steel or machinery are electric overhead cranes, sometimes called bridge ~~cranes~~ because they span large factory

Mass production is capital intensive and energy intensive, as it uses a high proportion of machinery and energy in relation to workers. It is also usually automated while total expenditure per unit of product is decreased. However, the machinery that is needed to set up a mass production line (such as robots and machine presses) is so expensive that there must be some assurance that the product is to be successful to attain profits.

One of the descriptions of mass production is that "the skill is built into the tool", which means that the worker using the tool need not have the skill. For example, in the 19th or early 20th century, this could be expressed as "the craftsmanship is in the workbench itself" (not the training of the worker). Rather than having a skilled worker measures every dimension of each part of the product against the plans or the other parts as it is being formed, there were jigs ready at hand to ensure that the

part was made to fit this set-up. It had already been checked that the finished part would be to specifications to fit all the other finished parts—and it would be made more quickly, with no time spent on finishing the parts to fit one another. Later, once computerized control came about (for example, CNC), jigs were obviated, but it remained true that the skill (or knowledge) was built into the tool (or process, or documentation) rather than residing in the worker's head. This is the specialized capital required for mass production; each workbench and set of tools (or each CNC cell, or each fractionating column) is different (fine-tuned to its task).

ADVANTAGES AND DISADVANTAGES

The economies of mass production come from several sources. The primary cause is a reduction of nonproductive effort of all types. In craft production, the craftsman must bustle about a shop, getting parts and assembling them. He must locate and use many tools many times for varying tasks. In mass production, each worker repeats one or a few related tasks that use the same tool to perform identical or near-identical operations on a stream of products. The exact tool and parts are always at hand, having been moved down the assembly line consecutively. The worker spends little or no time retrieving and/or preparing materials and tools, and so the time taken to manufacture a product using mass production is shorter than when using traditional methods.

The probability of human error and variation is also reduced, as tasks are predominantly carried out by machinery. A reduction in labor costs, as well as an increased rate of production, enables a company to produce a larger quantity of one product at a lower cost than using traditional, non-linear methods.

However, mass production is inflexible because it is difficult to alter a design or production process after a production line is implemented. Also, all products produced on one production line will be identical or very similar, and introducing variety to satisfy individual tastes is not easy. However, some variety can be achieved by applying different finishes and decorations at the end of the production line if necessary. the starter cost for the machinery can be expensive so the producer must be sure it sells or the producers will lose a lot of money.

The Ford Model T produced tremendous affordable output but was not very good at responding to demand for variety, customization, or design changes. As a consequence Ford eventually lost market share to General Motors, who introduced annual model changes, more accessories and a choice of colors.^[5]

With each passing decade, engineers have found ways to increase the flexibility of mass production systems, driving down the lead times on new product development and allowing greater customization and variety of products.

BATCH PRODUCTION

Batch production is a technique used in manufacturing, in which the object in question is created stage by stage over a series of workstations. With job production and flow production it is one of the three main production methods.

Batch production is most common in bakeries and in the manufacture of sports shoes, pharmaceutical ingredients, purifying water (APIs), inks, paints and adhesives. In the manufacture of inks and paints, a technique called a color-run is used. A color-run is where one manufactures the lightest color first, such as light yellow followed by the next increasingly darker color such as orange, then red and so on until reaching black and then starts over again.

For example, in small bakeries and many homes, as opposed to large food manufacturing companies, cookies are baked in batches. A baker must first make the dough, then place it onto baking sheets, and then bake it. People are limited as to how many cookies they can produce at one time by the number of baking sheets and ovens they possess, and by the size of bowls available to mix each batch.

This is batch production, since a large number of cookies is baked at the same time, and bakers can't skip from one step to the next until each process is complete. They can't start cooking the cookies until they've made the dough, and they can't remove the cookies from the oven (in most cases) until all the cookies are done, unless using an oven with a conveyor belt. There are necessary steps that apply to the whole batch of cookies. Cooking may requires a baker to bake in individual batches, increasing the final time between finishing the dough and actually having completed baking all the cookies.

Sometimes, this type of production is necessary when a manufacturer is producing similar things, but with variants. For instance, if a company manufactures two colors of the same shoe, it would probably use batch production. Any dyeing of leather or fabric can't apply to the whole set of shoes since they're different colors, which can mean stopping in between each batch to change or clean machines, or prepare to add new dyes for the next variation. The necessity of stopping between batches is called "down time," and is why some people find this method of production an inefficient manufacturing process. Time needed to prepare equipment or machines for the next batch can reduce total amount that can be manufactured and take longer in total production time.

ADVANTAGES AND DISADVANTAGES

There are several advantages of batch production; it can reduce initial capital outlay (the cost of setting up the machines) because a single production line can be used to produce several products. As shown in the example, batch production can be useful for small businesses who cannot afford to run continuous production lines. If a retailer buys a batch of a

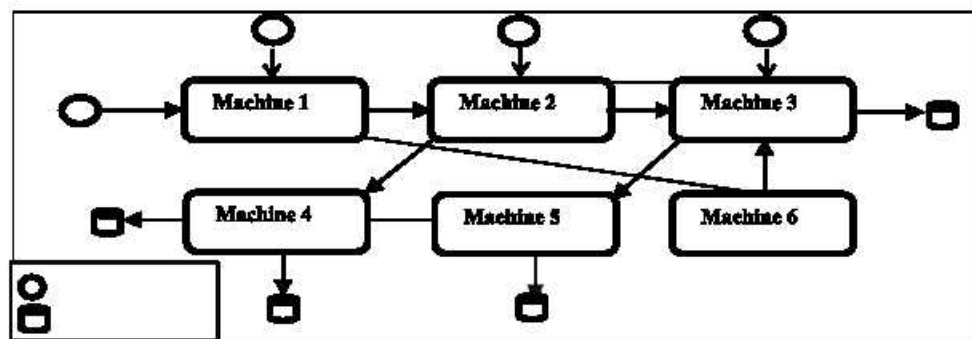
product that does not sell, then the producer can cease production without having to sustain huge losses. Batch production is also useful for a factory that makes seasonal items, products for which it is difficult to forecast demand, a trial run for production, or products that have a high profit margin.

Batch production also has some drawbacks. There are inefficiencies associated with batch production as equipment must be stopped, re-configured, and its output tested before the next batch can be produced. Idle time between batches is known as downtime. The time between consecutive batches is known as cycle time. Cycle time variation is a Lean Manufacturing metric.

Continuous production is used for products that are made in a similar manner. For example, a certain car model has the same body shape and therefore, many of the same model cars can be made at the same time without stop, decreasing manufacturing cost.

JOB SHOP PRODUCTION

Job shops are typically small manufacturing systems that handle job production, that is, custom/bespoke or semi-custom/bespoke manufacturing processes such as small to medium-size customer orders or batch jobs. Job shops typically move on to different jobs (possibly with different customers) when each job is completed. In job shops machines are aggregated in shops by the nature of skills and technological processes involved, each shop therefore may contain different machines, which gives this production system processing flexibility, since jobs are not necessarily constrained to a single machine. In computer science the problem of job shop scheduling is considered strongly NP-hard.



In a job shop product is twisted, also notice that in this drawing each shop contains a single machine.

A typical example would be a machine shop, which may make parts for local industrial machinery, farm machinery and implements, boats and ships, or even batches of specialized components for the aircraft industry. Other types of common job shops are grinding, honing, jig-boring, gear manufacturing, and fabrication shops.

The opposite would be continuous flow manufactures such as textile, steel, food manufacturing and manual labor.

ADVANTAGES

- High production mix flexibility
 - High flexibility in product engineering
 - High expansion flexibility (machines are easily added or substituted)
 - High production volume elasticity
 - Low obsolesce
 - High robustness to machine failures
- Compare to transfer line

DISADVANTAGES

- Very hard scheduling
- Low capacity utilization

Self Assessment Questions

1. What is scheduling?
2. Mention the types of scheduling.
3. What are the inputs to scheduling?
4. Explain the scheduling strategies.
5. Discuss the scheduling methods.
6. Describe different types of production method.

