UG BA S4-03
(DSC/DSE)

FOUR YEAR BACHELOR'S DEGREE COURSE

(CBCS in Accordance with NEP 2020)

semester - IV

PRODUCTION AND OPERATIONS MANAGEMENT

MANAGEMENT



Maniram Dewan School of Management
KRISHNA KANTA HANDIQUI STATE OPEN UNIVERSITY

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BACHELOR IN BUSINESS ADMINISTRATION
PRODUCTION AND OPERATION MANAGEMENT

Block

DETAILED SYLLABUS

UNIT 1: Introduction to Production and Operations Management **Pages : 9 – 20**

Basic Concepts; Production management concepts; Types of Process Design; Automation in Production and Operations.

UNIT 2: Process Design **Pages : 21 – 32**

Types of process design, cellular manufacturing, Inter relationship among product design, process design and Inventory Policy, Automations in Production and operations.

UNIT 3: Plant Location & Layout **Pages : 33 – 46**

Concept of Location; Plant Location; Plant Location Methodology; Plant Layout.

UNIT 4: Job Design **Pages : 47 – 58**

Job Design; Work Study; Method Study; Work Measurement; Work Sampling.

UNIT 5: Product Design **Pages : 59 – 71**

Types of New Products, The Process of New Product Development, Design For Manufacturability, Designing For Quality, Rapid Prototyping, Designing And Developing New Services.

UNIT 6: Inventory Management **Pages : 72 – 78**

Concept of Inventory, Types of inventory, Disadvantages of high level and low level inventories, Reasons for maintaining Inventory, Types of Inventory System

UNIT 7: Techniques of Inventory management **Pages : 79 – 93**

Economic Order Quantity, ABC analysis.

UNIT 8: Maintenance Management **Pages : 94 – 109**

Objectives and Types of maintenance, Maintenance Policy,Need for replacement, Replacement problems, Determination of maintenance crew size, Reliability and Information system for maintenance management

UNIT 9: Capacity Planning **Pages : 110 – 129**

Concept of Capacity Planning, Types of Capacity, Measures of Capacity, Capacity Planning Strategies, Flexibility in Capacity in a facility, Increasing the capacity of a plant, Estimating Capacity of a Facility and Capacity Planning

UNIT 10: Production Planning and Control **Pages : 130 – 140**

Meaning and definition of Production Planning and Control,Elements of Production Planning and Control,Techniques of Control and Advantages of Production Planning and Control

UNIT 11: Introduction to Purchasing **Pages : 141 – 155**

Overview Of Purchasing Function, Activities Under Purchasing Function, Transition Of Purchase To Supply Management, Types Of Calls For Bids, Locating Tenders, Selection Of Bidders, Bidding Process, Technical Evaluation, Commercial Evaluation, Negotiating, Selection And Award and Post-Award Administration

UNIT 12: Material Requriment Planning **Pages : 156 – 168**

Product Structure, Bill of Material,concept of Material Requirements Planning (MRP), Using the MRP System, Manufacturing Resources Planning (MRP–II), Meaning and Definition of Production Planning, Control and Elements of Production Planning and Control and Techniques of Control.

UNIT 13: Quality Management **Pages : 169 – 185**

Quality Management Evolution, definitions of Quality, Benefits of Quality Management, Dimensions of Quality, Determinants of Quality, Causes of Quality Failure, Quality Control, Inspection, Quality Assurance, Quality in Services, Quality Costs and Control Surplus and Waste Disposal

UNIT 14: Maintenance Management **Pages : 186 – 204**

Objectives and types of Maintenance, Maintenance Policy , Need for replacement, Criteria for Replacement, Replacement problems, Reliability, Determination of Maintenance crew size and Information system for Maintenance Management

UNIT 15: Total Quality Management **Pages : 205 – 222**

concept and essentials Of TQM Culture, Top Management Leadership In TQM, Human Resource Development,Process Management In TQM System, Benefits Due To TQM, TQM “Gurus” And Their Contributions, Components Of TQM , concept and meaning of Six Sigma Quality and JIT Philosophy and its Benefits

COURSE INTRODUCTION:

The course “Production and Operation Management” of B.B.A. 4th Semester will focus on the different aspects of production in the organisation. With the increasing complexities in business organisation the production process also has changed. The business organisation need to produce goods or services at least cost with better quality so that it can get competitive advantage.

Therefore, it is very important for the learners of management programme to be well versed with production and operation management.

deals with the concepts of production and operations management,Process Design,Plant Location and Layout,Job Design,Product Design,Inventory Management and Techniques of Inventory Management

concentrates on Maintenance Management, capacity planning, production planning and control, purchasing , materials requirement planning, quality management, supply chain management and total quality managemenmt.

The structure of the course as follows:

UNIT 1 : Introduction to Production and Operation Management,

UNIT 2 : Process Design

UNIT 3 : Plant Location and Layout

UNIT 4 : Job Design

UNIT 5 : Product Design

UNIT 6 : Inventory Management

UNIT 7 : Techniques of Inventory Management

UNIT 8 : Maintenance Management

UNIT 9 : Capacity Planning

UNIT 10 : Production Planning and Control

UNIT 11 : Introduction to Purchasing

UNIT 12 : Material Requriment Planning

UNIT 13: Quality Management

UNIT 14: Supply Chain Management

UNIT 15: Total Quality Management

Each unit of these blocks includes some along-side boxes to help you know some of the difficult, unseenterms. Some “EXERCISES” have been included to help you apply your own thoughts. You may find some boxes marked with: “LET US KNOW”. These boxes will provide you with some additional interesting and relevant information. Again, you will get “CHECK YOUR PROGRESS” questions. These have been designed to self-check your progress of study. It will be helpful for you if you solve the problems put in these boxes immediately after you go through the sections of the units and then match your answers with “ANSWERS TO CHECK YOUR PROGRESS” given at the end of each unit. you in making your learning more active and efficient. And, at the end of each section, you will get “CHECK YOUR PROGRESS” questions. These have been designed to self-check your progress of study. It will be better if you solve the problems put in these boxes immediately after you go through the sections of the units and then match your answers with “ANSWERS TO CHECK YOUR PROGRESS” given at the end of each unit.

UNIT 1 : INTRODUCTION TO PRODUCTION AND OPERATIONS MANAGEMENT

UNIT STRUCTURE

1.1 Learning Objectives

1.2 Introduction

1.3 Basic Concepts

- 1.3.1 Definition of Production and Operations Management
- 1.3.2 Functions of Production and Operations Manager
- 1.3.3 Decision Making in Production and Operations

1.4 Basic production management concepts

- 1.4.1 Basic Manufacturing Process
- 1.4.2 Major factors affecting process design decisions

1.5 Let Us Sum Up

1.6 Further Reading

1.7 Answers To Check Your Progress

1.8 Model Questions

1.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concept of Production and Operations Management
- describe application of Production and Operations Management in various industries
- discuss the types of Process Design
- explain about the benefits of implementing the modern production and operations management techniques
- get a brief overview of different manufacturing processes.

1.2 INTRODUCTION

In the last two decades the world has witnessed major trends of innovation in this area. Information and Communication technology has influenced the manufacturing and service operations to a large extent.

Automation investment in manufacturing and service industries has improved the quality of products and services. With the help of internet the firms can market and sell their products. With the help of "Enterprise Resource Planning" software packages, now organizations are able to integrate their business processes. Most major companies in the world today operate in many countries. Geographic barriers are no more a constraint for business. In this competitive environment organizations need to operate with limited resources with the tight constraints of time, material, man and money. That is why a better understanding of the concepts of production and operations management and its related issues has become very essential for the academicians and industry professionals. Hence, there is a need for understanding of the concepts of Production and Operations Management. In this unit, we will discuss in detail different issues related to production and operation management.

1.3 BASIC CONCEPTS

1.3.1 Definition of Production and Operations Management

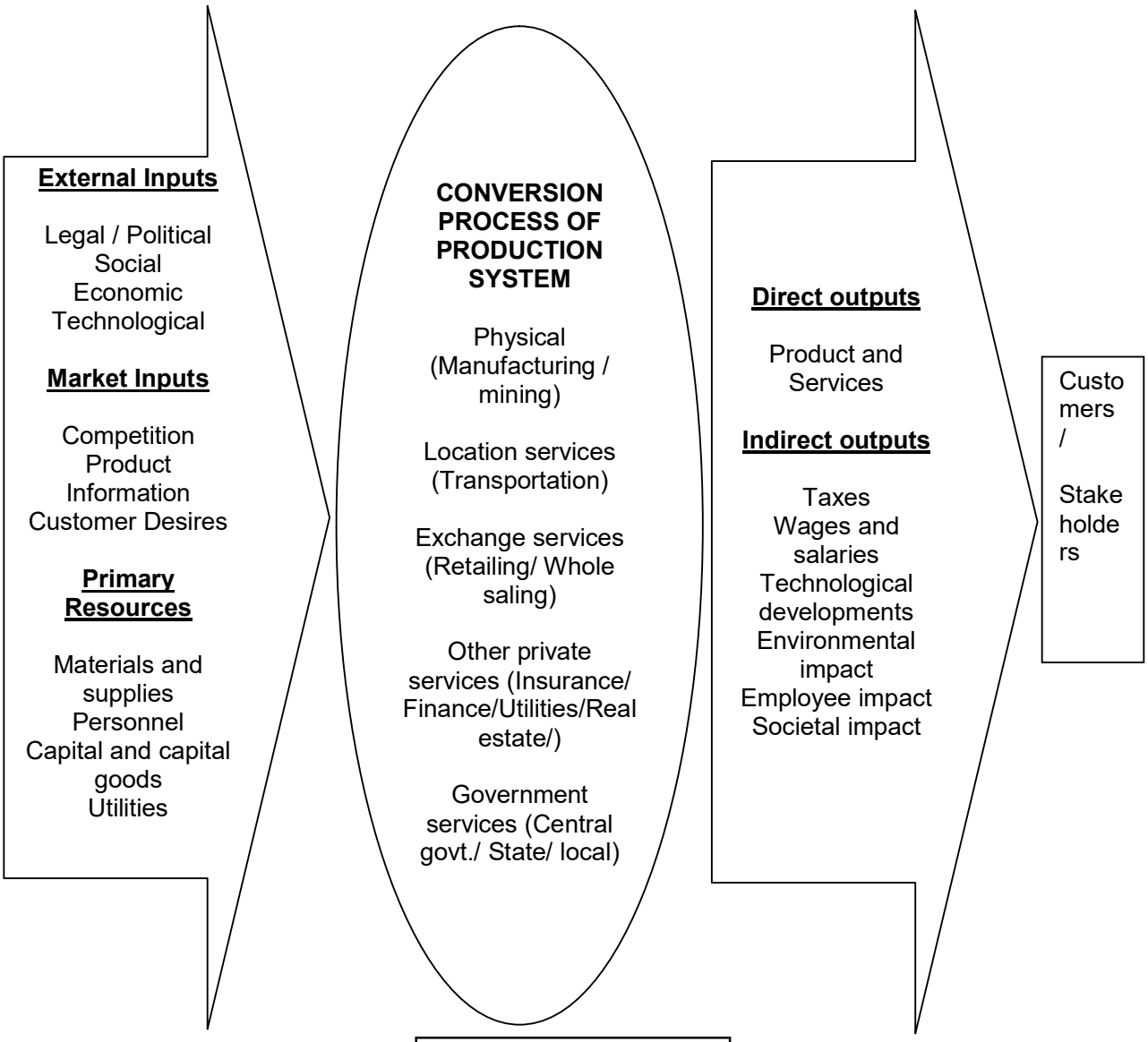
Production Management is the management of an organization's productive resources or its production system, which converts inputs into the organization's product and services.

A Production System takes inputs, such as – raw materials, men, machines, building, technology, cash, information and other resources and converts them into outputs in the form of product or services. This conversion process is the heart of the production system. A Production Manager whom we often term as 'Operations Manager' manages this production system. His primary concerns remain in effectively generating the output from this production system by optimized utilization of inputs viz. raw materials, men, machines, building, technology, cash, information etc.

Different components of production system are discussed as follows:

A. External inputs are information in character that provides

production managers knowledge about external environment conditions outside the production system. Legal or political inputs may establish constraints within which the system must operate. Technological inputs may come from foreign trade journals, government bulletins, trade association news letters and other scientific and management journals. This information equips the product manager to run the production system more effectively by applying modern technologies, tools and machineries.



The production System

Fig. 1.1

B. Market inputs are also tending to be informational in character. Information regarding consumer behaviour pattern, demand, competition, customer expectations and other aspects of the market are the essential inputs for the production system to meet the customers demand effectively.

C. Primary resources are the inputs that directly support the production and delivery of tangible goods and intangible services. These are raw materials, electricity, oil, coal gas, personnel etc.

D. The direct outputs of production system are of two forms:

1. Tangible Goods or Products – e.g: automibles, toothpaste, clothes, soap, shampoo
2. Intangible Services – Hospitals, legal services, management consultancy, banking, insurance etc.

E. Along with the direct output, production system also generates some indirect outputs such as taxes ,wages and salaries, technological developments, environmental impact, employee impact, societal impact etc.

Some examples of the production system, their inputs, outputs and the conversion system is shown in the following table:

Table 1.1

Production System	**Primary inputs**	**Conversion System**	**Outputs**
Departmenta store / Shopping Mall	Displays Shopping carts machines, stock goods, personnel supplies, utilities customers	Attract customers stores foods sells products	Marketed goods
Accounting firm	Supplies, personnel,	Attracts customers	Tax services, Management

	computers govt.	compiles data,	information,
	information, pvt. company's information, buildings, office	uses domain knowledge processes information,	audited financial statements
Food factory	furniture Food grain, water, preservatives machines, packaging materials, buildings, other utilities	computes taxes Converts food ingredients in to packaged foods products	packaged foods products
Automobile factory	Purchases motor parts, supplies, raw materials, tools, machineries, paints, equipments, personnel, building	Transforms raw materials into finished automobiles through machining, fabrication and assembly operations	Automobiles (Cars/Trucks)
College or University	Students, books, personnel, building, laboratory, computers, faculties	Transmits information and develops skills and knowledge	Educated persons.

1.3.2 Functions of Production and Operations Manager

The overall objective of an operations manager is to provide conversion capability to the organization to meet organizational goals and objectives.

The sub goals of the production subsystem must specify

the following:-

a) Production Planning and Control (PPC), when what and how to produce
b) Product services characteristics
c) Product/ Service Quality
d) Efficiency .

The following figure 1.2 explains the basic functions of a production and operations manager. A production and Operation manager has to plan, organize and control the input resources, and the conversion process to get the desired level of output.

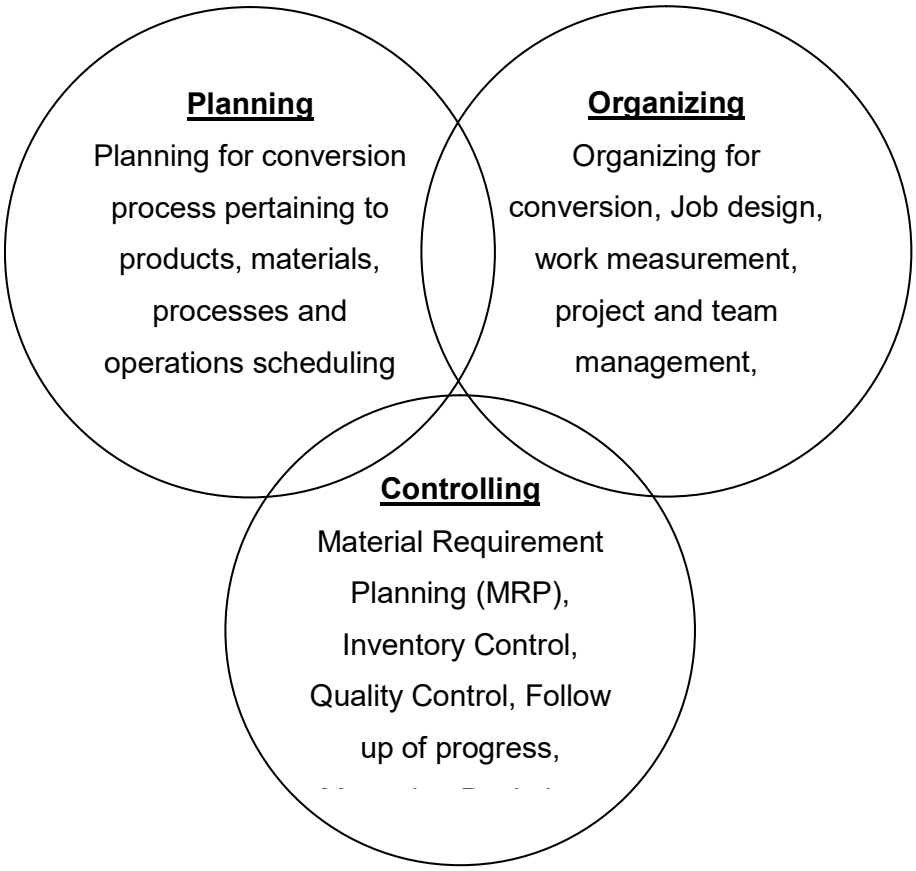


Fig- 1.2

1.3.3 Decision Making in Production and Operations

We can classify the production and operation decisions as follows:

a) Strategic Decisions: The decisions about products, processes and facilities are called strategic decisions. These

decisions are of strategic importance and have long term significance for the organization

b) **Operating Decisions:** The decisions about planning production to meet desired demand are called operating decisions. These decisions are necessary if the ongoing production of goods and services is to satisfy the demands of the market and provide profits for the company.

c) **Control Decisions:** The decisions about planning and controlling the production and operations are control decisions. These decisions concern the day to day activities of the workers, the quality of products and services, production and overhead costs and the maintenance of equipment.

1.4 BASIC PRODUCTION MANAGEMENT CONCEPTS

1.4.1 Basic Manufacturing Process

The production processes for each industry is different from each other. The following exhibit shows some of the common manufacturing processes in different types of industries:

Table 1.2

METAL WORKING PROCESSES

Cutting	*Forming*	*Finishing*	*Assembly*	*Foundry*
Turn	Punch	Clean	Weld	Cast
Drill	Extrude	Paint	Cement	Mould
Mill	Draw	Polish	Solder	Injection
Grind	Roll	Buff	Fasten	Powdered
Shape	trim	Heat treat	fit	Investment casting

Table 1.3

NON METAL

Wood Working	*Textiles*	*Chemicals*	*Food*	*Mining*
Cure	Knit	Absorb	Cook	Excavate
Join	Polish	Cure	Can	Dry
Plane	Spin	Distil	Freeze	Mine
Saw	Weave	Evaporate	Sterilize	Crush
Turn	Wash	Purify	Pasteurize	Smelt

The operations strategy of a company leads to the selection of the production process. The design of a product is directly related to the process design. Therefore, the product or service design is to be done taking the process design into consideration. This is called designing for manufacturing and assembly.

For developing the detail process design the requisite knowledge in depth for the following is needed:

- Production and operation strategy of the company
- Product or service design
- Technology of production system
- Market needs

1.4.2 Major Factors Affecting Process Design Decisions

The process design depends on the following factors:

(1) Nature of Product/ Service demand : The capacity to produce goods or service should be sufficient to match the demand in terms of volumes. The process design varies depending on the type of product and service demanded.

(2) Degree of Vertical Integration : Vertical integration is the portion of production and distribution from the raw material to the delivery of products/ services to the customer under the ownership of a company. A small business house or a startup venture will have low degree of vertical integration.

Considerable components and production process will be sub-contracted/ out sourced to other manufacturers or suppliers. Out sourcing is considered when it is found to be cost effective for the company. While developing the process design one should take into consideration as to what items are to be manufactured under its own roof.

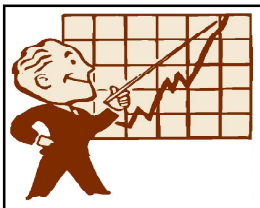
(3) Production Flexibility : The ability to meet the customer's changing demand is production flexibility. It has two parts :

- **Product Flexibility :** It tells about the ability of the production system to produce different designs of the product with the same manufacturing setup. This is possible with flexible manufacturing process using CNC (Computer Numeric Control) machines.
- **Volume Flexibility :** It means the production system's ability to meet the sudden increase or decrease of demand in terms of volume. The process can be made flexible to meet changing market demand pattern.

(4) Degree of Automation : How much automation is to be introduced in production, the process is a key question. The automation of the production process needs an in-depth study and analysis because automation involves heavy capital expenditure. Automation has the potential of:

- Cost reduction in product and service
- Cycle time reduction
- Improvement of Quality of product and service

(5) Quality of product and service : Market is driven by quality of products and services these days. Customers are willing to pay premium price for better quality of products and services. In this competitive environment, one has to design the process of production in such a way that it is capable of producing the products of desired quality consistently.



CHECK YOUR PROGRESS

Q.1: Define Production Management.

_____

_____

Q.2: State the major factors affecting process design decisions.

_____

_____



LET US KNOW

Automation is implemented in service industry also. The following is a table of some examples of automation in service industry :

Service Industry	Automation Examples
Retailing and Wholesaling	● Bar Code system
	● Optical Scanners
	● Point of scale terminals
	● Auto Weighing
	● Auto warehouse
	● Automated payment system
Healthcare/Hospitals	● CAT scanners
	● Magnetic resonance imaging
	● Auto patient monitoring
	● Home and hospital robots
	● Bedside terminals
Airlines	● Auto pilot system
	● Air traffic control system
	● Ticket reservation system
	● Cargo Handling



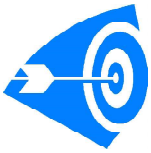
1.5 LET US SUM UP

In this unit we have discussed different functions of production and operation management. Then we have discussed basic manufacturing process and different types of process design. The better understanding of Production and operations Management is vitally important for managers to meet the organization's goal and objectives. Product design and process designs are interrelated concepts. Hence they have to be considered as a whole. Modern manufacturing processes and techniques have changed the production and operations methods of organizations.



1.6 FURTHER READING

1. K. Aswathappa K.S. Bhat(2015), Production and Operations Management, Himalaya Publishing House.
2. K. Bedi(2013) ,Production and Operations Management, Oxford University Press.
3. S.N. Chary(2017), Production and Operations Management, Tata-McGraw Hill Publishing Company Limited.
4. R. Panneerselvam (2012),Production and Operations Management, Prentice Hall of India Private Limited.



1.7 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q. No. 1: Production management is the management of an organisation's productive resources, which converts inputs into organisation's product and services.

Ans to Q. No. 2: (a) Nature of product/service demand

(b) Degree of vertical integration

(c) Production flexibility

(d) Degree of automation

(e) Quality of product and service.



1.8 MODEL QUESTIONS

Q.1 Process design depends on variety of product design and quantity of products – Explain.

Q.2 Define the systems approach of Production and operations management with examples.

Q.3 What is cellular manufacturing process? How does it help the production managers?

Q.4 What are the factors affecting the choice of process design in an operation?

Q.5 Write a short note on Computer integrated Manufacturing (CIM).

Q.6 Explain the importance of production and operations management in the present business environment.

Q.7 Discuss the managerial decision making process and decision making of the production managers.

*** ***** ***

UNIT 2: PROCESS DESIGN

UNIT STRUCTURE

2.1 Learning Objectives

2.2 Introduction

2.3 Types of Process Design

- 2.3.1 Product Focused
- 2.3.2 Continuous Production
- 2.3.3 Process Focused
- 2.3.4 Cellular Manufacturing
- 2.3.5 Inter relationship among product design, process design and Inventory policy
- 2.3.6 Deciding among Process Alternatives

2.4 Automation in Production and Operations

- 2.4.1 Types of Automation
- 2.4.2 Computer Integrated Manufacturing

2.5 Let Us Sum Up

2.6 Further Reading

2.7 Answers To Check Your Progress

2.8 Model Questions

2.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- describe different types of Process design
- explain inter relationship among product design, process design and Inventory policy
- discuss process alternatives
- difine automation in Production and operations
- explain computer Intergrated Manufacturing.

2.2 INTRODUCTION

In this unit we are going to discuss about Porcess design. Process design is the activity of determining the workflow, equipment needs, and

implemention requirements for a particular process. Process design typically uses a number of tools including flowcharting, process simulation software, scale model etc.

In this unit we will discuss different types of process design. At the end of this unit we will also discuss automations in Production and operations management.

2.3 TYPES OF PROCESS DESIGN

Different types of process designs are: Product Focused, Continuous Production, Process Focused, and Cellular Manufacturing, which are discussed as follows:

2.3.1 Product Focused

Here the production department and the machines/ equipments are organized according to the type of product/ services. Alternatively, one department makes one product. These are called production lines. For example: One production line for one type of gear, suppose the 1st speed gear of an automobile. That production line may involve several manufacturing/ machining processes viz. turning, gear tooth cutting, boring, drilling, shaving etc. Again the **shop floor** may have separate production lines for 2nd speed gear, 3rd speed gear, 4th speed gear and so on. Product focused manufacturing systems are generally expensive and are suggested for standard products and for mass production produced in batches.

2.3.2 Continuous Production

In a continuous production process there is a constant flow of materials. Also it is not possible to identify the successive units of the output.

Continuous production process design can be adopted for the highly standard products that require mass production. In most of the chemical factories we see a continuous process design. For example, in a refinery of Indian Oil Corporation Limited we see a process design of continuous production.

2.3.3 Process Focused

The type of production set up where operations are grouped as per type of operations with similar characteristics or technological groups, which are placed together in a process is called the **process focused process design**. For example, in a manufacturing factory, we may have departments like turning shop, milling shop, grinding shop, boring shop, drilling shop, painting shop, fabrication shop, sheet metal forming shop, nitrogen cleaning shop, lubrication shop, etc. Process focused manufacturing follows irregular, zig-zag paths. The advantage of this system is that it is flexible to manufacture products of different designs; hence it is more products flexible but on the other hand the volume flexibility may suffer.

2.3.4 Cellular Manufacturing

Cellular manufacturing or group technology is a form of production that has become popular in the last two decades. It was first used in Soviet Union in late 1940s by Mitrofanov and Sokolovskii. Since the end of world war-II, it has been studied and applied in most of eastern and western Europe, and also in India, Hongkong, Japan and the United States of America. This is widely used in metal working shops.

Cellular manufacturing is a subset of broader group technology concept. In group technology, coding system is developed for the parts made in factory. Each part receives a multi-digit code that describes the physical characteristics of the part. For example, let us say that a part is cylindrical, 6 inches long, 1 inch in diameter and made of stainless steel. The part code for the specified part would describe these physical characteristics. By the use of this coding system for parts the production activities are simplified in the following ways:

- It is easier to determine how to route parts through production because the production steps required to make the parts are obvious from the code.

- The number of part designs can be reduced because of part standardization. When new part is designed, the code of existing part may be assessed in the computer database to identify similar part. New designs can be made like the existing ones.
- Parts with similar characteristics may be grouped in part families because parts with similar characteristics are made in similar ways.
- Some part families can be assigned to manufacturing cells for production, usually one part to a cell. The organization of the shop floor in to cells is referred to as cellular manufacturing.



CHECK YOUR PROGRESS

Q.1: Define Cellular Manufacturing.

_____

_____

_____

Q.2: Define Process Focused procers design.

_____

_____

_____

2.3.5 Inter Relationship among Product Design, Process Design and Inventory Policy

The strategy for positioning the manufacturer has three components (i) product design (ii) process design (iii) inventory policies. The manufacturers have different alternatives available in the three as under:

(1) Process Design: Product Focused, Continuous Production, Process Focused, Cellular Manufacturing

(2) Product Custom build or standard design

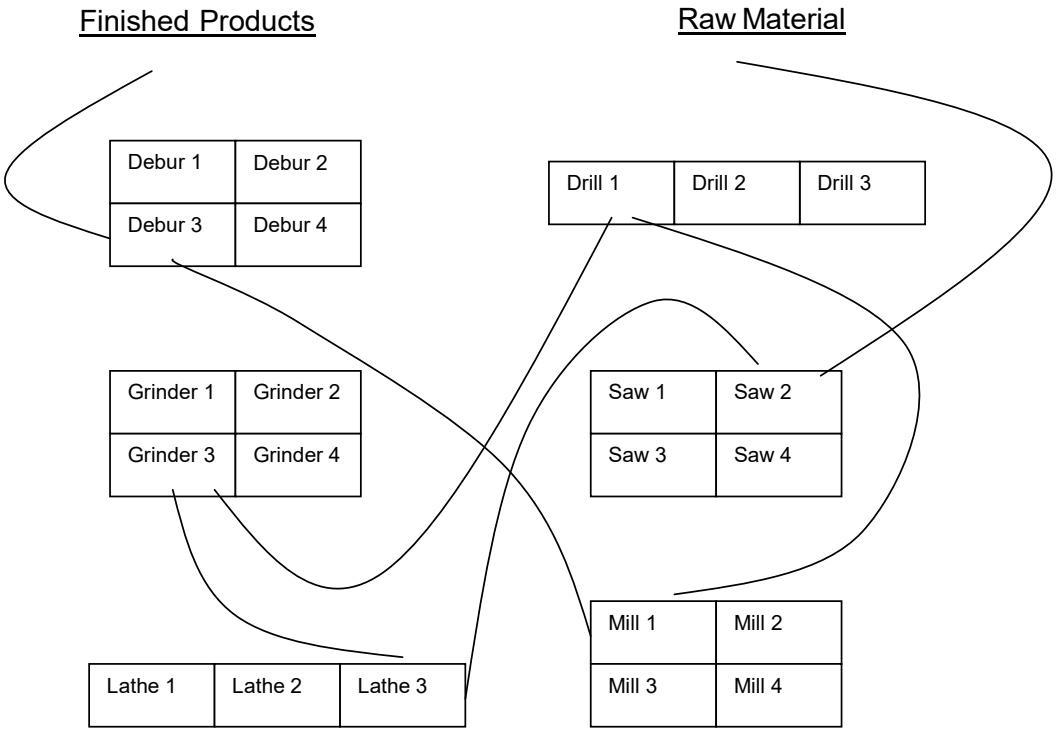
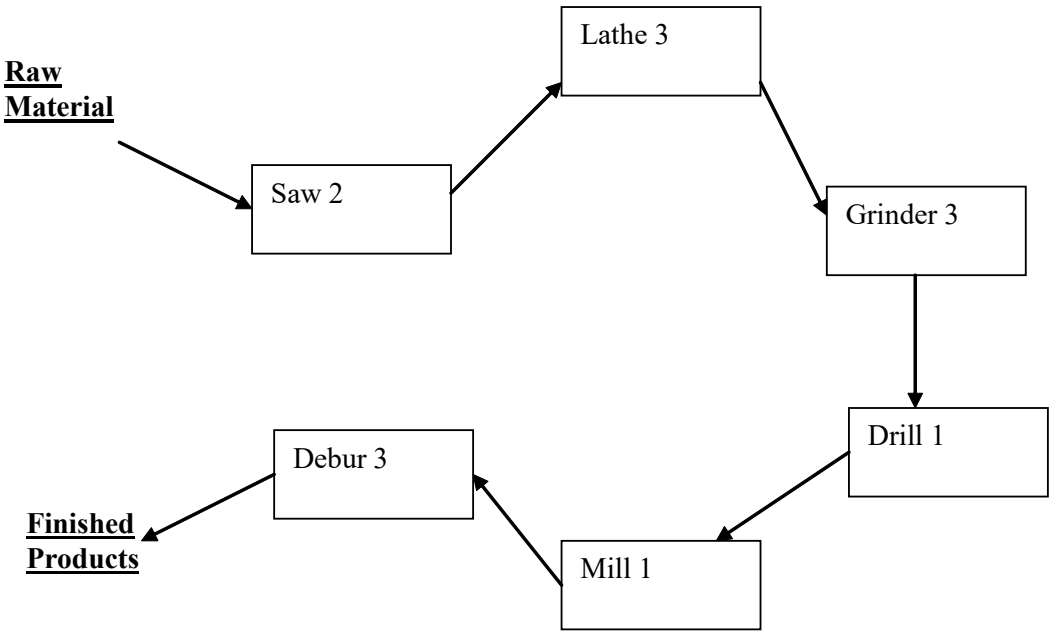


Figure 2.1

(3) Inventory policy – Produce-to-stock , Produce-to-order



Production Cell

Figure 2.2

Custom products: Custom made product designs are generally to produce to order. The items are not produced unless there is a specified order. After the receipt of the order the planner develops plans for producing the product. That is, production plans are made for the specific product. After the starting of the production customers are informed about the delivery. An Example: Making a dining table set as per customer's order or fabricating a water storage tank as per customer's specific requirement.

Standard Products: Standard products are generally made for produce to stock inventory policy. The finished goods are stocked after producing and from time to time goods are released from stock as per customers demand from the market. Designs are not changed for individual customers. For example Maruti 800 car, Godrej 165 litre refrigerator, Colgate toothpaste, Liril soap etc.

2.3.6 Deciding among Process Alternatives

Let us now discuss about the factors responsible for our decision on process alternatives.

Several factors affect the production process. These are (1) Batch Size (2) Capital Requirement (3) Economic Analysis.

(1) The Batch Size: The process design has direct effect on product variety and batch size. The following exhibit explains this issue in detail. When the batch size is small and design variety is more, a manufacturer is required to go for process focused Job shop type of process design. It is quite obvious that unless an organization has flexible manufacturing process and if it deals with a wide range of product variety the batch size will automatically be small. Once the variety of designs of the products becomes less i.e as the organization moves slowly towards standardization of the product designs the batch size increases. At that stage the organization may opt for cellular manufacturing. When design variety is very less and the batch size is substantially high in that case the process design suggested is the product focused batch system.

With the highly standardized products, without any variety and large batch size, the organization may opt for the process design of a product focused dedicated system for continuous production.

(2) The Capital requirements: The capital requirements for different production systems change for each type of production. In the figure 2.3, A is the process design where capital requirement is the highest and D is the process design where capital requirement is the lowest.

(3) Economic Analysis: In choosing the production processes economic analysis is of great importance. The analysis tools under consideration are as follows:

- Cost of each process alternatives available
- Break even analysis
- Financial analysis

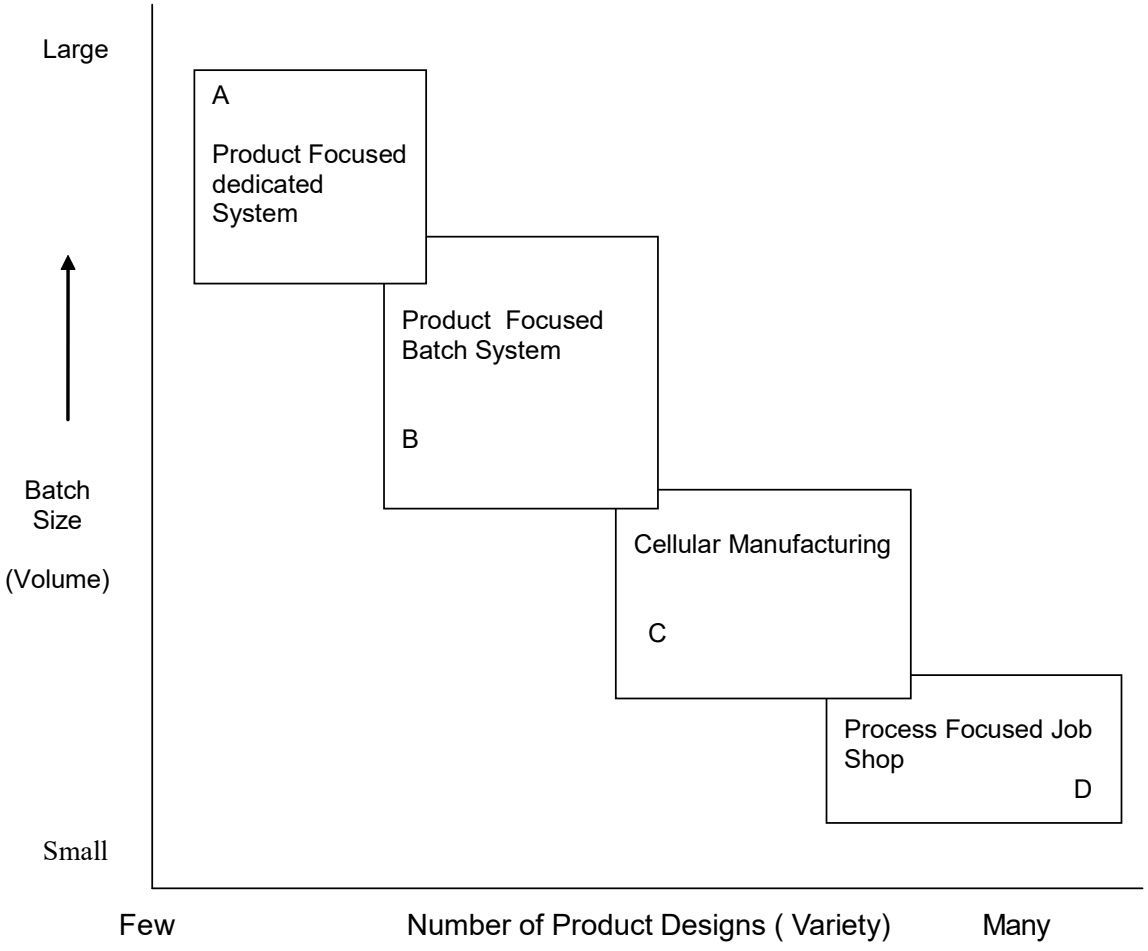
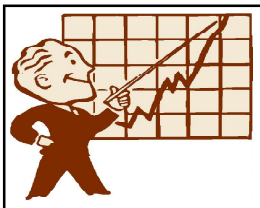


Figure 2.3



CHECK YOUR PROGRESS

Q.3: Write the factors that affects the production process.

_____

_____

_____

2.4 AUTOMATION IN PRODUCTION AND OPERATIONS

Production and operations management have evolved by adopting new technologies. The change in technology improves production and operation and keeps managers busy in study, adopting and adapting to the advancement. To be competitive in the market, organizations must adopt new technologies. The adoption of new technologies should be made an essential part of planning and operations strategies. The application of new technology or scientific knowledge to design, to operations and production process is called “Advanced Technology”.

2.4.1 Types of Automation

Industrial automation is growing faster with more knowledge base added to the field of electronics and control systems. The developments in the last two decades have brought variety of automation with diverse features. The areas of development are in mainly machine attachments, numerical controlled machines (NC Machines), Computer numerically controlled machines (CNC Machines), Industrial Robots, Automated quality control, Automatic Identification system and Automated process control etc.

Machine attachments: These are added to the existing machines to reduce human effort or to save time. This is the first step in automation.

Numerically controlled machines (NC Machines) : NC machines were started in Europe in 1950s and India started using the same in

mid sixties. Machines are controlled by using numerical control logic.

Computer numerically controlled machines (CNC Machines): These machines are not only numerically controlled but can also be programmed to perform desired operations with the help of the computer attached with it. These machines have very high degree of accuracy and precision.

Industrial Robots: Industrial robot is defined as a programmable, multifunctional manipulator designed to move materials, parts, tools or specialized devices through variable programmed motions for the performance of variety of tasks. The micro computer gives the necessary instructions to the robots and act as brain. Robots can operate in environments like hazardous zones of a nuclear plant or a chemical plant, where man cannot enter.

Robots can handle a variety of jobs and are controlled by computers. This makes robots flexible. Robots have sensors for locating objects. Robots work in known programmed work and repeated work can be given to robots.

Automated Quality Control Inspection(AQCI): Automated quality control and inspection machines or systems are incorporated into inspection of products for quality checks. These machines test and take physical dimensions, compare measurements to standards set and separate parts that do not meet the set specifications. AQCI machines are used in electronic industry to check performance of electronic parts and circuits. Computers are checked by special software that checks each system to be in order as per performance standards.

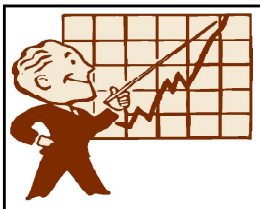
Automatic Identification System: It is generally known as bar code system. It consists of radio frequencies, magic strips, optical character recognition, sensor to machine visioning and data input to computer. Data is read from bar codes given to the product. The system reads the identification number from bar code on the item, accesses the database of the number and retrieves necessary information. Data is also fed into the inventory system as well as in

the billing system.

Automated Process Control: In Automated Process Control (APC) sensors are used to collect measures and performances of industrial processes. The measurements are compared to standards. If variability is above the tolerance limit then the signals are sent to change the settings of processing. The system is costly and is preferred for large volume operations.

2.4.2 Computer Integrated Manufacturing

CIM is defined as a computer system to bridge the various computerized systems to make it a connected coherent whole. In CIM, all the functions are clubbed in an integrated computer system. This means that the system works from the receipt of a sales order to the point of shipment of the order through manufacturing with CNC (Computer Numerical Control) Machines. CIM is integrated with ERP (Enterprise Resource Planning).



CHECK YOUR PROGRESS

Q.4: Define Computer Intergrated Manufacturing.

_____

_____

_____

Choose from the following options :

Q.5: For a large batch size of a highly standardized product, the preferred process design is—

(a) Product focused dedicated system

(b) Cellular manufacturing

(c) Process focused job shop



2.5 LET US SUM UP

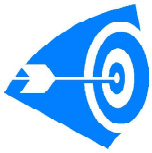
In this unit we have discussed different types of process design. Then we have discussed basic manufacturing process and inter relationship among them. Product design and process designs are interrelated concepts. Hence they have to be considered as a whole. Modern manufacturing processes and techniques have changed the production and operations methods of organizations.

At the end of the unit, we have discussed different automation techniques used in production management.



2.6 FURTHER READING

1. K. Aswathappa K.S. Bhat(2015), Production and Operations Management, Himalaya Publishing House.
2. K. Bedi(2013) ,Production and Operations Management, Oxford University Press.
3. S.N. Chary(2017), Production and Operations Management, Tata-McGraw Hill Publishing Company Limited.
4. R. Panneerselvam (2012),Production and Operations Management, Prentice Hall of India Private Limited.



2.7 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q. No. 1: Cellular manufacturing is a process of manufacturing which is a subsection of just in time manufacturing and lean manufacturing in compassing group technology.

Ans to Q. No. 2: Process focused is the type of production set up where operations are grouped as per type of operations with similar characteristics or technological groups, which are placed together in a process.

Ans to Q. No. 3: (a) Capital requirements.

(b) Economic Analysis

(c) Batch Size

Ans to Q. No. 4: CIM is defined as a computer system to bridge the various computirized system to make it a connected coherent whole.

Ans to Q. No. 5: Product focused dedicated system



2.8 MODEL QUESTIONS

Q.1: What are the factors affecting the choice of process design in an operation?

Q.2: Write a short note on Computer integrated Manufacturing (CIM).

Q.3: Explain the importance of production and operations management in the present business environment.

Q.4: Discuss the managerial decision making process and decision making of the production managers.

*** ***** ***

UNIT 3: PLANT LOCATION AND LAYOUT

UNIT STRUCTURE

3.1 Learning Objectives

3.2 Introduction

3.3 Concept of Location

3.4 Plant Location

- 3.4.1 Factors Affecting Location Decisions
- 3.4.2 Primary Factors
- 3.4.3 Secondary Factors

3.5 Plant Location Methodology

- 3.5.1 Factor Rating

3.6 Plant Layout

- 3.6.1 Types of Plant layout
- 3.6.2 Job Shop Production
- 3.6.3 Batch Production
- 3.6.4 Mass Production

3.7 Let Us Sum Up

3.8 Further Reading

3.9 Answers To Check Your Progress

3.10 Model Questions

3.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concept of Plant Location and Plant Layout
- describe the factors to be taken into consideration to decide on plant location
- explain the factors to be taken into consideration to decide on plant layout
- get a brief overview of different plant layouts

3.2 INTRODUCTION

In the earlier unit, we have discussed the basic concepts of production and operation management. In this unit, we are going to discuss about plant location and layout facilities. A good location plays the vital role for the production of any goods or services. Proper location and layout can reduce cost and make the production process more effective.

3.3 CONCEPT OF LOCATION



Fixture : An object firmly fixed in place.

A good location of a production or service facility will give cost advantage to production or services and may also reduce the raw material and distribution costs. The location aspect is particularly advantageous to small business enterprises and service units. Location adds to competitive advantages and improved profits. Usually location question arises when (1) a new plant or service facility is planned (2) there is addition to the existing business or added capacities in the other regions (3) existing facilities are to be relocated or modified to remove drawback (4) to get advantage of better infrastructure or incentives from the government sources. Location of organization plant or service facilities is a permanent fixture and has considerable expenditure. The selection has to be done considering all relevant aspects. If there is any mistake or wrong choice of location, all the expenditure in the form of site development, factory construction, installation of machinery and other infrastructure development will go waste.

The location selection has three main issues:

(i) **Selection of the region**: It is imperative to produce near the raw material base or customer to meet set competition, trade agreement and transport costs.

(ii) **Selection of locality**: The choices are the rural place, the urban place or suburban area near the metro. The selection usually boils down to developed industrial area or having government sponsored advantages.

(iii) **Selection of site**: Advantages of low labour cost, low land cost, infrastructure or transport facilities chosen.

After the selection of location of manufacturing or services, the next important activity is facilities layout. The arrangement of various departments, machines in the building and plant services is to be done in order to get the maximum efficiency by the optimum usage of resources. The type of production equipment and product characteristics are to be considered while evolving a good factory layout. A factory layout means location of different departments, like foundry, forging, machine shop, tool room, administration, maintenance shop whereas a plant layout means the location sequence or arrangement of machines and equipments in a department.

3.4 PLANT LOCATION

Selection of proper location is very important for the success of any business. Plant location is considered as the function of determining where the plant should be located for maximum operating economy and effectiveness.

3.4.1 Factor Affecting Location Decisions

Manufacturing and service companies make location decisions based on many criteria. Following are the factors that should be considered for location of an industry or service unit :

(1) **Primary Factors :**

a) Nearness to customers

b) Near raw materials

c) Supply of capital

d) Logistic facilities and infrastructure

e) Skilled labour availability

f) Power supply

g) Business climate

(2) **Secondary Factors**

a) Host community and political factors

b) Natural factors

c) Historical factors

d) Initial start and living conditions

e) Personal factors

f) Government policies

g) Environmental considerations

h) International factors

3.4.2 Primary Factors

(a) **Nearness to Customers:** Nearness to customer helps a plant to incorporate customer needs into the products being made in the unit. Finished goods to customers can reach faster and in less cost. There is less chance of breakage or damage during transportation. A fast food joint should necessarily be located in a place where customers can reach easily or are available nearby

(b) **Nearness to raw materials:** Cost of raw material input is a large cost in case of manufactured goods. The time & cost of transporting raw material is less if the plant is located near the source of raw material. For example, thermal power plants are located near to the coal mines

(c) **Supply of capital:** Short term and long term funds are required for any manufacturing or service industry. A company decides to locate its plant in such a location where fund movement is hassle free.

(d) **Logistic facilities and Infrastructure:** Adequate roads, rail, phone, postal and transportation facilities are to be considered while deciding on the location of plant and service facilities.

(e) **Skilled labour Supply:** Regular supply of skilled labour is one of the major factors to be considered while deciding on the plant or service location. Example: Software companies are located in Bangalore, Hyderabad and New Delhi

(f) **Power Supply:** This is a very critical factor to be analyzed. Uninterrupted power supply with proper voltage is one of the prerequisites of plant location decision.

(g) Business Climate: Companies must find a positive business climate or environment in the area, state or a country to set-up manufacturing or service facility there.Companies would not like to invest in Egypt or Libya, since the political set up in both these two countries are not smooth but passing through a phase of transition.

3.4.3 Secondary Factors

(a) Host community and political factors: The community near the industry proposed location should be willing to welcome the new industry. Local people should feel that there will be improvement in their quality of life due to the new industry. The Brahmaputra Crackers and Polymers Limited at Lepetkata in Dibrugarh district, Assam is perceived as a welcome approach by the local community

(b) Natural Factor: Land, water, climate condition, sources of material attract and help some industries Example: Tea industry, cotton industry, coffee industry,coconut oil industry etc.

(c) Historical factors: Capitals of old kingdoms of yesteryears, large religious places sometimes attract companies to set up their plants.

(d) Initial start and living conditions: Some industries were started earlier in certain places during the British era in its early stages. The industries since then have developed making good living conditions. The related industries start getting located in the place. e.g: Jamshedpur, Kirloskarwadi.

(e) Personal factors: The history of the entrepreneuring company or family or personal considerations play a key role in location decision.

(f) Government policies: Government play their own role in the location decision of new industries. The Government of India and the state governments have made special efforts in making industries grow and made manufacturing and service units all

over India with a view to have a balanced developmental spread all over the country and the region.

(g) Environmental considerations: Environmental issues for certain industries for a particular location are to be checked before deciding on location.

(h) International factors: For companies deciding to go overseas for locating a unit for manufacturing or service must consider behavioral aspects, cultural differences, technology, government policies etc.

3.5 PLANT LOCATION METHODOLOGY

One of the most popular method for selecting plant location, is discussed as follows:

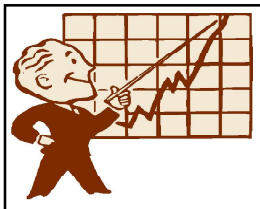
3.5.1 Factor Rating

1. In this method all the major factors associated with the site location are identified.
2. Points are assigned fro each location alternative being considered. For a given location a higher rating is assigned for a factor which is beneficial as compared to the other(s)
3. The location which has the highest total point is chosen as the site for commissioning the facility.

   Suppose A and B are two possible locations for commissioning an oil refinery. The ratings for the various factors are identified and are arranged in descending order of priority. The ratings for the different factors for the corresponding sites are also identified. The sum total for the ratings for different factors for each site is conducted. The site with the highest sum total is selected for the refinery.

Table 3.1

Major factors for dite selection	Point Range	Sites	
		A	**B**
Fuels in the region	0-330	123	156
Power availability and reliability	0-220	150	100
Labour climate	0-100	54	63
Living Conditions	0-100	24	96
Transportaion	0-50	45	50
Supplies	0-60	5	50
Climate	0-50	8	4
Tax policies and laws	0-20	5	20
Water Supply	0-10	4	5
Total Points		418	544
Site B is selected for the refinery.			



CHECK YOUR PROGRESS

Q 1: The location selection of a plant has three main issues. They are (i) .....
(ii) ..... (iii) .....

Q 2: Identify the 'Primary' and 'Secondary' factors from the following factors affecting location decisions.

(a) Near to customer

(b) Historical factors

(c) Supply of Capital

(d) Government policies

(e) Power supply

(f) Personal factors

3.6 PLANT LAYOUT

The layout of a manufacturing facility refers to the physical arrangement of production facilities. It is the configuration of departments, work centres and equipments in the conversion process. It is a floor plan of the physical facilities, which are used in production.

3.6.1 Types of Plant Layout

Broadly there are two types of plant layout. They are a) Product layout and b) Process layout.

Product Layout: Product Layouts, often called production lines or assembly lines, are designed to accommodate only a few product designs. Such layouts are designed to allow a direct material flow through the facility for products. Auto manufacturing plants are good examples of facilities that use a product layout.

Process Layout : Process layout, functional layouts or job shops as they are sometimes called, are designed to accommodate variety of product designs and processing steps. If a manufacturing facility produces a variety of custom products in relatively small batches, the suitable plant layout will be process layout.

Different types of production layout are discussed as follows:

3.6.2 Job Shop Production

Job shop production is most often associated with small firms (making railings for a specific house, building/repairing a computer for a specific customer, making flower arrangements for a specific wedding etc.) but large firms use job shop production too. Examples include:

- Designing and implementing and advertising campaign
- Auditing the accounts of a large public limited company
- Building a new factory
- Installing machinery in a factory
- Fabrication of vessels as per customer's specification.

ADVANTAGES AND DISADVANTAGES

Advantages include:

The key advantages of job shop production are as follows:

- work is generally of a high quality
- a high level of customization is possible to meet the customer's exact requirements

- significant flexibility is possible, especially when compared to mass production
- workers can be easily motivated due to the skilled nature of the work they are performing

Disadvantages include:

- higher cost of production
- requires the use of specialist labour (compare with the repetitive, low-skilled jobs in mass production)
- slow compared to other methods (batch production and mass production)

3.6.3 Batch Production

Batch production is a manufacturing method used for producing or processing any product in batches, as opposed to a continuous production process, or a one-off production. The primary characteristic of batch production is that all components are completed at a workstation before they move to the next one. Batch production is popular in bakeries and in the manufacture of sports shoes, pharmaceutical ingredients, inks, paints and adhesives.

Batch production is useful for a factory that makes seasonal items or products for which it is difficult to forecast demand. Batch production has many "pros" and "cons" but it is effective and used worldwide, mainly by larger businesses on higher profit margins.
There are several advantages of batch production. It can reduce initial capital outlay because a single production line can be used to produce several products. Batch production can be useful for small businesses which cannot afford to run continuous production lines. Also, companies can use batch production as a trial run. If a retailer buys a batch of a product that does not sell then the producer can cease the production without having to sustain huge losses.

3.6.4 Mass Production

Mass Production system layout is also called flow production. Repetitive flow production, or series production is the production of large amounts of standardized products on production lines. It was popularized by Henry Ford in the early 20th century, notably in his Ford Model T. Mass production typically uses moving tracks or conveyor belts to move partially complete products to workers, who perform simple repetitive tasks to permit very high rates of production per worker, allowing the high-volume manufacture of inexpensive finished goods. Mass production is capital intensive, as it uses a high proportion of machinery in relation to workers. With fewer labour costs and a faster rate of production, capital is increased while expenditure is decreased. However, the machinery that is needed to set up a mass production line is so expensive that there must be some assurance that the product is to be successful so the company can get a return on its investment. Machinery for mass production such as robots and machine presses have high installation costs as well. Thus, mass production is ideally suited to serve large, relatively homogeneous populations of consumers, whose demand would satisfy the long production runs required by this method of manufacturing. As such, it is not surprising that, given a number of other factors, mass production first became prevalent in the United States.

Use of Assembly Lines in Mass Production

Mass production systems are usually organized into assembly lines. The assemblies pass by on a conveyor, or if they are heavy, hung from an overhead monorail. In a factory for a complex product, rather than one assembly line, there may be many auxiliary assembly lines feeding sub-assemblies (i.e. car engines or seats) to a backbone "main" assembly line. A diagram of a typical mass-production factory looks more like the skeleton of a fish than a single line.

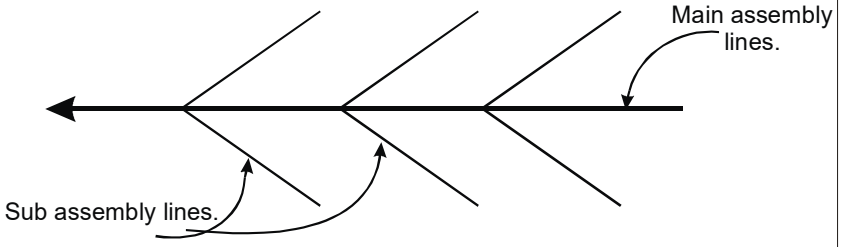


Figure 3.1 Diagram of Assemby & Sub assembly lines

Advantages and Disadvantages of Mass Production

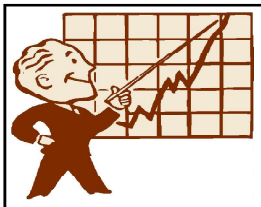
There are some definite advantages and a few disadvantages of mass production.

Advantages:

1. Reduction in labour costs
2. Increased rate of production
3. Human error in the production process is reduced
4. Identical units of production

Disadvantages:

1. Difficult to alter the design or the production process
2. Introduction of variety for customizing to the requirements of individual tastes.



CHECK YOUR PROGRESS

Q 3: For a small scale fabrication factory, producing small volume of vatious designs of grill panels the preferred plant layout is :

(a) Job shop production

(b) Batch Production

(c) Mass production

Q 4: For a medium scale food processing factory, producing moderately large volume of different types of pickles the preferred plant layout is

(a) Job shop production

(b) Batch Production

(c) Mass production

Q 5: Assembly lines can be seen in the plant layout

(a) Job shop production

(b) Batch Production

(c) Mass production

(d) Both Batch Production and Mass production

Q 6: Which of the following statement is true ?

(a) Job shop falls between Batch and Mass Production

(b) Batch Production falls between Job shop and Mass Production

(c) Mass production falls between Job shop and Batch Production



3.7 LET US SUM UP

In this unit we have discussed the following :

- Plant location decision is strategic. Organizations take the location decision considering various factors related to customers, supply of capital, raw material, power supply, business climate, manpower availability, government policies etc.
- There are mainly two methodologies to decide the plant location viz. Factor Rating and Centroid method. The type of product or services and the type of production system basically effects the plant layout.
- There are different plant layouts for different types of production systems viz. Job Shop, Batch production and Mass production. In mass production, euipments are expensive and used for a solitary purpose. A very small variety of goods are produced in this type of layout. In Job shop type of layout machineries are general and all-purpose machinery. Various designs of products may be manufactures in such facilities. Batch production falls between mass production and jobbing. One batch of products must be completed before work on the next one may begin. Similar products are produced

on a batch basis, in large quantities.

- The plant layout must ensure the optimum usage of resources by minimizing the movements of the resources with in the plant.



3.8 FURTHER READING

1. K. Aswathappa K.S. Bhat(2015) ,Production and Operations Management, Himalaya Publishing House.
2. K. Bedi(2013) ,Production and Operations Management, Oxford University Press.
3. S.N. Chary(2017), Production and Operations Management, Tata-McGraw Hill Publishing Company Limited.
4. R. Panneerselvam (2012),Production and Operations Management, Prentice Hall of India Private Limited.



3.9 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q No 1: (i) Selection of the region (ii) Selection of the locality (iii) Selection of the site

Ans to Q No 2: (a) Primary (b) Secondary
(c) Primary (d) Secondary
(e) Primary (f) Secondary

Ans to Q No 3: (a) Job shop Production

Ans to Q No 4: (b) Batch Production

Ans to Q No 5: (d) Both Batch Production and Mass Production

Ans to Q No 6: (b) Batch Production falls between Job shop and Mass Production



3.10 MODEL QUESTIONS

Q.1: What are the major issues to be considered while deciding on the location of a plant? Explain.

Q.2: What are different primary and secondary factors affecting the location decisions?

Q.3: Define Plant Layout.

Q.4: What are the major advantages disadvantages of Mass Production plant layout ?

Q.5: What are the major advantages disadvantages of Job Shop plant layout?

Q.6: What are the typical characteristics of a Job Shop plant layout?

Q.7: What are the advantages and disadvantages of batch production?

*** ***** ***

UNIT 4: JOB DESIGN

UNIT STRUCTURE

4.1 Learning Objectives

4.2 Introduction

4.3 Job Design

- 4.3.1 Definition of Job Design
- 4.3.2 Specialisation
- 4.3.3 Multi-tasking
- 4.3.4 Job Enlargement
- 4.3.5 Job Enrichment

4.4 Work Study

4.5 Method Study

4.6 Work Measurement

4.7 Work Sampling

4.8 Let Us Sum Up

4.9 Further Reading

4.10 Answers To Check Your Progress

4.11 Model Questions

4.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concept of job design
- describe the concepts of Multi Tasking, Job Enlargement and Job Enrichment.
- explain the different branches of work study
- explain the basic concept of method study
- explain work sampling method

4.2 INTRODUCTION

In this unit we are going to discuss on job design. Proper job design can improve manufacturing process. Focus on people at work is

critical aspect of an operation management. Work system in production or service context has three important elements i.e. technical skills (of personnel), machines or equipment, tools and third being the time. Work systems detail guidelines and boundaries for all concerned in production activities.

In any work or production context there will be man-material-machine importance. In fact, the term work itself has different meanings to deferent people. For a social scientist work is central to human life, some view it from behavioural perspective. Technologist sees it as tool, technique and method used in any production method, the economic concepts, employment and wages. Work system is a systematic investigation of present and desired working and set ideal system. Work system help in increasing productions by seeking better and less expensive ways to perform production or services.

4.3 JOB DESIGN

Definition of job is a group of related tasks or activities that must be performed to meet organisational objectives. Jobs are basic building blocks of any manufacturing or service activity.

4.3.1 Definition of Job Design

Job design is the set of activities that give the contents of each job and determine how work is distributed in an organisation. Job design follows the planning and designing process.

To get a good job design, the operation manager should have found knowledge of job details:

(i) How work is being done?

(ii) What tasks are done for the job. Are they necessary?

(iii) Jobs that are okay and jobs that are difficult and become bottlenecks

Industrial engineering techniques can be used to study and analyse the problem areas and to find alternate solutions to solve them regarding training of workers, quality control as part of job of

workers, when and in what sequence the job will be done, method of performance and motivation.

4.3.2 Specialisation

Specialisation of labour means making a worker or a group of workers to learn a particular job and go on doing the same narrow range of job for years. Give them special training, tools, tackles to excel in the job. It is specialisation that gives consistent quality, fast speed and low cost. Again, specialisation brings repetition and boredom to workers, and hence, has adverse effects on the workers. The boredom and lack of attention starts its effect on lowering efficiency and quality and lead to high rate of absenteeism and turn over. To provide job satisfaction the jobs are modified from specialisation.

Following are the advantages and disadvantages of specialization :

Advantages of Specialisation

To Management

1. Quick training of existing workers
2. Easy to train new workers.
3. High output due to repetition.
4. Labour can be substituted and lower labour costs.
5. Control over work flow and management.

For Workers

1. Easy to learn the job.
2. Little education and training.

Disadvantages of Specialisation

To Management

1. Quality not consistent.
2. Worker gets bored and cost of absenteeism, poor work, disruption in work may pose problems.
3. Little or no flexibility.
4. No improvement in process as workers do not know other processes or problem areas.

For Workers

1. Boredom to workers
2. Workers are not happy because small contribution.
3. Frustration due to monotony and no control on jobs.
4. On small learning of job no job progress or promotions.

4.3.3 Multi tasking

It is training workers in different jobs or work stations. For example say worker is trained in milling machines, grinding machines and quality inspection then he can be moved from jobs as per requirement. Multitasking is also called cross training.

4.3.4 Job Enlargement

Similar tasks are added to the present jobs of a worker. Usually a specialised job is added to make it more interesting. Here the worker performs a large number of tasks. This is horizontal job enlargement. Here worker is permitted to perform, whole unit of work.

4.3.5 Job Enrichment

In job enrichment worker does his normal allotted job and he is also involved in planning, organising and quality inspection of his own work. Here job is enlarged vertically. Vertical enlargement or job enrichment gives workers satisfaction of doing manager's job. The productivity and quality improve in job enrichment as worker assumes ownership on himself.



CHECK YOUR PROGRESS

Q.1: Specialization in job brings

(a) consistent quality

(b) Fast speed

(c) Low cost

(d) All of the above

Q.2: Multi tasking means

(a) Training workers in different jobs or work stations

(b) Similar tasks are added to the present job of the worker

(c) The worker does his normal allotted job and he is also involved in planning, organizing and quality inspection of his own work.

Q.3: Job enlargement means

(a) Training workers in different jobs or work stations

(b) Similar tasks are added to the present job of the worker

(c) The worker does his normal allotted job and he is also involved in planning, organizing and quality inspection of his own work.

Q.4: Job enrichment means

(a) Training workers in different jobs or work stations

(b) Similar tasks are added to the present job of the worker

(c) The worker does his normal allotted job and he is also involved in planning, organizing and quality inspection of his own work.

4.4 WORK STUDY

Work Study is defined as a combination of method study and work measurement which are used for ensuring the optional use of human time and material resource in doing the specified activity.

Work study help in improving and upgrading the productivity levels in an organisation in the areas of men, material, time and machines. The branches of work study are shown in the following figure.

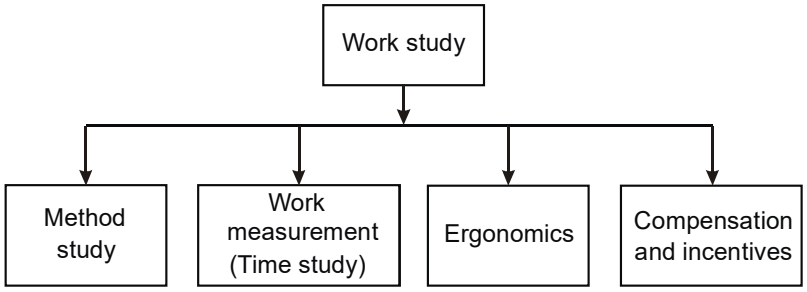


Figure 4.1

branc Method study finds ways to reduce the work content and work measurement establishes time standards for the work content set by method study. Work study aims are:

(i) Effective use of plant and equipment.

(ii) Effective use of human effort.

(iii) Evaluation of human work

4.5 METHOD STUDY

Method study aims at improving method of production that result in effective use of resources like plant, equipment, materials, time and manpower. It is hence essential in any production or service organisation to achieve higher level of productivity. Method study or method analysis is made in an organisation by industrial engineering department or consulting companies specialising in the work. The method study approach is making helpful charts like operation charts, machine-worker charts, simultaneous motion charts and activity charts. A method study design chart given below gives design aids for different activities.

Table 4.1

Method study Design Chart		
Activity Base	**Aims of Study**	**Study Technical**
Production process	Study delays, combine or eliminate steps, cut transport distances and bottlenecks	Flow diagrams, process chart, service chart
Worker at Fixed work	Minimize unwanted motions, simplify method	Operation chart apply motion and economy principles SIMO charts
Interaction between worker and equipment	Remove idle time of machines and men. Find combination of machines to reduce overall cost	Worker-machine chart, activity chart.
Interaction between worker to worker	Minimize interference, avoid confusion,	Activity chart, Team process charts. productivity



SIMO Chart :
Simultaneous Motion cycle chart is used to study basic motion time in production unit.

The four activities to be studied in details and analysed are :

(1) Production Process: The study and analysis have aims at simplifying the operation by identification of delays, cut unwanted processes, reduce handling and transport. The key is cut out processes that do not add value to the product. The question technique is common. The flow chart of process is taken and each is asked the following questions.

- What is the process? Why it is done? Is it necessary? Can it be eliminated? Can it be simplified?
- Location is proper? Can we do else where?
- Is sequence ideal? When is the task planned?
- Is it the best way to do the job? Can it be done simpler? Is there another cheaper, faster better way?
- Should the worker of lower skill can do the job? Can somebody else do the job? Is he the right man with training?

The answers and findings of all these questions help in removing unnecessary work.

(2) Jobs at Fixed Workplace: When a worker has to do his job at a Fixed place, mostly it is a manual type of job, the study and analysis will be to simplify the work by reducing operator imitation. The aim will be ease of operation with less effort and time. The jobs in this category are usually assembling work, sorting, inspection or data entry. The motions of limbs while doing the job is studied and movements are economised. A film study of a worker on the job is made to identify extra movements. For a detailed study SIMO or simultaneous chart is made. With SIMO charts coordination of both hands and use of tools can be studied to reduce unnecessary efforts.

(3) Worker Interacting with Equipment: Efficient use of worker and equipment, time and coordination is critical to get good use of both. A worker-machine chart is made indicating engagement time of both on a job. Analysis is done as per the importance of the job.

(4) Worker Interacting with Other Workers: Usually in a production operation one worker hands over his job to next worker for faster processing or assembly work. If the assembly work is a group activity the interaction will be with many. In such cases a gang process chart is drawn to give

interaction between various groups. The examples of this type are a hospital work of handling a large operation or a group maintenance work in a chemical process plant. Here a worker to worker interaction analysis will help each worker to know whom to interact, when and the operation goes smooth.

The systematic approach to method study aims to choice of charting method of one or two of above four approaches. The steps in method study are as follows:

1) Select the work to be studied
2) Record all the relevant facts associated with the proposed method
3) Conduct a critical examination of the facts in the same sequence in which they occur
4) Develop the method effective and economic method for the work under study
5) Install the developed method as a standard practice
6) Maintain the installed method

4.6 WORK MEASUREMENT

Work measurement is determining the amount of time required to perform a unit of work. The knowledge of time element and its break up gives the manager to compare alternate methods. The time measurement helps in planning and scheduling of jobs and for salaries and incentives. The work measurement helps to find the human work in a work and finds answer "how long should a specified job take to complete?"

Definition of work measurement is application of technique designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance. Purpose of work measurement is setting time standards for a job. The tools of work measurements are:

(I) To allocate capacity: All scheduling and allocation work need some estimates of time for the work being scheduled for period.

(2) To assist method study and to help balancing of work load.

(3) Objective basis for motivating the workmen and measuring their performance: Based on the measured standard times the incentive plans are made. The standards will give fair basis for incentive schemes.

(4) New contracts and evaluation of existing ones. How we are performing all the jobs on hand or can we take up a new one? How we propose to complete in time? Questions can be answered with standards on hand. This also helps in estimation of labour requirements and costs.

(5) Serve as bench mark: Standards help for compensation and evaluation of performance within the company and for similar jobs in other companies.

(6) Basis for budgeting: Standards will be used in making labour budgets and budgetary control systems.

4.7 WORK SAMPLING

Work sampling involves observing a portion of sample work activity. Based on this study of work sample, statement can be made of activity. Suppose a telephone department gets 100, complaint calls an hour and if it is found that 25 calls are for billing and payment of the 100 then it is estimated that 25 per cent of them involve payment issue. These studies are used to estimate percentage of employee's time spent in a particular activity. The results of these studies are used to set allowances used in computing labour standards. The issues to be decided in work sampling are:

(I) What level of statistical confidence is required in the results?

(2) How many observations to be made?

(3) What are the observations to be made and at what intervals?

Primary Applications of Work Sampling are

(a) Activity time percentage for workmen and equipment.

(b) Development of performance index for workers.

(c) Set time standards to obtain standard time for task.

Steps in Work-sampling Study

(I) Identify an activity for study. Example idle time of an equipment.

(2) Calculate the percentage of time of activity of interest to the total time. In the above example idle time say is 14% of total time. This figure is arrived by experience of the analysis or from previous records.

(3) Not cleared designed accuracy in the study result.

(4) Fix when each study observation is to be made.

(5) Between the studies, recompute number of observations necessary for the studies.



CHECK YOUR PROGRESS

Q.5: Define work study and Method Study

.....

.....

.....

Q.6: State objectives of work measurement.

(a) .....

(b) .....

(c) .....



4.8 LET US SUM UP

In this unit we have discussed different aspects of job design. In a globalize economy the application of sophisticated technologies are making human resource more important than ever. The companies are looking in to effective job design. The optimum utilization of human resource may be achieved by effective job design. Work study and work measurements are tools for job design. We have also discussed different work measurement techniques like time study, motion study etc.

- Work study helps in improving the productivity levels in an organisation.
- Method study approach is to making helpful charts to improve production.
- Work measurement determines amount of work required to perform a task.



4.9 FURTHER READING

1. K. Aswathappa K.S. Bhat(2015) ,Production and Operations Management, Himalaya Publishing House.
2. K. Bedi(2013) ,Production and Operations Management, Oxford University Press.
3. S.N. Chary(2017), Production and Operations Management, Tata-McGraw Hill Publishing Company Limited.
4. R. Panneerselvam (2012),Production and Operations Management, Prentice Hall of India Private Limited.



4.10 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q. No. 1: (d) All of the Above

Ans to Q. No. 2: (a) Triaining workers in different jobs or work stations.

Ans to Q. No. 3: (b) Similar tasks are added to the present job of the worker.

Ans to Q. No. 4: (c) The worker does his normal allotted job and he is also involved in planning, organizing and quality inspection of his own work.

Ans to Q. No. 5: Work study is used for ensuring the optimal use of human time and material resource in doing a specific activity and Method study aims at imporving method of production that result in effectived use of resources like plant equipment etc.

Ans to Q. No. 6: (a) To allocate capacity (b) To motivate the employees (c) To set banch mark.



4.11 MODEL QUESTIONS

Q.1: Define Job design.

Q.2: What are the different advantages and disadvantages of specialisation in job?

Q.3: Explain Multi Tasking, Job enlargement and Job Enrichment with the help of examples.

Q.4: What are different branches of work study?

Q.5: Describe method study.

Q.6: What are different steps involved in method study?

Q.7: Describe work sampling method.

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UNIT 5: PRODUCT DESIGN

UNIT STRUCTURE

5.1 Learning Objectives

5.2 Introduction

5.3 Types of New Products

5.4 The Process of New Product Development

- 5.4.1 Idea Generation
- 5.4.2 Idea Screening
- 5.4.3 Concept Development and Testing
- 5.4.4 Business Analysis
- 5.4.5 Beta Testing and Market Testing
- 5.4.6 Technical Implementation
- 5.4.7 Commercialization

5.5 Design For Manufacturability (DFM)

5.6 Designing For Quality

5.7 Rapid Prototyping

5.8 Designing And Developing New Services

5.9 Let Us Sum Up

5.10 Further Reading

5.11 Answers To Check Your Progress

5.12 Model Questions

5.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concept of Product Design
- know the design Considerations in the Product Design Process
- describe Product Design Strategy for Organization's Competitiveness.
- outline design for Manufacturability and Quality.

5.2 INTRODUCTION

In this unit we are going to discuss on product design which plays an important role in production. New product development (NPD) is the term used to describe the complete process of bringing a new product or service to the market. In New product development process, there are two parallel paths involved: one involves the idea generation, product design, and detail engineering; the other involves market research and marketing analysis. We know that the various stages of product life cycle are (i) introduction (ii) growth (iii) maturity and (iv) decline. In order to revive from the decline stage the company has to go for design modification in the product. The design modifications are decided on the basis of the feedback received from the market. Therefore New Product Development is a strategic process of product life cycle management. New product development and innovation is a continuous process to sustain and grow in the competitive business environment.

5.3 TYPES OF NEW PRODUCTS

As viewed against different criterion we get several categories of new products.

Entirely New to the world : On the basis of results and findings of some basic and applied research activities, a company may innovate/ design a new product. Example: Vaccine for AIDS.

New to a market: A company may decide to launch a new product in the market which is not available in that specific market so far. Example: Launching umbrella made of Assamese Muga silk in Switzerland.

New to the company : Maruti Udyog, the largest four wheeler producing company in India launching two wheelers in India.

When viewed against different criteria, some new product concepts are merely minor modifications of existing products (e.g: changing only the colour of an existing model of a car) while some are completely innovative to the company (Tata Motors launching Tata Nano).

Considering the above mentioned criteria, the different categorizations are as follows:

- Changes to Augmented Product
- Core product revision
- Line extensions
- New product lines
- Repositioning
- Completely new product

5.4 THE PROCESS OF NEW PRODUCT DEVELOPMENT

There are various phases in the entire new product development process. The phases are, Idea generation, Idea screening, Concept development and testing, Business analysis, Beta testing and market testing, Technical implementation and Commercialization, which are discussed as follows –

5.4.1 Idea Generation

- The initial ideas for new products can be obtained from the findings of basic or applied research. A detail SWOT analysis (Strength, Weaknesses, Opportunities and Threat analysis) may be conducted to understand the feasibility of using the research findings to develop a new product. The issues to be considered while doing the SWOT analysis are market and consumer trends, facilities in the company's R&D department, competitors, focus groups, target market, human and manufacturing resource of the company etc. The finding of this analysis may lead to the idea generation for a new product or a new product line.
- Brainstorming process is very effective for idea generation for a new product. In brainstorming, during collective discussion lots of ideas come up, and some of the ideas lead to conceptualizing a new product.

5.4.2 Idea Screening

Routing procedure involves the following different activities:

- Idea screening is done to eliminate unsound concepts prior to devoting resources to them.
- The screeners must ask the following questions:
  - Will the customer in the target market benefit from the product?
  - What is the size and growth forecasts of the market segment/target market?
  - What is the current or expected competitive pressure for the product idea?
  - What are the industry sales and market trends the product idea is based on?
  - Is it technically feasible to manufacture the product?
  - Will the product be profitable when manufactured and delivered to the customer at the target price?

5.4.3 Concept Development and Testing

- In the concept development phase, the detail feasibility analysis of technical, financial and marketing aspects takes place. The following questions are to be answered during this phase.
  - Who is the target market and who is the decision maker in the purchasing process?
  - What product features must the product incorporate?
  - What benefits will the product provide?
  - How will consumers react to the product?
  - How will the product be produced most cost effectively?
  - Prove feasibility through virtual computer aided rendering, and rapid prototyping
  - What will it cost to produce it?
  - Test the concept by asking a sample of prospective customers what they think of the idea.

5.4.4 Business Analysis

- A detail business plan is formulated in this stage. Following activities are to be carried out during this stage.
  - Estimate likely selling price based upon competition and customer feedback
  - Estimate sales volume based upon size of the market
  - Estimate profitability and breakeven point

5.4.5 Beta Testing and Marketing Testing

- Produce a physical prototype or mock-up
- Test the product (and its packaging) in typical usage situations
- Conduct focus group customer interviews or introduce at trade shows.
- Make adjustments where necessary
- Produce an initial run of the product and sell it in a test market area to determine customer acceptance



LET US KNOW

Focus Group: This is essentially a group discussion on a given subject conducted by a trained moderator. The purpose of this is to create less formal situation, where people can exchange views, bringing out their options, attitudes, and feelings about the given subject. Usually a group consists of 6-10 persons. The length of the discussion can be about an hour to an hour and a half, or until the group has nothing left to add.

Test Market : This is the marketplace defined to conduct consumer behavior research for a newly launched product. A series of controlled experiments may be done in this controlled marketplace to get the response/feedback on the new product.

5.4.6 Technical Implementation

Following activities are to be carried out in this phase of new product development

- New program initiation
- Resource estimation
- Requirement publication
- Engineering operations planning
- Department scheduling
- Supplier collaboration
- Logistics plan
- Resource plan publication
- Program review and monitoring
- Contingencies - what-if planning



NPD : New Product Development.

5.4.7 Commercialization

In this phase the actual commercial launch of the new product takes place. Following activities are to be carried out in this phase of new product development

- Launch the product
- Produce and place advertisements and other promotions
- Fill the distribution pipeline with product
- Critical path analysis is most useful at this stage

These steps may be iterated as needed. Some steps may be eliminated. To reduce the time that the NPD process takes, many companies are completing several steps at the same time (referred to as concurrent engineering or time to market). Most industry leaders see new product development as a proactive process where resources are allocated to identify market changes and seize upon new product opportunities before they occur (in contrast to a reactive strategy in which nothing is done until problems occur or the competitor introduces an innovation). Many industry leaders see new product development as an ongoing process (referred to as

continuous development) in which the entire organization is always looking for opportunities.

Because the NPD process typically requires both engineering and marketing expertise, cross-functional teams are a common way of organizing projects. The team is responsible for all aspects of the project, from initial idea generation to final commercialization, and they usually report to senior management (often to a Vice President or Program Manager). In those industries where products are technically complex, development research is typically expensive, and product life cycles are relatively short, strategic alliances among several organizations helps to spread the costs, provide access to a wider skill set, and speed the overall process.



CHECK YOUR PROGRESS

Q.1: A product may be called a new product if it

(a) Entirely new to the world

(b) New to an existing marketplace

(c) New to the company

(d) All of the above

Q.2: Product repositioning is also a category of new product development

(a) Ture (b) False

Q.3: Marketing and Engineering details of the new product is developed in the—

(a) Idea Generation phase

(b) Idea screening phase

(c) Concept development and testing phase

(d) Business analysis phase

Q.4: Test marketing and focus group interviews are conducted in the—

(a) Idea screening phase

(b) Concept development and testing phase

(c) Business analysis phase

(d) Beta testing and market testing phase

5.5 DESIGN FOR MANUFACTURABILITY (DFM)

Design for Manufacturability is a proven design methodology that works for any size company. By using DFM techniques companies can design products right the first time by utilizing concurrent engineering design teams to optimize manufacturability, quality, reliability, serviceability, cost, flexibility, market acceptance and time-to-market.

While designing a product, the available manufacturing and assembly facilities are to be considered. A product should be designed in such a way, so that it can be manufactured and assembled in desired time frame by optimum utilization of resources.

An organization must begin considering its unique process capabilities and developing company specific design guidelines. While the design of a custom part or selection of a new part may be the most optimal approach to meet product requirements from the designer's point of view, it may not be the best overall approach for the company. Product cost and quality may be negatively affected by the proliferation of specialized items that require specialized capabilities or prevent efficient manufacture procurement. Minimizing the number of active or approved parts through standardization not only simplifies product design, but can also result in operational efficiencies and lower inventories. A formal policy of parts standardization and emphasis on use of parts from an approved parts list for certain commodities provides management direction to the designer. Product development teams need to understand basic DFM principles that are applicable to a wide range of products. Some basic principles to follow are:

- Simplify and reduce the number of parts.
- Standardize and use common parts and materials.
- Design for ease of fabrication.
- Mistake proof product design and assembly. (poka-yoke)
- Design for parts orientation and handling to minimize nonvalue-added manual effort.
- Minimize flexible parts and interconnections.

- Design for ease of assembly.
- Design for efficient joining and fastening.
- Design modular products to facilitate assembly with building block components.
- Design for ease of service.
- Design “robustness” into products.
- Avoid tight tolerances.

DFM may require additional effort early in the design process. However, the integration of product and process design through improved business practices, management philosophies and technology tools will result in a more producible product to better meet customer needs, a quicker and smoother transition to manufacturing, and a lower total program/lifecycle cost.

The greatest challenges exist not in implementing new techniques, business practices, or technology, but in overcoming the organizational barriers and the resistance to changing the way things are done. As new products and time to market become crucial in achieving competitive advantage, the use of DFM concepts as a basis for new product development will become essential.

5.6 DESIGNING FOR QUALITY

A crucial element in product design is its impact on quality. Whether products of superior quality are received by customers is ultimately determined in large part to the extent that products are designed for quality. Building product quality in to product design is the first step in producing products of superior quality.

5.7 RAPID PROTOTYPING

Rapid prototyping is the automatic construction of physical objects using solid freeform fabrication. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today, they are used for a much wider range of applications

and are even used to manufacture production quality parts in relatively small numbers. Some sculptors use the technology to produce complex shapes for fine arts exhibitions

The word “rapid” is relative: construction of a model with contemporary methods can take from several hours to several days, depending on the method used and the size and complexity of the model. Additive systems for rapid prototyping can typically produce models in a few hours, although it can vary widely depending on the type of machine being used and the size and number of models being produced simultaneously.

Some solid freeform fabrication techniques use two materials in the course of constructing parts. The first material is the part material and the second is the support material (to support overhanging features during construction). The support material is later removed by heat or dissolved away with a solvent or water.

Traditional injection molding can be less expensive for manufacturing plastic products in high quantities, but additive fabrication can be faster and less expensive when producing relatively small quantities of parts.

Rapid prototyping is now entering the field of rapid manufacturing and it is believed by many experts that this is a “next level” technology. Pioneer companies claim to have already mastered this new technique.

5.8 DESIGNING AND DEVELOPING NEW SERVICES

The design considerations for developing a new service are different from design considerations for tangible product (goods) design. There are three general dimensions of service design to be considered while developing a new service.

- The degree of standardization of a service – Is the nature of the service customized for particular customers or is the same of the service the same for all customers.
- The degree of customer contact in delivering the service – Is there a high level of customer contact as in dress boutique or low level of customer contact as in a fast food restaurant

- The mix of physical goods and intangible services –Is the mix dominated by intangible services as in a university or by physical goods as in a tailored suit

There are both advantages and disadvantages of the amount of each of these dimensions to include in a service design. For example services that are standardized with a low degree of customer contact are usually less expensive and quicker to deliver and may be appropriate for strategies of some services. On the other hand custom services with a very high degree of customer interaction may be appropriate for some other services. All these dimensions come together as service designs are established, and the final choice of design may be based on the desired competitive priorities of the business strategies adopted.

There are some basic differences between tangible product design and service design. Unless services are dominated by physical goods their development usually does not require the engineering, testing and prototype building of product design. And because many service businesses involve intangible services, market sensing tends to be more by surveys rather than from markets tests and demonstrations.



CHECK YOUR PROGRESS

Q.5: Rapid Progotyping Technique is used for—

(a) Conceptualizing a new design

(b) Converting a new design concept to a physical product or mock-up

(c) Evaluating a new product design

(d) Both (b) & (c)

Q.6: In Concurrent Engineering—

(a) Product design and process design is done separately

(b) Process design takes place after product design

(c) Product design takes place after process design

(d) Product design and process design is done simultaneously.



5.9 LET US SUM UP

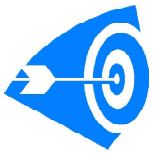
In this unit we have discussed different aspects of new products like, types of new products, the process of new product development, design for manufacturability, and quality, rapid prototyping and designing and developing new services etc.

Innovation is one of the important tools for competitive advantage. There is no limitation of expectations of customers; therefore, new product development is a continuous process. Product developers need to be brought into contact with the customer through a representative group of prospective customers. Marketing and program management functions need to be involved in product development to provide this type of customer/market input. Concurrent Engineering is based on the integrated design of products and manufacturing and support processes. It is not a matter of assessing manufacturability of the product after it has been designed and making appropriate changes to the product design to enhance its productivity.



5.10 FURTHER READING

1. K. Aswathappa K.S. Bhat(2015) ,Production and Operations Management, Himalaya Publishing House.
2. K. Bedi(2013) ,Production and Operations Management, Oxford University Press.
3. S.N. Chary(2017), Production and Operations Management, Tata-McGraw Hill Publishing Company Limited.
4. R. Panneerselvam (2012),Production and Operations Management, Prentice Hall of India Private Limited.



5.11 ANSWER TO CHECK YOUR PROGRESS

Ans to Q. No. 1: (d) All of the above.

Ans to Q. No. 2: (a) True.

Ans to Q. No. 3: (c) Concept development and testing phase.

Ans to Q. No. 4: (d) Beta testing & market testing phase.

Ans to Q. No. 5: (d) Both (b) & (c).

Ans to Q. No. 6: (d) Product design and process design is done simultaneously.



5.12 MODEL QUESTIONS

Q.1: Why new product development activity is essential for an organization?

Q.2: What are the various types of new products?

Q.3: What is DFA (Design for Manufacturing and Assembly)? Explain.

Q.4: Explain the new product development process in detail.

Q.5: What is Rapid Prototyping? How does it help in the new product development process?

Q.6: Discuss various factors for considerations in designing a new service.

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UNIT 6: INVENTORY MANAGEMENT

UNIT STRUCTURE

6.1 Learning Objectives

6.2 Introduction

6.3 Types of Inventory

6.4 Advantages and Disadvantages of high level and low level inventories

6.5 Reasons for maintaining Inventory

6.6 Types of Inventory Systems

6.7 Let Us Sum Up

6.8 Further Reading

6.9 Answers To Check Your Progress

6.10 Model Questions

6.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concept of Inventory Management
- discuss the different types of Inventory
- to identify the advantages and disadvantages of high and low inventory levels.
- describe the basic concepts of EOQ(Economic Order Quantity) and its application
- explain ABC analysis and its applications

6.2 INTRODUCTION

In this unit, we will deal with how to manage inventory. Inventory means storage of goods or services. In production process company needs to store various materials like raw material, semi finished goods or finished goods etc. So, to maintain proper balance of these materials, inventory management is very essential.

6.3 TYPES OF INVENTORY

Inventory may be classified into the following categories

1) **Cycle Inventory :** This type of inventory occurs when productions is carried out in batches which are cyclical. It refers to the inventory essential to meet an inventory cycle.
2) **Anticipation Inventory :** This inventory takes care of inventory which is expected from increase in sales or to take care of special occasions that would trigger enhanced sales. Such special occasions are not a part of the regular sales projections.
3) **Decoupling Inventory :** This inventory is used to de-link or disassociate the operations of different machines working in sequence. Decoupling inventory ensure the smooth operation of the different machines in the event of breakdown of any machine.
4) **Safety stock :** This inventory is managed to protect against the variations of demand and supply. It safeguards against loss of customers due to unavailability of inventory of the type required
5) **Pipeline Inventory :** This inventory refers to the inventory in between two points of the supply chain or between two places. It is inventory *in-transit*.

6.4 ADVANTAGES AND DISADVANTAGES OF HIGH LEVEL AND LOW LEVEL INVENTORIES

Advantages :

Advantages of Inventory management:

Managing inventory is important in all aspects of business. Following are the main advantages of keeping appropriate inventory:

- Increased sales: Inventory management also helps in increasing the sales.
- Increased information transparency: Inventory management helps in knowing the details about when items are received, picked, packed, shipped, manufactured etc.
- Shorter lead time: Proper inventory management helps in reducing the lead time.

- Lower costs: Effective inventory management practices help result in decreased inventory write offs, plus lower inventory holding costs.
- Improved delivery performance: Real time inventory updates improve the flow of goods to customers.
- Increased employee efficiency: Good inventory management solutions save time. Less time spent on managing inventory results in greater productivity.
- It helps in accurate planning.
- Business who actively manages their inventory can decrease in stock outs.
- Increased Customer loyalty: If customer needs can be fulfilled on time, loyalty will increase.
- Increased inventory turnover: It helps in optimizing the value of goods and increase inventory turnover by keeping fewer slow moving products on hand, while increasing your stock levels on profitable goods.

Following are the disadvantages of high level inventories.

- Excess funds will be blocked in materials, part of which could have been used for other
- needs of the organization.
- Large storage and storage costs, inventory carrying costs and insurance charges will be high.
- Excess stocks will be tempting to employees and others to indulge in wastage, pilferage.
- Situation displays unplanned and unorganized way of working.
- For few materials this leads to deterioration, rusting, dent, bends, etc.
- For chemicals, gases and powder quality and also effective strength may be lost.
- Chances of obsolescence are more which speaks of poor management strategies.

Following are the disadvantages of low level inventory

- Production stoppages will be frequent and consequently creates idleness of machines and workers.

- Fail to satisfy customer in terms of committed deliveries.
- Situation may lead to loosing some potential customers or orders due to delays
- This may create a situation of too many incomplete sub-assemblies due to lack of some or other matching components. Despatch of fully assembled and completed goods gets delayed.



CHECK YOUR PROGRESS

Q.1: Discuss three disadvantages of high & low level inventories.

(a) .....

(b) .....

(c) .....

Q.2: Name any four types of inventory.

(a) .....

(b) .....

(c) .....

(d) .....

6.5 REASONS FOR MAINTAINING INVENTORY

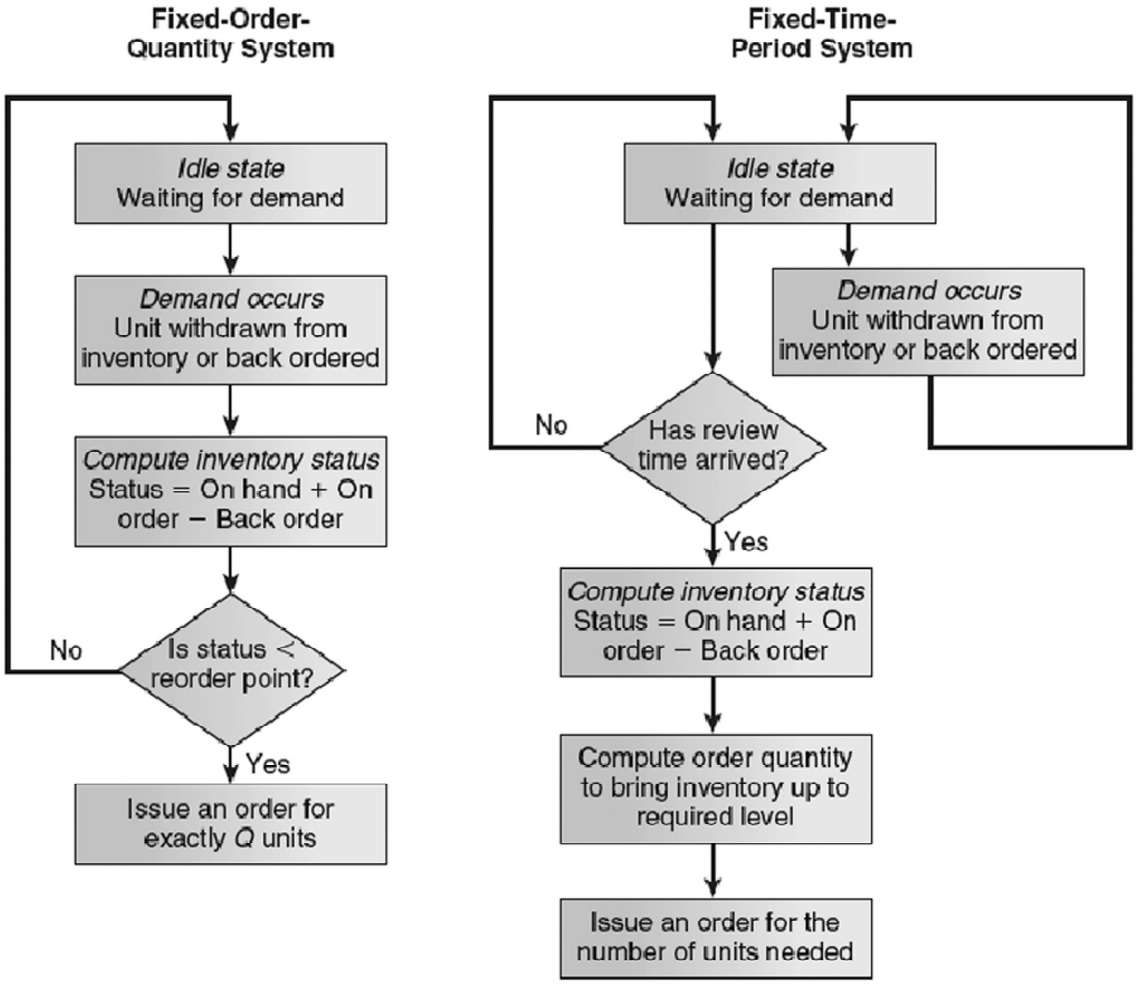
Following are the basic reasons for maintaining inventory and implementing a professional inventory control system.

- To protect against uncertainty:
  - Shortages of raw materials.
  - Work-in-process variations.
  - Changes in demand for finished products.
- To support a strategic plan
  - As a cyclic demand buffer for a level-output strategy.
- To take advantage of economies of scale
  - Large quantity purchases reduce the average total unit costs related to fixed ordering, setup costs, and transportation costs.

6.6 TYPES OF INVENTORY SYSTEMS

There are two types of inventory systems, viz. Fixed Order Quantity and Fixed Time Period.

- *Fixed-Order Quantity*
  - A system where the order quantity remains constant but the time between orders varies.
    - It is preferred for important or expensive items because average inventory is lower.
    - It provides a quicker response to stockouts
    - It is more expensive to maintain due to inventory record-keeping costs.
    - Example: Always purchasing a dozen eggs when there are only two eggs left in the refrigerator.
- *Fixed-Time Period*
  - A system where the time period between orders remains constant but the order quantity varies.
    - Has larger average inventory to prevent stockouts.
    - Useful when purchasing multiple items from one vendor to save on costs.
    - Example: Always refilling the gas tank of a delivery truck at the end of each day.



Comparison of Fixed-Order-Quantity and Fixed-Time-Period Reordering Inventory Systems

Fig. : 6.1



6.7 LET US SUM UP

In this unit,we have discussed about inventory management.

Inventory management is one of the most important topic for thinking of effective cost control. In any manufacturing business, material constitute 50% to 70% of the input value. A very detailed study of material, consumption pattern, sourcing and planning of purchase and storage is going to help in a big way to reduce the cost input and hence improve cost efficiency and profitability.

Any available resource having economic value but kept idle is called inventory. Hence in manufacturing company raw materials, work in progress materials and finished goods form inventory. Though WIP is

not idle, it is still an inventory as long as it remains in the company premises. Similarly, unused or idle manpower and unused financial resources are categorised as inventory. Hence the basic objective of inventory management is optimum allocation of resources for increased productivity.



6.8 FURTHER READING

1. Production and operations management by S Anil Kumar & N. Suresh, New age international (2008)
2. Production Management, by K. Aswathappa, Himalaya Publishing House
3. Production and Operations Management, by R. Panneerselvam, PHI publications.
4. Production and Operations Management, by S.N. Chary, Tata Mc Graw Hill.



6.9 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q No. 1: (a) Large storage and storage cost
(b) Wastages (c) Excess funds will be blocked

Ans to Q No 2: (a) Safety stock
(b) Anticipation Inventory
(c) pipeline Inventory
(d) Cycle Inventory



6.10 MODEL QUESTIONS

Q.1: Describe the basic concept of Inventory Management

Q.2: Describe the functions of inventory control

Q.3: What is Economic Order Quantity?

Q.4: Explain various inventory costs

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UNIT 7: TECHNIQUES OF INVENTORY MANAGEMENT

UNIT STRUCTURE

7.1 Learning Objectives

7.2 Introduction

7.3 Economic Order Quantity (EOQ)

- 7.3.1 Model 1 : The Classical EOQ Model
- 7.3.2 EOQ Model 2 : EOQ With Price Breaks
- 7.3.3 EOQ Model 3 : EOQ Model For Production Runs
- 7.3.4 Safety Stock

7.4 ABC Analysis

7.5 Let Us Sum Up

7.6 Further Readings

7.7 Answers To Check Your Progress

7.8 Model Questions

7.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic techniques of inventory management
- describe the basic concepts of EOQ (Economic Order Quantity) and its application in inventory management
- explain the ABC analysis and its applications

7.2 INTRODUCTION

In the earlier unit, we have discussed about inventory management. In this unit, we are going to discuss on different techniques of inventory management. A good inventory control practice minimizes the cost of inventory and brings better efficiency and agility to the manufacturing processes. Organizations are required to follow scientific inventory control practices in their organization. There are different types of inventory as mentioned below:

- *Raw Materials*
  - Vendor-supplied items that have not had any labour added by the firm receiving the items.
- *Finished Goods*
  - Completed products that are still in the possession of the firm that manufactured them.
- *Work-in-Process (WIP)*
  - Items that have been partially processed but are still incomplete.

These three types of inventory is to be controlled so as to minimize the inventory cost while maintaining the smooth production flow.

7.3 ECONOMIC ORDER QUANTITY (EOQ)

Economic order quantity (EOQ) is that level of inventory that minimizes the total of inventory holding cost and ordering cost. When the purchase order quantity increases the ordering cost (set up cost) decreases but the carrying cost (holding cost) increases. On the other hand when purchase order quantity decreases, ordering cost (set-up cost) increases but carrying cost (holding cost) decreases. With the help of EOQ we can determine the purchase order quantity , i.e how many materials should be purchased at a time so that the total cost is minimum.

Inventory Costs may be classified as follows:

- *Holding or Carrying Costs*

Carrying or holding cost is the cost incurred to store the materials in the warehouse. The carrying cost is directly proportional to the quantity and the time of holding.

- Storage costs (facility, insurance, taxes, utilities)
- Capital costs (opportunity costs)
- Obsolescence/shrinkage costs (depreciated value)

- *Setup or Ordering Costs*

This is the cost incurred in formalizing a purchase order. This includes the cost of processing a purchase order i.e floating tender, receiving

quotations, technical and financial evaluation of those quotations. Transportation cost and the cost of inspection of the incoming material is also included here.

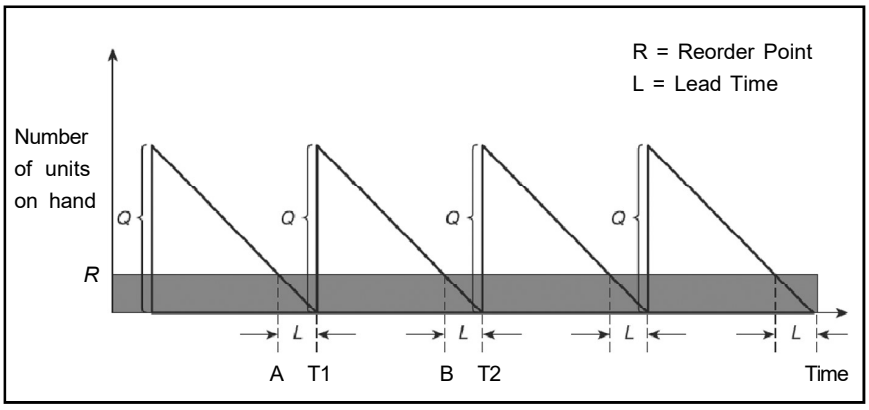
- *Shortage (or Stockout) Costs –*

This is the cost of loss of business opportunity due to shortage of material in stock. Due to shortage of material the production or the assembly line may remain idle. Again, if the right quantity of material is not being delivered to the customer at the right time it may lead to customer dissatisfaction. Customers' dissatisfaction is cost to the company.

- *Purchase Costs*

It is the purchase price of the material. Again, if the material is being produced inside the factory only, then the cost of production will be the purchase cost.

7.3.1 MODEL 1 : The Classical EOQ Model



Inventory profile of CLassical EOQ Model

Fig. : 7.2

The basic assumptions of classical EOQ model are as follows:

- The demand for the item is certain, continuous and constant over time
- The lead time i.e the time between placement of an order and receipt of the material is known and fixed.
- Within the range of the quantities to be ordered, the per unit carrying cost and the ordering cost are constant and independent of the quantity ordered.

- The purchase price of the item is constant. There is no price variations on the basis of the quantity
- The inventory is replenished immediately as the stock level reaches exactly equal to zero. Consequently, there are no stock overages or shortages.

Let us assume that we begin with a stock of Q initially. The stock is consumed at a rate of d units per day. When stock is consumed inventory has to be filled up at time T1 and again at T2 and so on. Again, as there is a lead time "L" for the material we need to place the order at time A, so as to reach the material at time T1. Similarly, for the next cycle, order has to be placed at the time B so as to reach the material at time T2. Therefore, we need to fix a reorder level "R" to avoid stock out during the lead time.

In this inventory cycle,

- The maximum inventory held would be Q
- The minimum inventory would be zero
- The average inventory would be Q/2

The cost model for a period of one year

T(Q) = O (Q) + H(Q)

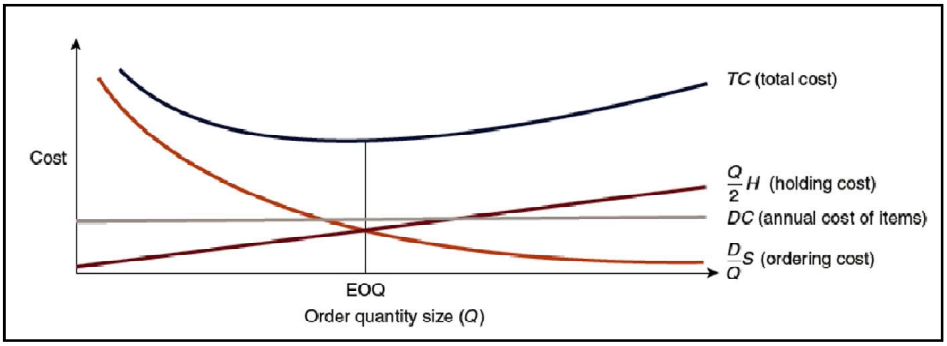
Where

Q = the ordering quantity

T(Q) = Total variable annual inventory cost

O (Q)= Total annual ordering cost

H (Q) = Total annual holding cost



Graphical representation of EOQ

Fig. : 7.3

The Economic Order Quantity is derived by taking following considerations:

– The optimal quantity to order taking into consideration both the cost to carry inventory and the cost to order the item.

– Minimizes total inventory cost

We can obtain the value of EOQ using the following formula

$$EOQ = \sqrt{\frac{2DS}{H}}$$

Where

D = Annual demand in units

S = Setup or ordering cost

H = Annual holding cost per unit

Again

Reorder level (R) = Demand during lead time = (lead time) X (daily demand)

Total variable inventory cost = $\sqrt{2DSH}$



CHECK YOUR PROGRESS

Q.1: A company manufactures decorative table lamps procuring glass lamp shades from outside source, then assembling it and then sells. It needs glass lampshades of a particular design as per the following details:

Annual Demand (D) = 1000 units

Ordering cost (S) = Rs. 5 per order

Holding cost (H) = Rs.2 per unit per year

Lead Time (L) = 5 days

Number of working days in a year = 250 days

Calculate the

a) Economic Order Quantity (EOQ) of the lampshades

b) Number of orders

c) Total variable inventory cost

d) Reorder Level

Q.2: Carrying or holding cost is the _____

a) Purchase price of the material

b) Transportation cost

c) cost incurred to store the materials in the warehouse

d) This is the cost of loss of business opportunity due to shortage of material in stock

Q.3: Transportation cost will come under _____

a) Carrying cost

b) Ordering or set-up cost

c) Stock out cost

d) Purchase cost

Q.4: Setup or Ordering Cost is _____

a) Purchase price of the material

b) Cost incurred to store the materials in the warehouse

c) Cost of loss of business opportunity due to shortage of material in stock

d) The cost incurred for formalizing and placement of a purchase order.

7.3.2 EOQ Model 2 : EOQ with price breaks

EOQ Model 1 is based on the basic assumption that the unit price of the material is constant. But it is being observed that in certain cases suppliers offer discounts for bulk purchase of the material. In this case, the price of the material varies with quantity. In such a case inventory cost model would include the purchasing cost along with the ordering and carrying cost

Thus the total cost

$T(Q) = (D/Q)*S + (Q/2)*H + CjD$

Where

D = Annual demand in units

S = Setup or ordering cost

H = Annual holding cost per unit

Cj is the unit price of the material.

So for various price alternatives we may calculate the total cost and examine the feasibility. With the help of this iterative process we deicide on the EOQ.

7.3.3 EOQ Model 3 : EOQ Model for Production Runs

One of the basic assumptions of EOQ Model 1 was that the entire quantity of the material is received in a single lot at a time. In the EOQ model for production runs, we consider that materials are received for inventory at a constant rate and they are also being consumed at a constant rate.

Total cost = T(Q) = (D/Q)S + (Q/2)H [1-(d/p)]

EOQ = $\sqrt{\frac{2DS}{H[1-(d/p)]}}$

Total Variable Inventory Cost = $\sqrt{2DSH[1-(D/P)]}$

Where

D = Annual demand in units

S = Setup or ordering cost

H = Annual holding cost per unit

p = Production rate

d = depletion rate

7.3.4 Safety Stock

The two common assumptions in the three EOQ models discussed so far are:

- Demand of the material is constant and known
- Lead time of the material is constant and known.

That is why these models are called deterministic models. Now, let us consider that the demand and the lead time of the material is not known. Demand and the lead time is variable. In the deterministic models, the stock is replenished as soon as the stock reaches the point of exhaustion. Therefore, under such

idealistic situations there is no need to maintain any extra stock because the moment stock reaches zero, new supply of material comes in the inventory. Therefore, there is no question of stock out.

But when -

- Demand of the material is variable and is not known
- Lead time of the material is variable and not known

There is a need to provide safety stock. It is also termed as buffer stock. This safety stock or buffer stock is created to meet the stock out problems that may arise due to variable demand and lead time of the material.

In such a situation, while estimating the reorder point, safety stock must be considered. The reorder level must be determined as follows :

Reorder level = (expected demand of the material during lead time) + (safety stock)

Or, R = Ld +SS

Where

L = Lead time in days

d = average daily demand of the material

SS = Safety stock for the material

7.4 ABC ANALYSIS

ABC analysis is very useful in categorizing the inventory items, priority wise. The items are classified on the basis of their usage in monetary terms. It has been observed that a small number of items account for a large share of total cost of the inventory. Again for a large number of items consumption rate is very high. The inventory items are divided into three categories, A, B, and C on the basis of consumption and value of the items.

A : High consumption value items

B : Moderate consumption value items

C: Low consumption value items

The division of items into these three categories is conducted by plotting the usage value of the item in a Pareto curve. The process of ABC analysis is given below:

Step 1 : Obtain the list of the items along with information on their unit cost and the periodic consumption (usually annual)

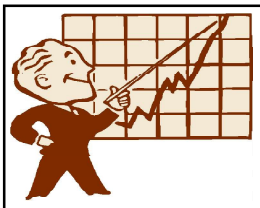
Step 2 : Determine the annual usage value for each of the items by multiplying the unit cost with number of units and rank them in descending order on the basis of their respective usage values

Step 3 : Express the value for each item as a percentage of the aggregate usage value. Then cumulate the percent of annual usage value

Step 4 : Obtain the percentage value for each of the items. For n items, each item should represent 100/n percent. For example, if there are 20 items involved in the classification, then each item would represent 100/ 20 = 5% of the materials. Cumulate these percentage values as well.

Step 5 : Using the data on cumulated values of items and the cumulated percentage usage values, plot the curve by showing these, respectively in X and Y axes.

Step 6 : Determine the appropriate divisions for the A, B and C categories. The curve would rise steeply up to a point. This point is marked and the items up to that point constitute the A- type items. The curve would be moderately sloped towards upright. The point beyond which the slope of the curve is negligible is marked. The items covered beyond that point are classified as category C type. The items falling between point A and C will be items under category B.



CHECK YOUR PROGRESS

Q.5: Perform ABC analysis using the following data

Items	Number of units reqd.	Unit price (Rs.)
1	800	5
2	400	10
3	40	50
4	60	100
5	300	200
6	400	40
7	50	10
8	60	40
9	30	40
10	150	20
11	30	30
12	400	20
13	300	30
14	250	200
15	50	500
16	400	30
17	500	20
18	30	400
19	50	500
20	200	20



7.5 LET US SUM UP

In this unit, we have discussed different technique of inventory management. Two most important technique are EOQ & ABC analysis. The determination of Economic Order Quantity (EOQ) is very important

in order to optimize the inventory cost. It is a deterministic model with the help of which the inventory manager may decide on the purchase order quantity and the number of purchase orders to be placed in order to meet the inventory demand. It also determines the total variable inventory cost under a particular situation.

ABC analysis help an inventory manager to segregate materials as per usage value. This helps him to prioritize the items he/ she is dealing with in his/her inventory



7.6 FURTHER READING

1. Inventory management section of Operations Research by V.K Kapoor



7.7 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No.1: Given that

Annual Demand (D) = 1000 units

Ordering cost (S) = Rs. 5 per order

Holding cost (H) = Rs.2 per unit per year

Lead Time (L) = 5 days

Number of working days in a year = 250 days

a) $EOQ = \sqrt{\frac{2DS}{H}}$

= $\sqrt{\frac{2 \times 1000 \times 5}{2}}$

= 70.7

= 71

Answer, EOQ of the lampshades = 71

b) Number of orders = 1000 / 71 = 14

c) Total annual inventory cost

= $\sqrt{2DSH}$

= $\sqrt{2 \times 1000 \times 5 \times 2}$

= Rs.141.42

d) Reorder level = d x L

Demand per day, d = 1000/ 250 = 4

Therefore Reorder level, R = 4 X 5 = 20

Ans. to Q. No.2: Carrying or holding cost is the

c) cost incurred to store the materials in the warehouse

Ans. to Q. No.3: Transportation cost will come under

b) Ordering or set-up cost

Ans. to Q. No.4: Setup or Ordering Cost is

d) The cost incurred for formalizing and placement of a purchase order

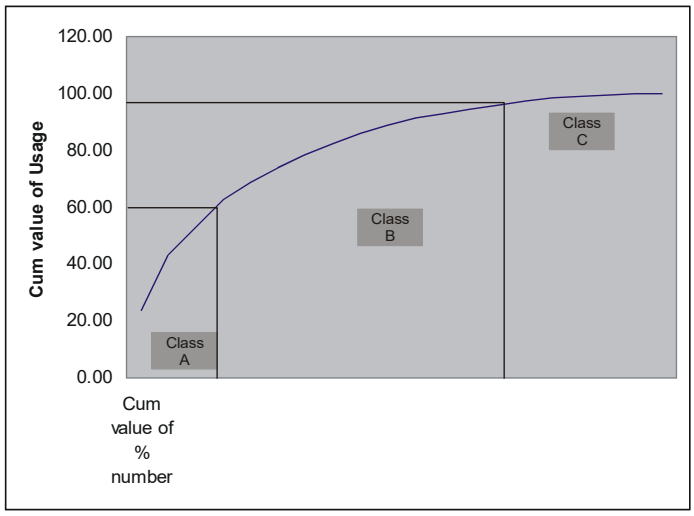
Ans. to Q. No.5: Determination of usage values

Items	Number of units reqd.	unit Price (Rs.)	Usage	Percentage	Rank
1	800	5	4000	1.57	12
2	400	10	4000	1.57	13
3	40	50	2000	0.78	17
4	60	100	6000	2.35	11
5	300	200	60000	23.53	1
6	400	40	16000	6.27	5
7	50	10	500	0.20	20
8	60	40	2400	0.94	16
9	30	40	1200	0.47	18
10	150	20	3000	1.18	15
11	30	30	900	0.35	19
12	400	20	8000	3.14	10
13	300	30	9000	3.53	9
14	250	200	5000	19.61	2
15	50	500	25000	9.80	3
16	400	30	12000	4.71	6

17	500	20	10000	3.92	8
18	30	400	12000	4.71	7
19	50	500	25000	9.80	4
20	200	20	4000	1.57	14

Rank wise Determination of cumulative percentages. Items are arranged ascending rank wise i.e descending percentage wise. As there were 20 items under consideration, therefore % number is 5

Items	Percentage	Rank	Cum value	% Number	Cum value of % number
5	23.53	1	23.53	5	5
14	19.61	2	43.14	5	10
15	9.80	3	52.94	5	15
19	9.80	4	62.75	5	20
6	6.27	5	69.02	5	25
16	4.71	6	73.73	5	30
18	4.71	7	78.43	5	35
17	3.92	8	82.35	5	40
13	3.53	9	85.88	5	45
12	3.14	10	89.02	5	50
4	2.35	11	91.37	5	55
1	1.57	12	92.94	5	60
2	1.57	13	94.51	5	65
20	1.57	14	96.08	5	70
10	1.18	15	97.25	5	75
8	0.94	16	98.20	5	80
3	0.78	17	98.98	5	85
9	0.47	18	99.45	5	90
11	0.35	19	99.80	5	95
7	0.20	20	100.00	5	10



ABC classification of item using the Pereto Curve

Simplification and Codification

Normally, in inventory management system the materials are denoted by codes. These codes are unique for each material. Similar items are grouped together and a part of the code denotes the group identification. From the code one can even identify the material composition and the manufacturing processes involved with a particular material. This method also helps in computerized inventory control system.



7.8 MODEL QUESTIONS

Q.1: What is Economic Order Quantity?

Q.2: Explain various inventory costs

Q.3: Describe Economic Order Quantity Model 1

Q.4: Describe in detail the ABC analysis

Q.5: Calculate the EOQ, Reorder level, Total variable inventory cost and number of purchase orders for the following data

Annual Demand (D) = 5000 units

Ordering cost (S) = Rs. 10 per order

Holding cost (H) = Rs.6 per unit per year

Lead Time (L) = 5 days

Number of working days in a year = 250 days

Q.6: Perform ABC analysis using following data

Items	Number of units reqd.	Unit price (Rs.)
1	1000	50
2	2000	70
3	3000	400
4	400	500
5	600	45
6	2500	600
7	1000	30
8	3000	40
9	45	30
10	80	60
11	3000	1000
12	200	5000
13	2000	2000
14	200	800
15	300	600
16	2400	70
17	1200	80
18	500	1200
19	600	600
20	2500	800

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