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MATERIALS AND FINANCIAL MANAGEMENT

C.M. Sadiwala • Ritesh C. Sadiwala

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Preface

The developing countries like India are facing the various types of problems about materials and other resources, which are scarce or imported from other countries. The various Industries, which will have to compete with Internationally, established manufacturing organizations to manage their production and materials they are marketing and procuring after liberalization to sell their products at the competitive rates have to purchase, store and produce their products very economically. After liberalization Industries in our country have realized the importance of materials and financial management to manage and utilize all their resources in the best possible way. The revolutionary changes have been taking place in Industries for various activities to optimize the cost of materials and production operation. The Industries in our country and globally are managing their resources and all types of materials by the new techniques, methods and use of computers to utilize them most economically considering various costs involved in purchasing, procuring, storing and utilizing various types of materials and products. The materials and financial management is the subject which deals with the study of techniques of appropriate materials supply and materials flow procedures to control the production system. It helps in materials management and control of inventories. The financial management shows how to economize the cost of purchase of materials and inventory control. It is therefore necessary to introduce and teach our students studying for graduation and post graduation in engineering, management, finance, economics and science the subject of 'Materials and Financial Management'. This subject is the part of syllabus of B.E., B.Tech., AMIE, M.B.A. M.Tech., M.E., M.C.A., and other management and engineering courses, practitioner engineers working in various organizations and competitive examinations. The various Universities in India and other countries have prescribed this subject in various Engineering and Management Institutions in their course of study.

I have attempted to introduce and cover the various topics of materials and financial management in this book. I have also emphasized the need for materials management in every Industry and other organizations to manage and economize their costs. The stores planning and control is very essential in every organization to manage and control the various types of materials, items and parts required to manufacture and market their outputs to develop and meet the demands of their customers and market. The materials management, inventory control, materials purchasing and supply chain management, stores control, standardization, simplification, classification, coding of materials and forecasting are the part of materials management department. Break even analysis, inventory planning and materials requirements planning, manufacturing resources planning, cost control, value engineering help in financial management of the organization. M.R.P.- I and M.R.P.- II, Just in time, materials handling, automatic storage and retrieval system, CAD/CAM, Flexible manufacturing system, computer integrated manufacturing and value engineering are the recent fields in

industrial engineering which have practical applications in all the manufacturing and other types of organizations. The use of computers has become essential in materials management. MRP is the computerized system to control manufacturing activities using database management system. Vast amount of clerical work, employees activities and other work involved in the organization in continuously changing conditions to receive customers orders, delays in receiving materials supplies, machines breakdowns and timely delivery of production for sales are the information the management must receive for appropriate decisions in time. MRP, ERP and MIS have made it possible.

This book of **'Materials and Financial Management'** is useful to all engineering, finance, management students and practicing engineers in organizations for their study and practice. The topics included in this book are given below:

Chapter – I	Materials Management
Chapter - II	Purchasing and Supply Chain Management
Chapter - III	Stores Management and Control
Chapter – IV	Standardization, Simplification, Classification and Coding of materials
Chapter – V	Forecasting
Chapter – VI	Inventory Planning
Chapter – VII	Materials Requirements Planning
Chapter – VIII	Break Even Analysis
Chapter – IX	Inventory Control
Chapter – X	Value Engineering
Chapter – XI	Materials Handling
Chapter – XII	Just in Time

All these topics and their contents mentioned above in various chapters from I to XII are essential to study and implement the techniques of Materials and Financial Management in any organization to work efficiently and productively. They are therefore introduced in various Universities and Institutions in India and all over the World as part of the curriculum in Engineering, Technology and Management studies for B.E., B.Tech., AMIE, M.E., M.Tech., M.C.A. and M.B.A. examinations. It will also be useful for general study by any one.

The suggestions are welcomed from the readers of this book for any mistakes, omissions, additions and improvement in the book.

Chandra Mohan Sadiwala

Ritesh Sadiwala

Acknowledgement

This Project of writing the book on Materials and Financial Management and its Publication is completed because of encouragement from my wife, my children and students. I am very much thankful to them.

The patience and timely encouragement to me and helping me to write the book, the author's wife Srimati Uma Sadiwala, daughters Srimati Minal Wani and Srimati Manisha Kanugo and son Shri Ritesh Sadiwala who had also written some chapters and helped me in typing the book and editing supported me in spite of all inconvenience and problems arising time to time to complete the work. They deserve all praise and thanks from me for their help and endurance.

The suggestions for further improvements in the book and inclusions of new topics for further editions will be invited from the students and readers. I am grateful to the publisher M/s New Age International (P) Limited Publishers and thank them for initiating this project on 'Materials and Financial Management' and its timely completion.

Chandra Mohan Sadiwala

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CHAPTER I

Materials Management

Introduction

Materials Management is simply the process by which an organization is supplied with the goods and services that it needs to achieve its objectives of buying, storage and movement of materials. Materials Management is related to planning, procuring, storing and providing the appropriate material of right quality, right quantity at right place in right time so as to co-ordinate and schedule the production activity in an integrative way for an industrial undertaking. Most industries buy materials, transport them in to the plant, change the materials in to parts, assemble parts in to finished products, sell and transport the product to the customer. All these activities of purchase of materials, flow of materials, manufacture them in to the product, supply and sell the product at the market requires various types of materials to manage and control their storage, flow and supply at various places. It is only possible by efficient materials management.

The materials requirements planning, purchasing, inventory planning, storage, inventory control, materials supply, transportation and materials handling are the activities of materials management. They will be discussed in details in various chapters to follow.

About 20-25 years ago, there was no cut-throat competition in the market to sell the various consumer items manufactured by different industrial undertakings and the availability of materials to manufacture these items was not scarce. Therefore, materials management was not thought to be so important and its separate identity in the organization was not felt. But today it has become an important management activity to streamline production.

Actually before the production begins it is necessary to ensure availability of all the types of materials needed for production and its supply at the various production centers. Planning, purchasing and scheduling are the main functions of materials management. It aims at improved productivity. It is used to reduce the cost, which increases profitability and streamlines the production. Apart from management of material cost and its supply it helps in its proper utilization, transportation, storage, handling and distribution.

The market research and forecasting both for sales of company's product and purchasing of various materials required for producing the product are needed at the planning stage.

Purchasing, procurement of materials, transportation, storage, inventory control, quality control and inspection of materials and goods supplied at various production centers before production are also managed as routine work. Materials handling, packaging, warehouse

planning, accounting, scrap, surplus and obsolete materials disposal, finished goods safety and care are the activities managed by the materials management department.

Selection of personnel for marketing, purchasing, inventory control, stores management and materials handling and their training and placement is also to be seen by the materials management department

This indicates that it is very essential to have a materials management department in any organization to support the management in the production activities. It also helps in the marketing, sales promotion and control of all the types of materials for its quantity, quality and cost.

Definition

The International Federation of Purchasing and Materials Management accept the definition of materials management given below. According to it, materials management is a total concept having its definite organization to plan and control all types of materials, its supply, and its flow from raw stage to finished stage so as to deliver the product to customer as per his requirements in time. This involves materials planning, purchasing, receiving, storing, inventory control, scheduling, production, physical distribution and marketing. It also controls the materials handling and its traffic. The materials manager has to manage all these functions with proper authority and responsibility in the material management department. The historical background about the materials management is as follows.

Historical Background

The scarcity of materials, which was felt during World War I in USA to a very large extent and it, has become difficult for production managers to supply the War goods. This has created it necessary to organize the Materials Management department for managing large inventories in stores and to analyze the problems arising to control and economize inventory cost problems and shortage elimination. The materials management was included as an important function of the management.

With the development of principles of scientific management by F.W. Taylor in 20th century, the economic use of materials in all the organizations was critically felt to reduce the cost of production.

The early years of developments in the field of materials purchase and supply systematically begins from 1850. Charles Baggage's book on the economy of machinery and manufacturing published in 1832 refers to the importance of purchasing function. Baggage is also known as "Materials Man".

The growth of Rail Road industries by 1866 started in America. The Book on 'The Handling of Railway Supplies and their Purchase and Disposition' in 1887 discussed the purchasing issues. Purchasing gained importance during World War I. Howard T. Lewis was a purchasing professional from 1905 to 1945. He developed importance of sound procurement to company operation.

The concept of materials management was widely spread during World War II. Professor Howard T. Lewis of the Harvard Business School made the extensive studies in Industrial Purchasing Practice. W.N. Michelle, N.F. Harriman, L.F. Buffy, Donald G. Clark, Edward T. Gushee, Russell Forbes, Stuart F. Hewritz and George A. Reward had contributed largely to

purchasing and materials management in procuring, receiving, inventory control and supply. World War II introduced a new period in purchasing history. The emphasis on obtaining required and scarce materials influenced a growth in purchasing interest. In 1933, nine colleges offered courses related to purchasing which was increased to forty-nine colleges in 1945 in America. The membership of the National Association of Purchasing Agents increased from 3400 in 1934 to 5500 in 1940.

The post-war period saw the development of the value analysis technique, pioneered by General Electric Company in 1947 on the evaluation of which materials or changes in the specification and design would reduce over all product cost. From 1947 to 1960 were 13 years on further developments in materials management. Firms initiated dramatic growth of the materials management during 1960-1970. The Vietnam War resulted in upward price and materials availability pressure. During 1970 Firms experienced widespread materials problems related to 'oil shortages and embargoes'.

Widespread agreement between countries taken place with the overall objective to solve materials problems including materials planning, inventory control, purchasing, quality control, stores control, materials movement and surplus disposal. The purchasing strategies and behaviors that evolved over in 1980 gave rise to foreign global competition .

The global era of trading in between 1970 and 1999 for materials management increased. Purchasing approaches beyond 2000 reflects a changing emphasis towards the improvement of quality of materials, supplier relationship, more co-operative approach, long-term strategies of cost management and database materials management systems for materials planning and utilization in industries to bring about overall improvement in production systems, in-cost reduction through economy and increased sales. In order to serve the corporate goals and perform materials activities efficiently, a functional organization of the materials management must be established to fulfill the objectives of materials program, elimination of materials wastages and duplication of efforts to do so in every organization. Then only the above-mentioned goals of materials management can be achieved.

Objectives and Functions of Materials Management

The objectives and functions of materials management can be categorized in two ways as follows:

(I) Primary objectives

(II) Secondary objectives

They are discussed below:

(I) Primary objectives

Which can be classified as:

(*i*) Efficient materials planning

(*ii*) Buying or Purchasing

(*iii*) Procuring and receiving

(*iv*) Storing and inventory control

(*v*) Supply and distribution of materials

(*vi*) Quality assurance

(*vii*) Good supplier and customer relationship

(*viii*) Improved departmental efficiency

(II) Secondary objectives

There can be several secondary objectives of materials management. Some of them are given below:

(*i*) Efficient production scheduling

(*ii*) To take make or buy decisions

(*iii*) Prepare specifications and standization of materials

(*iv*) To assist in product design and development

(*v*) Forecasting demand and quantity of materials requirements

(*vi*) Quality control of materials purchased

(*vii*) Material handling

(*viii*) Use of value analysis and value engineering

(*ix*) Developing skills of workers in materials management

(*x*) Smooth flow of materials in and out of the organization

To fulfill all these objectives, it is necessary to establish harmony and good co-ordination between all the employees of material management department and this department should have good co-ordination with the other departments of the organization to serve all production centers.

The basic objectives of management in an organization are:

(1) Sales increase through sales promotion

(2) Profit maximization

(3) Improvement in customer services

(4) Globalization of its product sales

(5) Meet the technological changes

(6) Good employer - employee relationship

(7) Selection of alternative materials

(8) Reduction in manufacturing and other cost.

(9) Social objectives

In order to fulfill these basic objectives of management the objectives of materials management should be set in such a way that they should totally help to meet ultimate goals.

The functions of materials management are discussed below:

In order to fulfill the objectives of materials management as stated above to meet the basic objectives and goals, the functions of the materials management are also categorized as primary and secondary functions.

(I) Primary Functions

To meet the primary objectives, the primary functions of the materials management are given as follows:

(i) Materials Requirements Planning (MRP)

Planning of materials requirements in manufacturing is a necessary function in any organization, as inventory of materials involve about 60% of the total investment of the organization. The profit earned depends on the utilization of these materials and reducing the inventory of the materials.

The latest technique used is called *Just in Time* (*JIT*) is referred practically to no inventory. However, in the present situations in any of the organization particularly manufacturing organization, it is not absolutely possible to keep no inventory of materials required for production. The MRP is a technique used to plan the materials starting from the raw materials, finished parts, components, sub-assemblies and assemblies as per Bill of Materials (BOM) to procure or produce them to support a Master Production Schedule (MPS). It is used on computers productively by any company that uses a MPS to manufacture products that require assemblies, components and materials to produce the final products. The MPS is exploded using the bills of materials to determine requirements of lower-level assemblies, components, finished parts and raw materials. It plans orders to meet these needs.

(ii) Purchasing

All the organizations needs an efficient and economic purchasing and procurement of its various supplies of materials from the suppliers. The materials management department has to perform this function of purchasing and procurement of materials very efficiently. Since 50% to 60% of sales turnover is spent on the purchase of various materials, the amount of profit earned on this sales very much depends how economically the materials are purchased and utilized in the organization. The profitability depends on the efficiency by which this particular function of purchasing and procuring the requisite materials at appropriate time will be done and its availability is assured.

The function of purchasing can be stated as follows:

(1) The requisition of material is necessary by proper authority to initiate its purchase.

(2) To select proper supplier for the materials requisitioned, before placing an order.

(3) To negotiate about the price of the material from the supplier and it will be purchased at the cheapest price.

(4) The quality of material must be assured and should not be compromised with the cost of the material.

(5) The material should be purchased of right quantity and right quality at proper time at the cheapest cost.

(6) To set the proper purchase policy and procedure.

(iii) Inventory Planning and Control

The modern concept of inventory planning is that the materials should be purchased and brought in the stores just before it enters the production or sold out so that inventory cost is negligible. The zero inventories are the ideal planning. There are three types of inventories.

(*i*) Raw materials

(*ii*) Purchased goods

(*iii*) Finished parts and components

The inventory control of these various materials lies with the materials management department, production department and sales department. Inventory at different levels is necessary to make sure about the availability of all these types of materials and goods and their proper flow from one facility to another at different levels of production centers in a manufacturing concern.

The storing of various types of materials and parts as inventory is therefore very essential before its delivery and use at different production centers. This involves inventory planning and control of materials in the stores department. Many a time, the supplier may not be in a position to supply the materials of the ordered quantity at the proper time. To maintain the continuity in production and line balance in assembly work, the various types of inventories are necessary to be maintained and kept in the stores. as shown in Figure 1 given below.

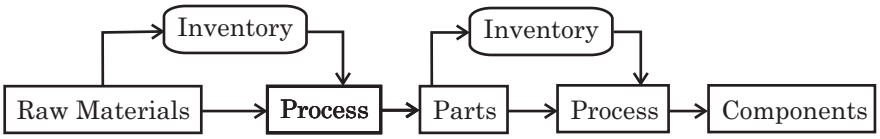


Fig. 1. Inventory of materials

The raw materials before being supplied to a production process, some of it is sent to store as inventory and rest is sent to production facility as per its requirements and in the same way, various parts manufactured and assembled as components and assemblies are also stored as finished parts inventories at the different places in the stores. The final products before being supplied to the customers are also stocked as inventory of the final products of the organization to meet the fluctuating demand and to regularize the supplies in the market. Thus, the inventory control is a very important function of the materials management department. The various types of inventory models are developed for the different materials to economise the purchase, supply, inventory control and production control to analyze and optimize the costs involved in ordering, set-up and inventory carrying of materials required in the production.

(iv) Ascertaining and Maintaining the Flow and Supply of Materials

Distribution of materials requisitioned by the various production centers and other departments must be ascertained and its flow and continuity of supply must be maintained by the materials management department. Insufficient or zero inventories many times create the situations of stock-outs and leads to stoppage of production. Failure of materials handling devices is also responsible for disruption of material supplies. Alternatives or emergency supply systems can be used for assuring production lines to continue.

Uncertainty in demand and production quantity is the main factor. As the customer requirements as per his needs and liking, are changing very fast. The management has to maintain continuity in production to meet this uncertainty in demand and control the situation by proper flow of materials supply and distribution at various production facilities and other departments as per changes in production quantity.

(v) Quality Control of Materials

The quality of the product manufactured by the organization depends upon the quality of the materials used to manufacture that product. It is a very important and necessary

function of materials management to purchase the right quality of materials. The inspection, quality control, simplification, specification, and standardization are the activities which are to be followed for the measurement of quality of the materials. The quality assurance is decided by inspection and checking. The various properties of materials as per their specifications and standard. The size and dimensional measurements within tolerance limits assures the interchangeability and reliability of components and parts.

Quality is largely determined by consumer taste and liking. The market is under buyer's control. Customer decides the quality of the product. Material quality control aims at delivering product at higher and higher quality at lower cost. The product will be specified not only by its dimensional accuracy but its quality standards, durability and dependability, high performance, reliability and aesthetic value. Each of this factor aids cost to the product. In order to achieve high quality, the materials input to the product should be of high quality, which will have higher cost. The performance decides the reliability, which is obtained through high quality production. The performance is checked by quality inspection and accuracy. This also aids cost to the product. The quality of the materials also decides the selection of vendors and the relationship between buyers and suppliers. The specifications, size and quality of materials must be referred and if possible the standard should be followed for specifications and sizes. The types of tests required for assuring the quality should be specified and conducted to establish the standards.

(vi) Departmental Efficiency

The objective of this function is to ensure the efficiency of the system adopted. If the system and procedure adopted for materials management are inefficient or faulty, none of the objectives mentioned above can be fulfilled, howsoever the procedure may be good. In order to maintain the things in proper way as per planning an efficient control is necessary in the department over each and every process. Management Information System (MIS) and feed back control at every stage of working must be adopted to control and make the management and employee work as efficiently as possible to achieve the best results.

(II) Secondary Functions

There can be number of secondary functions. Some of them are discussed below:

(i) Standardization and Simplification

The standards and specifications of various types of materials are fixed by design and technical department of the organization and they are followed by production department. Standards define the quality, reduction in sizes and variety, interchangeability of parts and products. It ensures efficient utilization of materials and reduces wastages. Standard materials are always available at reasonable cost. It also helps purchasing department in selection of materials and vendors. If less variety of items purchased and put in the stores the types of inventories will be reduced and in this way the cost of carrying the inventories in the stores will be reduced. The objective of this function will be to produce standard product reducing the overall cost of the product.

(ii) Design and Development of the Product

The variety in product and functionality are the important factors to promote the sales of a product. The new techniques of designing a product using Computer Aided Design (CAD)

has made possible to develop variety of products at faster rate. The new technological development in manufacturing using Computer Aided Manufacturing (CAM) can produce variety of products at much faster rate with all types of flexibility in the manufacturing as compared to conventional methods.

Materials management department has to act according to use of such variety of materials to produce variety of parts and ensure the supply of such materials. It should also be decided how to purchase and produce such variety of products with flexibility and economic cost.

(iii) Make and Buy Decisions

These types of decisions are the policy decisions of the management. The capacity of the organization and the various facility developed by the organization to manufacture various items is the main objective of every organization. This is the important planning activity of every undertaking. But when a company grows fast, its sales increases at rapid rate then it becomes an important matter to decide whether the company should buy the parts and components or increase and establish its facilities to cope up with the increased demand and sales. This will be greatly concern to materials management department. It will help in selecting the suppliers to buy the items at reduced cost. The material evaluation, its availability, alternative materials selection, procurement and inventory control are the functions influence the make and buy decisions.

The make and buy decisions are largely based on cost economics and cost benefit analysis made by the organization using the existing production capacity of labor, skill and machines available with the factory and how best they can be utilized.

(iv) Coding and Classification of Materials

This is an important function of the materials management to help the production and purchasing department of every organization. It uses its own methods of classification of materials used to manufacture the product or a company selling various goods. ABC analysis is one of the simple and standard method used by most of the firms for classification and storing their variety of materials.

The materials are recognized to purchase and store as an inventory by its codes and nomenclatures. The various methods of coding are used by every organization to control the variety of materials and its quantity and price rates.

(v) Forecasting and Planning

Materials requirements planning is based on correct forecasting of sales and demand of the products in the market. The market fluctuations are to be observed to control production of the organization. The various methods of forecasting are available and the materials management department can choose the one which gives the best results to the company.

Forecast of future demand of sales sets the planning of materials supply. Analytical methods are adopted for systematic forecasting and planning to procure the various materials required for production.

In case of fluctuating demands, there can be uncertainties in supply as well. This can be overcome by maintaining the proper quantity in inventory of short supply materials at proper time. The different techniques available to use correct forecasting have to be utilized by materials manager to plan the procurement, purchase, supply, managing the outside

and inside transport and storing of the materials to maintain the supply chain lines at every production facility to meet the changes in production quantity and schedule of production to meet the fluctuating demand of sales of products manufactured by the organization.

To fulfill the objectives and functions of materials management and control the activities of this department, they are thoroughly studied and analyzed. The topics for this study and analysis are given as follows:

(1) Materials management organization
(2) Materials requirements planning
(3) Forecasting
(4) Purchasing
(5) Inventory control
(6) Storing, warehouse planning and control
(7) Value analysis
(8) Materials handling
(9) Just In Time

The main functions of materials management are summarized as follows:

(1) Materials planning as per production requirements for quantity and time
(2) Purchasing the required materials
(3) Make or Buy decisions
(4) Receipts and inspections of materials
(5) Storage, warehousing securities and preservation
(6) Distribution of materials
(7) Transportation should be expedited and must be economically done
(8) Inventory control
(9) Disposal of over stock, surplus, scrap and salvage of materials
(10) Developing new sources of supply at competitive way
(11) Ancillaries industrial development
(12) Indigenous source of supply for foreign materials
(13) Material cost control and cost reduction
(14) Co-ordination and co-operation with the other departments
(15) Research and developments in materials management and their use

Scope of Materials Management

Referring to the various functions of materials management stated above the materials management co-ordinates various departments of manufacturing concern. Since the cost involved in manufacturing has maximum investment in the materials. It is about 55% to 65% of the sales value as has been investigated by the Directorate of Industrial Statistics during

1954-57 in India. As soon as materials are purchased and brought by the organization, its value goes on increasing as the other costs as required for ordering the materials, carrying the materials in inventory, its maintenance and handling charges must be assigned to the cost of materials before it enters in to a product or transformed in to some other form. In order to economize all the costs of materials management company has to adopt definite method of deciding the quantity of materials to be ordered, quantity to be stored as inventory and work in process inventory. In order to reduce the material cost and all other costs stated above, there has to be some efficient and effective materials management techniques, which must be dynamic to adjust with changing demand and production.

Integrated Materials Management Concept

Materials management concept is to manage resources in an integrative way for national economic development. This is possible with the development Management Information System (MIS), technological innovations and selection of economic and newly-developed materials for manufacture. It is the management's responsibility to develop the materials management system, which will find the ways and means for most efficient and most effective use of its resources using new technological processes, methods and ideas. The various resources to be fully utilized are men, money and materials and therefore there is importance of materials management. This will be further clear from the examples given below in the table about the expenditure incurred in the materials resource.

Materials worth Rupees 30,000 crores flow in various production channel annually in India, out of which about Rupees 15,000 crores are held up in the stock and out of which Rupees 1200 crores worth materials are inactive, obsolete and scrap.

Average Expenditure on the Materials by Various Industries

The various industries, which are spending their money on the materials to produce the products as percentage of average expenditure, are given below.

Table 1

S.No.	*Industries*	*Average expenditure on materials in percentage*
1.	Electrodes, rubber goods, cotton and silk yarns, electric motors, sugar, jute, motor vehicles etc.	65 % to 70 %
2.	Cotton, textiles, cables, wires and utensils	60 % to 65 %
3.	Engineering goods and non-ferrous metals	55 % to 60 %
4.	Ship building, cement, chemicals and electricity	50 % to 55 %
5.	Pharmaceuticals and medicines	45 % to 50 %
6.	Aircraft, fertilizer and steel	40 % to 45 %
7.	Other industries	40 %

Industries-wise expenditure on materials is given in the above table to show its importance. The integration of materials management functions is necessary in the following ways:

(1) Materials management will take decisions for purchase of materials.

(2) The centralization of authority is necessary.

(3) It will co-ordinate all the functions.

(4) Speedy and accurate decisions are needed.

(5) Data analysis through Electronic Data Processing (EDP) and use of computers is necessary.

(6) Opportunity for growth must be emphasized.

Types of Materials

The various types of materials to be managed are:

(*i*) *Purchased materials:* They are raw materials, components, spare parts, oils, grease, cotton waste, consumables and tools.

(*ii*) *Work in process (WIP) materials*: These are semi-finished and finished parts and components lying on the shop floor.

(*iii*) *Finished goods*: These are the final products either waiting to be assembled in the assembly lines or in stores which are stocked for final delivery waiting to sell.

The various costs involved in these materials are basic price, purchasing costs, inventory carrying cost, transportation cost, materials handling cost, office cost, packing cost, marketing cost, obsolescence and wastages.

Materials Management Organization

The major resources in any organization to manage are the materials out of seven main resources required to run any organization. They are management, materials, money, man power, machines, methods and matrix or facilities which include systems, plants, location and buildings etc. The purpose of materials management organization in any industry is to plan the materials requirements for the production of goods and services. The structure of the organization must be such so as to have the efficient management of materials controlling its flow, conservation and utilization. Its objective is to use judiciously and economically. The product must be produced from the available materials purchased at the economic price and bring together under one organizational component sharing responsibilities of all the aspects affecting flow, conservation, utilization, quality and cost of materials. Materials management include inventory management, purchase management, value analysis, store keeping, maintenance and upkeep of the inventories in hand and in process.

A typical Organization Structure is given below:

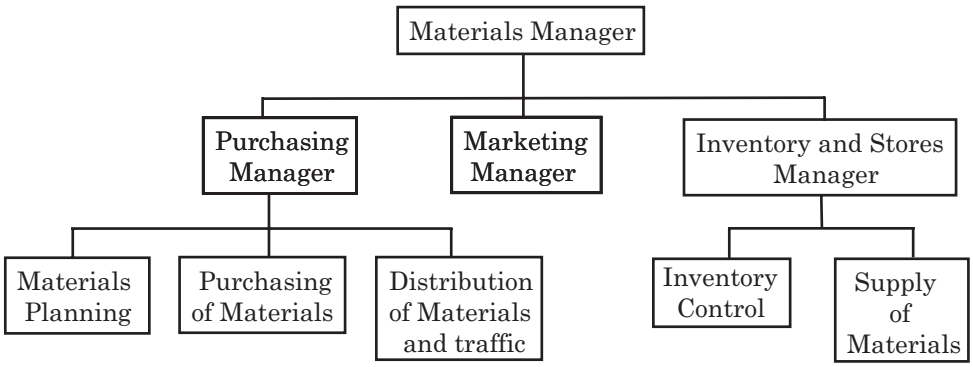


Fig. 2. Structure of materials management department

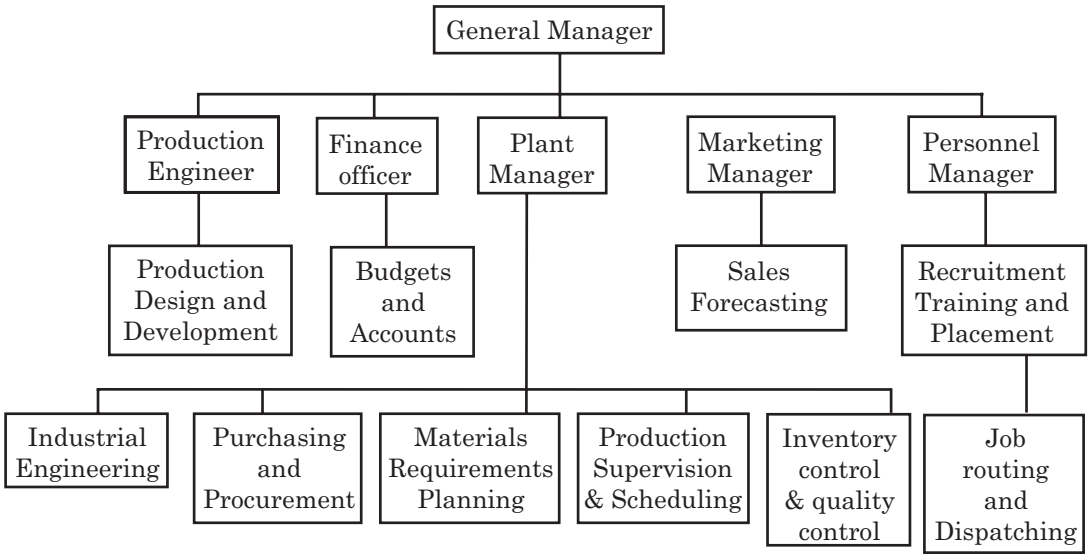


Fig. 3. Organization structure with functional activities

The organization of materials management must be such as to efficiently integrate the activities concerned with materials and regulate its use as per requirements in the production so as to have stability. The structural development and authority within the hierarchy of the system must be harmonious and integrative for proper decision making and achieving goals of the organization through proper information supply system.

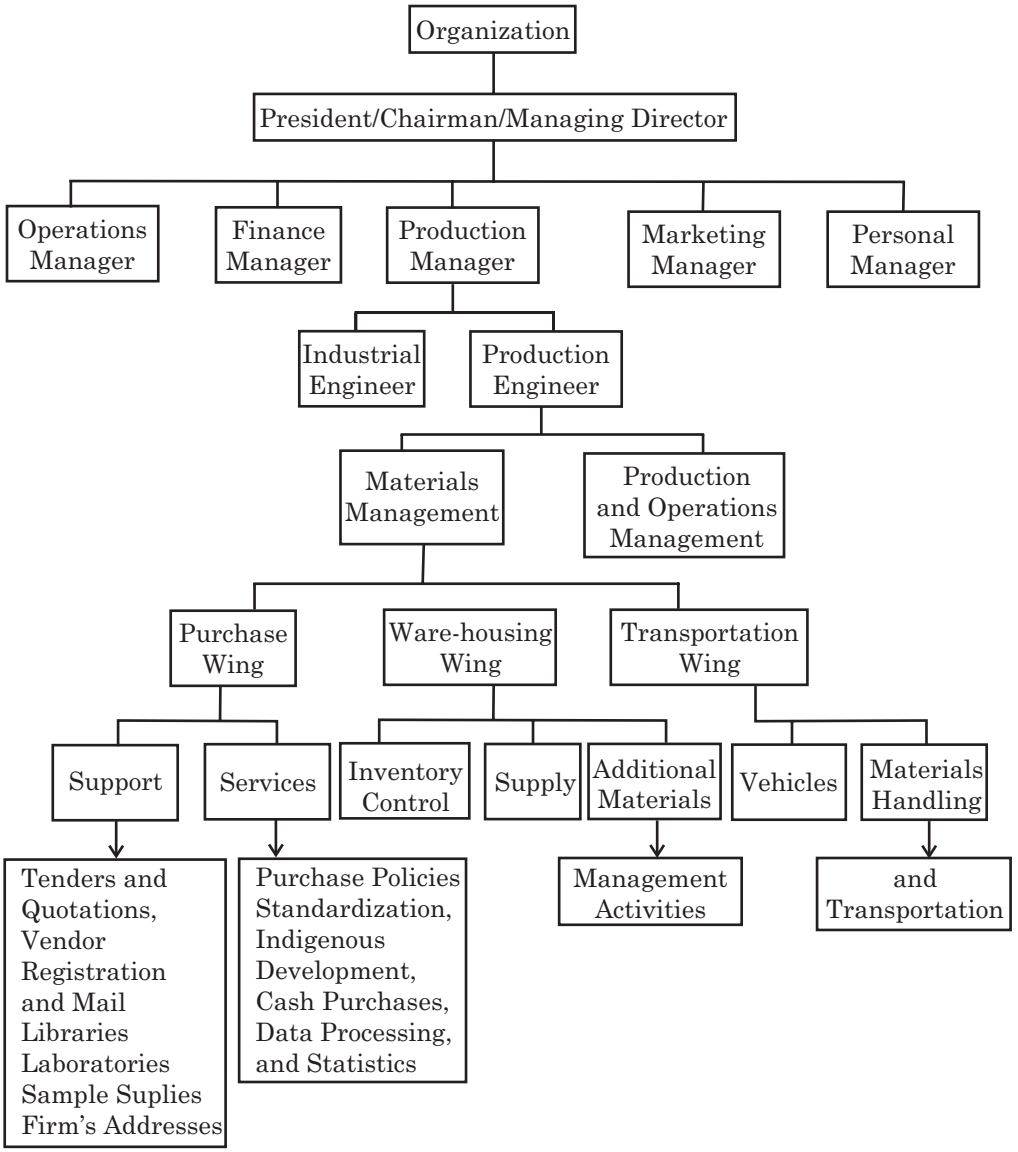


Fig. 4. Materials management activities in an organization

QUESTIONS

1. What is the importance of the materials management?
2. Explain the objectives of the materials management departments.
3. Give the various functions of the materials management and explain them.
4. What are the duties and responsibilities of the materials manager?
5. What is the scope of materials management?
6. How will you integrate the various activities of materials management?
7. Give a typical organization structure of materials management department.
8. What types of materials are to be managed?
9. What is materials requirements planning?
10. Give an organizational structure with functional activities.

CHAPTER II

Purchasing and Supply Chain Management

Introduction

About a decade ago, it was producers market. Whatever goods produced by the manufacturer were sold in the market, as the choice and the quantity of product available in the market were limited. Customer has to buy whatever was available in the market. Let us take the example of the automobiles. About 15 years ago, the number of brands of scooters and motorcycles available in India were so less that there was a queue for purchase of these vehicles. For example, Bajaj scooter and Escort motorcycle had lot of black marketing in purchase and sale of these vehicles. Today, there is tremendous change in sales of these vehicles. The automobile manufacturers are offering lot of discounts, gifts and other benefits like easy loans, free insurance and registration on purchase of these vehicles and other automobiles like car, jeep, matador and heavy vehicles because of competition in manufacturing them by various industries. Manufacturers are making and flooding their products in the market. Number of brands and varieties of products available are also very large. This example shows the vast change in purchasing and managing supply chain.

The complexity of marketing is faced both by customer and manufacturer. Due to this complexity of managing purchase and supply chains, organizations are exploiting their sales for competitive advantages. The companies have realized the customer value by improving performance of their products while simultaneously reducing costs and paying their attention to purchasing and supply chain management of their goods and services. The following points need the attention of the firms towards purchase and supply chain management.

1. Improved performance of their goods and services
2. Cost reduction
3. Improved material supplies
4. Quicker product development
5. Shorter production cycle and production time
6. Development of new technology for process improvement and its adoption
7. Quality improvement
8. Good customer-supplier relationship

Since last 20-25 years, revolution has occurred in the business and marketing. The rapid changes in the global markets and adoption of liberalization has necessitated to think radically in India to adopt the new techniques in purchasing and supply chain to meet the accelerated rate of change in the markets, products, technology and level of global competition to make decisions quickly for delivery of products of customer demands at a competitive price of good quality.

Another important change in today's marketing is the development of the world wide web spawning a new generation of "Electronic commerce" which has introduced the spread of information between marketing, sales, purchasing, finance, manufacturing, distribution, internal and outside transportation. This availability of information is transforming relationships throughout industry. This helps in reducing cost, improvement in product quality and availability and establishes better customer supplier relationships.

Definition

The purchasing can be defined as the process of buying and procuring the materials, parts, components, equipments, spare parts, tools and supporting items required by industries or any organization to deliver its products as per customer requirements at the competitive rates and of good quality.

Supply Chains

It includes all the activities related to flow and transformation of goods from raw material stage to the finished products required by the user or customer. Material and information flow both up and down the supply chain. The supply chain includes system management, operations and assembly, purchasing, production scheduling, order processing, inventory management, transportation, warehousing and customer services. Supply chain is link between suppliers and customers to reach the product to ultimate users. A firm or enterprise procures or produces raw materials and products from supplier network and delivers products of customer requirements through distribution network. The supply chain management collects all information about sources of procurement and purchasing and stream- lines materials management activities to supply the various materials to manufacturing systems like order processing, inventory control, storing, production scheduling, packaging and delivering products to customers. Thus, purchase and supply chain management are the most important organizational functions to link various activities of materials management and production system. This is shown below in Fig. 1.

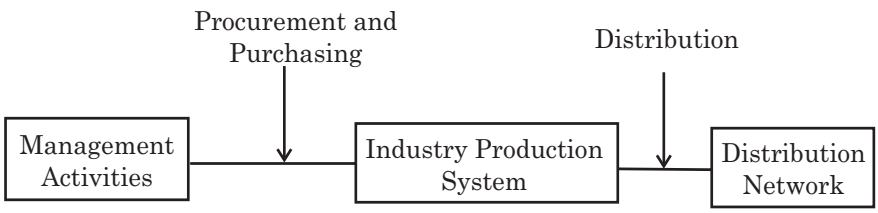


Fig. 1. Supply Chain Link

In the supply chain management materials and services flow down the chain from suppliers to customers where as funds flow up the chain from customers to suppliers.

Objectives of Purchasing

The primary objectives of purchasing are to buy materials of proper quantity and quality in proper time and at the cheapest cost. Apart from this, there are other objectives, which are described as follows.

(*i*) Support operational requirements: For supply to production system and maintain it buying all required materials as per Bill of Material (BOM), supporting systems and service items. It also helps in design and product development. Since in industries continuity in production is always critical, therefore, to ensure the flow of materials the following things are essential.

(1) Purchase of materials of right quantity

(2) Delivery of all materials at right time

(3) Delivery of materials at right place

(*ii*) Effective and efficient purchasing system: Investment in the materials should be minimum and full utilization of them is necessary. Proper classification and inventory control helps in material productivity. In order to do purchasing efficiently, the following points must be followed: -

(1) Selecting the proper purchasing staff

(2) Expenditure on purchase process must be limited to budget allocation

(3) Training the employees

(4) Making proper decisions of purchases

(*iii*) Source of supply: The main objective of the purchasing department is to select, develop and maintain the supply of materials. The selection of proper source of supply is always necessary to achieve this. It involves

(1) Purchasing proper items at lower price

(2) Purchasing from the right source

(3) Materials of proper specifications and quality are purchased

To develop better relationship with supplier and select reliable and high quality sources of supply is the objective to do purchasing effectively. To maintain standard of materials and its suitability of use and to eliminate the waste, the sources of supply should have high performance in delivering goods of high reputation.

(*iv*) Develop strong relationship with other functional groups and departments: The other functional groups are marketing, manufacturing, store, engineering, office and finance. The purchasing department should develop close relationship with them and communicate to avoid complaints and buying sub-standard materials at highest prices. Improper deliveries and untimely supply should not be there.

(*v*) To meet the objectives and goals of the organization: To develop and maintain the competitive position of the enterprise in the market the purchasing department should work to meet the objectives and goals of the company and establish its reputation. It must follow the directives of management. With the new concept of materials planning and Just In Time (JIT), the organization has the objective of keeping just sufficient inventory to maintain the production. Supply should also be just sufficient and more frequent to reduce

the cost of inventory carrying and large storage. But at the same time, it should also be ensured that just in time supply would not have shortage or stock out.

***(vi)* Purchase strategies:** It is necessary that the purchasing department should integrate purchasing strategies to develop and support organizational strategies.

To procure the materials of consistent quality at the lowest cost must be the prime strategy of every company, which is also the prime objective of purchase department. But sometimes due to improper selection and training of purchase personnel and not participating in the corporate planning process this strategy may not be fulfilled. Therefore, the purchasing department should actively participate in corporate planning process and do the following things.

(1) Observe the material prices, shortages and suppliers and monitor this to meet companies' objectives.

(2) To support companies' strategies, identify critical materials and services required particularly when new product is developed.

(3) To develop supply plans as per enterprises planning.

Functions of Purchasing

As per the objectives of purchasing which is to purchase right quality of materials at right time and right quantity at the economic price is the responsibility of purchase department. In order to fulfill these objectives, the functions of the purchase department can be summarized as follows:

(1) To receive purchase requirements and requisitions from various departments

(2) To select the materials to be purchased on priority

(3) To select the source of supply

(4) To decide the purchasing policy and procedures

(5) To prepare specifications and obtain tenders and quotations of materials

(6) To purchase the proper quantity at proper time

(7) To purchase good quality of materials at cheapest rate

(8) To get deliveries at proper place within the prescribed time

(9) To check and inspect the materials

(10) To make the prompt payments and co-operate

Types of Purchases

All the organizations purchase the materials, goods and services depending upon what they produce and sell. The make or buy decisions are important to decide what materials the purchase department have to consider for purchasing from outside and the production department to make the finished product. The following types of purchases are made.

Raw Materials

These items include petroleum products, coal, metals and non-metals. It may include agricultural materials like soybeans and cotton. These raw materials are converted in to semi finished and finished saleable products, by various firms.

The unforeseen factors affect the prices and availability of raw materials. Raw materials market particularly petroleum in South Africa and Middle East influence the industries to decide their strategies to make the purchases and store them.

Semi-finished Products, Parts and Components

These include all those items, which enter in to final production. They are single component, sub assembly, assembly, sub system and system. The automobile manufacturer purchases the semi-finished parts as tires, seat assemblies, wheel bearings and car frames etc. The computer and T.V. manufacturers purchase motherboards, I.C. and monitors. The purchase of these items is very important as the quality and cost of the final product depends upon them.

Finished Products

The organizations purchase the finished parts either for their internal use or resale. The big firms or brand names are used to procure the finished products from small manufacturers. These firms under their trade names sell the qualities specifications, which are prepared for wide range of products. The Godrej and Videocon in India and some of the Japanese and Korean companies like Nokia and Casio sell the products made by other firms.

Maintenance, Repair and Operating Items (MRO)

These items include any materials or products that does not enter production line but are essential for running the industry or business. They also include spare machine parts, office, computer, cleaning and maintenance supplies. It is advisable to avoid large inventories of these items. The purchase department always find it difficult to regulate the procurement and supply of these items. Website listing of these items now makes it very convenient to purchase these items Just In Time.

Production Support Items

For packing and shipping the final products packages and other supporting materials such as pallets, boxes, containers, tape, bags, wrapping, and handling items are required for the purchase as production support items. Sometimes large inventories of these materials are stored, therefore purchase of these items should be controlled and alternative items have to be selected to reduce the expenses on them.

Services

Like MRO the purchase of services for repair, maintenance, house keeping, building repairs, cafeteria, heating, cooling, and safety services are hired. Careful and specialized system of handling and hiring these services will save lot of investments.

Capital Equipment

General purpose material handling equipments, computer systems, furniture, special production machinery, machine tools and power generating equipments are called capital equipments required by industries to be purchased for establishing and running the plants. They depreciate and become obsolete after a particular period. Their replacement needs the

purchase of these equipments. The purchase department should do the necessary planning and provisions to replace and purchase of these items as and when required.

Purchase and Supply Chain Organization

Looking to the various functions and responsibilities, which the purchase department has to share in materials management, there has to be an efficient purchase and supply chain organization in every industrial firm to accomplish this function.

In order to have a good organizational structure, instead of focusing on vertical movements the information are managed to flow up and down in the layers of the organization towards the horizontal movement. The horizontal organization eliminates both hierarchy and functional or departmental clusters. It is necessary to group the key executives at the top and other persons for teamwork horizontally to perform important processes. The typical structure of organization is shown below in the Fig. 2. Vertical structure of the organization depicts the management of supply chain, logistics, operation, finance and the functional areas are shown in the horizontal structure as marketing, planning, purchasing, receiving and storage of inventories, engineering and financial control. Horizontal structure is more important to organize various processes of purchasing activities and a team work is necessary for the logistics of purchasing and supply chain management to accomplish the work of supplier evaluation and selection supplier management and development, receipt of customer orders and their fulfillment., receiving and storage of materials as inventories after purchasing them. The development of good relationship and co-ordination is must in the organization. The structure of organization should be developed to fulfill the functions of materials management and purchasing towards achieving the objectives and goals of the organization.

Every organization does not have a separate purchase department. It is either under materials management or controlled by finance department. The set up of purchase department varies from company to company depending upon its type and size. In some companies, the purchase department is under the control of production department and its manager does the purchasing through purchase agents. The production department often changes the quality of products, its policy and schedule which must be well informed to the purchase department.

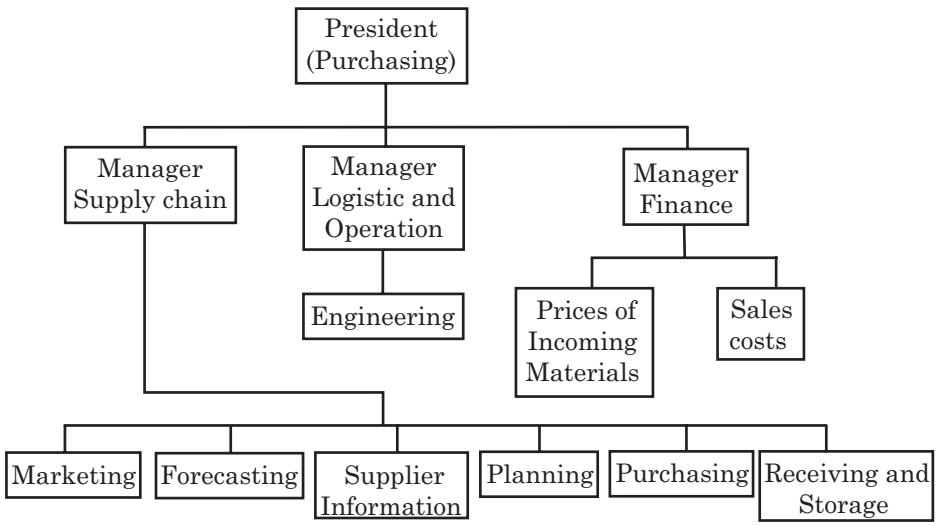


Fig. 2.

The Following Persons are Required in the Purchasing Department

(1) Manager for receipt of requisitions, record of materials and supplier information.

(2) Purchasing agents. They will communicate with suppliers.

(3) Managers for receipt and inspection of materials.

Qualifications, Duties and Responsibilities of Purchasing Officer

(*i*) Purchasing officer must be qualified in marketing, materials management. He should be well acquainted with purchase activities.

(*ii*) He or she must be well experienced in buying and must be able to negotiate with suppliers and their agents.

(*iii*) He or she must be technically sound to judge the material properties and qualities.

(*iv*) He or she should have good organizing ability.

(*v*) He or she should be able to analyze the market situations, demand and supply positions and prices of materials.

(*vi*) He or she should have knowledge about import and export of materials and should be well-acquainted with Government policies about this.

(*vii*) He or she should know the laws and rules about sales and purchases and contracts made.

(*viii*) He or she must be well conversant with the objectives, aims and policies of the organization.

(*ix*) He or she must be aware of excise duties, taxes and insurance policies regarding purchase of materials.

(*x*) The reliability, honesty and team spirit in working are necessary qualities of all the purchase personnel in the department.

(*xi*) Duties of purchasing officer are to purchase standard quality of goods and inspect the materials for standard quality.

(*xii*) He or she should see that timely delivery of the materials must be done at site.

(*xiii*) He or she should help the management in taking make or buy decisions.

(*xiv*) The responsibility of the purchasing officer is to organize all purchase activities planning and execution.

(*xv*) He or she should maintain the integrity and fair dealing with others while negotiating.

(*xvi*) He or she should see that purchasing department works most effectively and efficiently.

As organization grows and its policy adopts changes to suit market, the purchasing organization and purchasing manager must learn to acquire new techniques and knowledge must be flexible to adopt changes and must be able to improve his qualities and capabilities. The successful purchasing manager is one who takes risks in purchasing from new enthusiastic suppliers at cheaper cost without compromise for quality of the materials and goods.

Purchasing Policy and Procedure

Purchasing Policy : Every organization sets the purchasing policy. In order to accomplish the aims and objectives of the organization, the directives and instructions issued to purchase

the materials are called the policy of purchasing. Policy means the set of principles, purposes and rules of action framed written or otherwise applied to fulfill the goals of organization.

Advantages and Disadvantages of Policies

Advantages

(*i*) Policies define and clarify top management objectives.

(*ii*) The written instructions communicate views of management.

(*iii*) It provides guidance to the person to adopt the working method of same type.

(*iv*) It provides framework for decision-making.

Disadvantages

(*i*) In large size organization it is difficult to communicate the policy and particularly the changes, which are made quite often.

(*ii*) All the employees may not be aware of the purpose of policy.

(*iii*) Greater the number of policies it is more difficult to create awareness.

The policy statements are guidelines and they should be difficult to understand. Lengthy and too many policies have to be avoided.

The purchasing policy provides the guidelines and direction in the following categories. It defines:

(*a*) Rules of purchasing

(*b*) Conduct of purchasing personnel

(*c*) Social and minority business objectives

(*d*) Operational issues

Principles and Guidelines for Finalizing Purchase Contracts

The effective purchasing is possible by selecting and awarding the purchase contract by well defined principles and guidelines and setting a process accordingly.

This policy covers the following points:

(*i*) The limit of Buyer's authority to award a contract within particular amount of rupees.

(*ii*) Conditions of acceptance or rejection of competitive bids.

(*iii*) Process of analyzing competitive bids.

(*iv*) Conditions of purchasing other than lower bids.

(*v*) Operating guidelines to negotiate with suppliers.

The operational issues, which are decided in purchasing the materials where confrontation may arise, are

(*i*) Hazardous materials: The laws and regulations are already set for purchasing and controlling hazardous materials. Environment policy plays an important role in purchasing these materials.

(*ii*) Defective materials: The responsibility of supplier must be fixed for defective materials shipment and conditions for their replacement or cost returns, rework, repacking,

damage and penalties. The policy should be such so as to provide protection to buyer due to supplier causing problems. Now a days, various buyer forums are looking in to these matters of operational issues regarding supply of defective or damaged materials to customers. Customer protection acts are framed by the Government to provide compensation etc. or replacement of such items purchased.

Procedures of Purchasing

The procedures for purchasing describes the operating methods and instructions in a written form as Manual or Journals of purchasing to be followed as per the policy of purchasing to carry out duties and tasks of buying various materials of the organization needed for production or otherwise. This procedure is the best practice to be followed and identified through bench marking comparisons with leading firms. Procedures are information followed for successful purchasing strategies. There is no standard method describing this procedure but it will be guide to the new employees, purchasing persons, reference and clarification for experience personnel and a routine method to be followed. Time to time management must review and evaluate the procedure of purchasing to suite the changes and development needed.

Since procedures of purchasing are the functions carried out by purchasing persons. They can be stated as follows:

(*i*) Need for purchasing.

(*ii*) Full description of accurate specifications, properties, quality and quantity requirements of materials requisitioned.

(*iii*) Collection of purchase requisitions.

(*iv*) Selection of sources of supply and negotiations.

(*v*) Determination of prices and availability of quantity required.

(*vi*) Analysis of order quantity and time.

(*vii*) Order placement and follow up

(*viii*) Receipt of materials, Checking and inspection

(*ix*) Supply and storage of materials.

(*x*) Record keeping.

Before discussing the details of purchasing procedures let us see what methods the organization follow in purchasing. The purchasing department normally follows two types of purchasing methods.

(*a*) Centralized purchasing

(*b*) Decentralized purchasing

Depending upon the size of organization, types of materials purchased , quantity and variety of items purchased and number of departments requiring various types of materials it is management to decide whether to follow centralized method or decentralized method of purchasing.

Centralized purchasing: In centralized purchasing, one purchase department or its single authority will be authorized and made responsible to make all types of purchases of all the departments. Requisitions are supplied from all the departments to a centralized purchase system.

This type of purchasing is suitable to industries having single plant or number of plants in nearby location, which are manufacturing similar products at various plants, needs bulk purchase of few items. The purchase procedure is same and will be followed in long run.

Decentralized purchasing: Decentralized or localized purchasing permits every individual department or its authority to make purchases of its own requirements of materials and is responsible to make its deliveries. In industries having plants at different locations and manufacturing varieties of products cannot have centralized purchasing.. These types of industries require different types of materials and have lot of changes in purchasing policies and procedures. The decentralized type of purchasing system will be suitable to them.

The advantage of centralized purchasing will be the disadvantage of centralized purchasing which are discussed underneath.

Advantages of centralized purchasing	*Disadvantages of centralized purchasing*
(*i*) Experienced and highly-skilled purchase personnel will be available in the centralized purchase department.	(*i*) Wrong or inaccurate quantity of materials may be purchased because of misunderstanding. Sometimes substandard materials are purchased.
(*ii*) The duplication in purchasing or excessive purchasing is avoided since only one person or department makes all the purchases.	(*ii*) Centralized purchasing causes delays as various departments send their requisitions to one centralized place for scrutinizing indents and other purchase documents it takes time to place orders. Direct purchases are quick.
(*iii*) Availability of discounts and cost reduction is only possible in bulk or repetitive purchases from same supplier and this will be the responsibility of centralized purchase department**.** The purchases are directly done from manufacturers of bulk supplier eliminating purchase agents or middleman.	(*iii*) Centralized purchasing may not be suitable for some manufacturers or companies. The industries having their plants located at different remote places or companies having large network of their sales will have to plan there purchases by individual plants.
(*iv*) Engineering and production department are relieved to devote their time in purchasing activities and can spare more time in better and higher production. Efficient inspection and checking methods will make better quality purchases.	(*iv*) Under centralized purchasing individual department will not have any priority or flexibility to purchase their own requirements. They cannot take advantages of local resources.
(*v*) Purchases will have better control since all the purchases are done by one department and records will be available from centralized place.	(*v*) The centralized policy and procedures may not be suitable to all the departments of a big manufacturing industries or Government organization like Railways, steel plants and BHEL etc.
(*vi*) The standard and same uniform purchase policy helps the supplier to plan regular supply and adjust the payments made by the company.	

Process of Purchasing

The process of purchasing involves various steps to be followed as routine matter by the purchase department. Every organization more or less follow the same process of purchasing as discussed below.

Identification of materials: Identify the materials to be purchased by receiving the requisitions received from various departments.

(*i*) Purchase requisitions: Purchase requisitions are documents listing the requirements of materials from the various stores written by the storekeeper received by the purchase department from various production centers and departments. The planning department for special purchases for non-stock items also prepares the purchase requisitions. The purchase requisitions are made as Bill of Materials (BOM) of a product, which specifies quantities, needed as per Master Production Schedule (MPS).

The purchase requisitions are generally prepared in triplicate. One copy sent to the purchase department signed by the storekeeper, works manager and production controller, second copy sent to materials control or planning department and third copy Fig. 3. is retained by the requisitioner. The particular purchase requisition form is given below.

Purchase requisition form

Department ..... **Date .....**

Requisition reference no. .....

To,

Materials Manager

Kindly procure the materials mentioned below.

Sl. No.	*Description Of material*	*Quantity required*	*Code no.*	*Quantity in store*	*Date on which required*

Signed by

Requisitioner/Storekeeper **Approved by**

Fig. 3.

(*ii*) Traveling requisitions: They are the documents widely used for requisitioning materials that are required frequently in bulk quantities over a long period. They travel from requisitioning department to purchase department quite often and a purchase order is initiated. Material specifications and quantity etc. are permanently written on standard performa and it reduces clerical work.

After receiving the authorized purchase requisitions, the purchase is initiated by floating enquiries for calling tenders and quotations usually made in a standard performa mentioning the terms and conditions of purchase contracts.

(*iii*) Purchase enquiry: The purchase department calls the tenders or quotations for enquiry of the prices of materials from various suppliers in the form of purchase enquiry in a particular performa either by sending these enquiry letters to supplier or giving in news papers or purchase magazines the call of quotations or tenders.

The particular performa to call the quotations or tenders is given below in Fig. 4.

Quotations

Code.....

A B C Company
Address .....
.....
.....
.....
Phone no. .....
E mail .....

Reference no. ..... **Date .....**

M/s. .....
.....
.....

Dear Sir,

We are interested in the purchase of the following materials. Please quote your lowest prices and delivery period on or before..... in the sealed envelops.

Supplier conditions
.....
.....

Yours faithfully
A B C Company

Fig. 4.

Tenders/Quotations: On receipt of enquiry, the supplier quotes his prices and terms and conditions of supply of materials to the purchase department mentioning prices of materials, quantity and specifications of materials, delivery date, discount if any. The quotations/tenders are legal documents and must be handled properly and preserved by the purchase department. The request for quotation form is given below. The form provides the information that supplier is required to furnish, description, of items, quantity, date of delivery and location where material is to be supplied. The supplier completes the form providing name, contact person, unit cost and payment terms. The quotations are to be received on or before a particular date and time. The normal practice is for a buyer to request at least three quotations. Purchasing department evaluate the quotations and selects the supplier most suited to provide the item as per specification at the lowest price.

For the new or complex product, additional information like blue prints, samples drawings etc. are also provided to supplier. If the purchase contract requires negotiations between the buyer and seller, purchaser sends ' Request for Proposal' (RFP) to Supplier Request or Quotation (RFQ) and Request for Proposal (RFP) are similar (Fig. 5.).

Request for Quotation

(This is not purchase order)

X Y Z Company

……..

……..

……..

No. 1 **Quantity No.1 No.2 No. 3**

No. 2

No. 3

Delivery date ……

F.O.B. ……..

Freight cost ……..

Terms and conditions……

……

Please quote on the following items.

Item no.	*Description*	*Quantity*	*Unit cost*	*Discount*	*Net amount*

Delivery required by …… **For shipment to ……..**

Terms …….. **By ……..**

Purchasing department……..

Fig. 5.

Types of tenders: There are three type of tenders

1. Single tender
2. Closed tender
3. Open tender

1. Single tender: They are used to purchase materials urgently. The single tender or quotation is called from some reliable firm and purchase is done for the item required.

2. Closed tender/Limited tender: Only registered limited firms will be selected for inviting tenders and placing the order at lowest rate. This is also called limited tender system.

3. Open tender: It is unlimited tender system. In this system, publishing it in newspapers and trading journals openly invite tenders.

(*iv*) Analyzing Bids by the Comparative Statements

For selection of supplier after receipt of quotations to compare the prizes of items to be purchased and the terms and conditions of purchase, which should be favorable to the company, a comparative statement is prepared. This serves as the important document to analyze and negotiate with various suppliers for cost reduction of items and selection of proper supplier. The comparative statement can be prepared as follows (Fig. 6.).

Comparative Statement

Item	*Code*	*Description*	*Quantity*	*Quoted prices of various suppliers*			
				1	2	3	4

Lowest price bid by supplier.....

Checked by.....

Verified by.....

Fig. 6.

(*v*) Purchase Order

The purchase order (PO), which is a legal document, also called as *purchase agreement* is prepared after supplier selection is complete. Almost all purchase orders include legal conditions that the order include legal conditions that the order (contract) is subject to on the back side of the agreement. It helps the supplier to supply right quantity and right quality of materials at scheduled time at agreed price between purchaser and seller.

The purchase order must have detail information about the purchases as

(*i*) Description of materials

(*ii*) Quality

(*iii*) Specifications of the materials

(*iv*) Quality requirements and method of inspection

(*v*) Price

(*vi*) Delivery date and method of delivery

(*vii*) Place of delivery

(*viii*) Purchase orders number

(*ix*) Order due date

(*x*) Name and address of the purchasing company

Now since computers are used to prepare the purchase orders and save them in the computer files, therefore large number of copies is now available for sending the purchase orders to requisitioning departments, accounts and stores. The original copy in duplicate is sent to supplier. Supplier after signing the copy sends back to purchaser agreeing to supply the materials as per purchase order with its terms and conditions.

Companies are using computers to process all these database documents for ease of handling them and keeping records and mailing them to various other departments for their information. It also avoids lot of paper work. A typical form of purchase order is given below in the Fig. 7.

The reverse side of purchase order will have terms and conditions. The supplier should agree to them in writing and acknowledge the receipt of purchase order. The two types of money are normally demanded by the purchaser before the supply order is executed.

Many a firm also supply the tender or quotation forms at a particular price to restrict the quotations and meet the expenses of purchase procedure.

(*i*) Earnest money: This amount is demanded with the tenders so that supplier will not back out or refuse to supply the material at the quoted rate, otherwise this deposit of earnest money will be forfeited.

(*ii*) Security deposit: This amount will be deposited by the supplier as security against bad quality less quantity of material supplied and also security for warrantee.

In these terms and conditions, many a time the penalties are also imposed for wrong delivery on supplier.

(*iii*) Blanket purchase order: When a material or number of materials are ordered repetitively from a supplier, purchaser may issue a Blanket Purchase Order, which is an open offer effective for a year to the same supplier for supply of materials repeatedly required to be purchased. After agreeing to a particular price and conditions of supply, the buyer and seller agree to purchase the materials as routine purchase order by blanket purchase order very conveniently, only by changing the date and quantity of materials. When the demand for a particular item to be purchased is for a long time and supplier agrees to supply it with proper discount and constant price rate, both parties make an agreement of blanket purchase order for six months to one year supply and the agreement may further be continued for more years.

Purchase Order

Requested by	Requisition no.	Vendor no.	Account code

Name of the company X Y Z Purchase order no. ————————

Date	*Date of delivery required*	*F.O.B.*	*Location*	*Terms*

To,

..... Shipping instruction.....

..... Taxable..... Tax-exempt.....

.....

Terms and conditions are given on the reverse side

Item no.	*Quantity*	*Description*	*Price*

In case supplies cannot be delivered on date, kindly notify urgently

Purchasing department
X Y Z Company

Fig. 7.

Purchase Release

Buyer use material purchase to order items covered by blanket purchase orders. Purchasing specifies the part number, quantity, unit price, delivery date, method of shipment and location and sends it to supplier. This is a convenient method to be used on computer for repetitive types of purchase orders.

Payments

The supplier usually encloses the invoice or bill along with materials for payments and delivery note for the receipt of material supplied or a certificate that a proper quantity and quality of materials received by the purchaser. If any discrepancies may be found by purchasing department or receiver, it should immediately be reported to supplier and after proper verification and inspection of materials the invoices and bills are sent to accounts department for release of payments to supplier.

Verification of invoices and bills: After receipts of goods or materials in good condition as per purchase order, the purchase department will check the invoices sent by the supplier for the following things.

(*i*) Quality and quantity of materials received after inspecting and counting them.

(*ii*) Examining the prices and the amount in the invoices.

(*iii*) To check adjustments of claims, discounts, taxes and insurances etc.

(*iv*) Adjustment of damages, return of bad-quality materials.

After all such verification and checking of invoices, bills and other documents, the payments can be released by the accounts department.

Example 1 Three suppliers supplied the quotations for supply of a particular item A as follows, make a comparative statement and select the best supplier for purchase of item A 8000 units.

Supplier X Item A, price Rs. 11.50 per unit + supply charges at site Rs. 5000.00

Supplier Y Item A, price Rs. 10.00 per unit + all other charges Rs. 15000.00

Supplier Z Item A, price Rs. 15.00 per unit + no other charges

Comparative Statement

Supplier X	Supplier Y	Supplier Z
Rate Rs. 11.50	Rate Rs. 10.00	Rate Rs. 15.00
For 8000 units		
Charges Rs. 92000.00	Rs. 80000.00	Rs. 120000.00
Other charges Rs. 5000.00	Rs. 15000.00	Nil
Total charges Rs. 97000.00	Rs. 95000.00	Rs. 120000.00

Lowest cost of supplier Y is recommended for purchase of item A at Rs. 95000/8000 = Rs. 11.87 per unit.

Example 2 An automobile manufacturer requires a regular supply of head light bulbs invites tenders. The following three firms X, Yand Z are selected for comparative analysis to supply bulbs. The rates given by them are as follows:

Item	*Supplier*	*X*	*Y*	*Z*
Bulbs	Price	Rs. 5.00	Rs. 7.00	Rs. 8.00
	Packing charges	Rs. 500.00	Rs. 400.00	Rs. 300.00 for 5000 bulbs Rs. 200.00 for 10000 purchases
	Forwarding charges	Rs. 500.00	Rs. 400.00	Rs. 100.00
	Taxes	10%	8%	8%

Find out which supplier will be selected for regular supply of 15000 bulbs at a time. If only 5000 bulbs are to be purchased, who is to be selected. Also find out the cost of each bulb purchased.

For 15000 bulbs and 5000 bulbs purchase, the cost will be:

Supplier X $5 \times 15000 + 75000 \times 10/100 + 500 + 500 = \text{Rs. } 83500/-$

$5 \times 5000 + 25000 \times 10/100 + 500 + 500 = \text{Rs. } 28500/-$

Supplier Y $7 \times 15000 + 105000 \times 8/100 + 400 + 400 = Rs.\ 114200/-$

$7 \times 5000 + 35000 \times 8/100 + 400 + 400 = Rs.\ 38600/-$

Supplier Z $8 \times 15000 + 120000 \times 8/100 + 200 + 100 = Rs.\ 129900/-$

$8 \times 5000 + 40000 \times 8/100 + 300 + 100 = Rs.\ 43600/-$

In both the cases, Supplier X will supply the bulbs at cheapest cost, Rs. 83500 for 15000 bulbs @ Rs. 5.56 each and 28500 for 5000 bulbs @ 5.70 each.

Example 3 The two suppliers have given the prices of items as follows which is to be selected to purchase the items 20,000 units in one lot and in four lots.

Supplier Sx: Item A	Quantity	Discount	Rate
	Min 5000	4%	Rs. 200 each
	5000 to 10000	8%	
	10000 and above	10%	

Taxes are 4% and transportation cost is Rs. 5000.

Supplier Sy: Item A	Quantity	Discount	Rate
	Below 10000	Nil	Rs. 180 each
	Above 10000	5%	

Taxes are 10% and transportation is free

Which supplier is to be selected to purchase 20000 items A in one lot and 4 lots.

Supplier Sx for purchasing 20000 items A in 1 lot.

Rate will be 200 – 20 = Rs. 180

Total cost will be $20000 \times 180 + 20000 \times 180 \times 4/100 + 5000 = Rs.\ 3749000$

For purchasing 20000 in 4 lots i.e., 5000 at a time

Rate will be 200 – 8 = Rs.192

Total cost will be $5000 \times 192 + 5000 \times 192 \times 4/100 + 5000 = Rs.\ 1003400$

Supplier Sy for purchasing 20000 Items A in 1 lot

Rate will be 180 – 9 = 171

Total cost will be $20000 \times 171 + 20000 \times 171 \times 10/100 = Rs.\ 376200$

For purchasing 20000 in 4 lots i.e., 5000 at a time

Rate will be $5000 \times 180 + 5000 \times 180 \times 10/100 = Rs.\ 990000$

Supplier Sx will be selected to purchase items A 20000 units in 1 lot

Supplier Sy will be selected to purchase items A 5000 units in 4 lots.

Purchase of Machines or Equipments

For purchasing the machineries and/or other equipments the detailed descriptions. Size, shape, characteristics and other information necessary about quality etc. are to be supplied in the form of specifications in the tender or quotations forms.

The specifications are of many forms as given below.

1. Items, Trade Name or Brand

Depending upon producers, reputation for quality, the specifications specified by the brand or trade name the purchaser relies on it, sometimes they are also in vogue therefore other features should also be given.

2. Blue Prints

Engineering drawing in the form of blue print accompanies the purchase order giving all the dimensions, sizes, tolerances and materials of parts etc.

3. Physical and Chemical properties

The physical and chemical characteristics are considered to be ideal for raw materials and metallic parts. They are also required for laboratory tests and inspection.

4. Description of Use of Purchase Items

For the benefit of the buyer, the use of items is specified and supplier will be responsible to fulfill the requirement of purchaser or use.

5. Samples

The use of samples for specification is limited. When the items are not available then sometimes they are supplied or shown as samples.

6. Standard Specifications

Standard specifications published by Bureau of Indian Standards are called *Indian Standard*. They are the best to be given for purchase of materials. These standards are constantly being revised and are amended time to time. They are available in up-to-date printed form, at all the places in India.

The specifications given must have the following features.

(*i*) They describe the item fully which is to be purchased.

(*ii*) It should be as simple as possible to understand the requirement by supplier.

(*iii*) They should be exact.

(*iv*) They help in verification of items ordered after supply.

(*v*) They should be standard as far as possible so that many supplier can supply.

7. Performance Characteristics

The performance specifications are prescribed when other criteria's are not suitable to describe the product or equipment. The performance test or the function of the product to perform is specified as performance characteristics . The product specifications are generally determined from

(*i*) Individual standards developed by the purchaser

(*ii*) Private agencies

(*iii*) National agencies, like the Bureau of Indian Standards

Purchase Decisions

It is very difficult to arrive at proper decisions of purchases that how much to purchase and from whom to purchase. The various factors have to be considered as market conditions, demand and supply, organization goals for productivity and profitability and its budget.

The following things are to be taken into consideration for the purchase decisions:

Supplier Selection

The government department, large manufacturing and business companies like public sector firms keep the records of approved suppliers depending upon their

(*i*) Manufacturing capabilities

(*ii*) Financial conditions

(*iii*) Reputation

(*iv*) Service facility

(*v*) Quality of product produced by them

(i) Trade Journals and Trade Directories

Trade journals or magazines routinely publish the information about different companies about their technical or innovative developments of a material, product, process or service. Advertisements in trade journals about the products and services also help in selection of suppliers. Almost all the industries publish the directories of firms and companies which produce their items and services required to facilitate to refer to the selection of supplier and vendors.

(ii) Industrial Exhibitions and Trade Fairs

These are the best ways of exposure directly for the industrial products to sell and purchase of items. It is also exhibiting the latest technological developments, introduction of new products and information about latest prices.

(iii) Internet Searches

Now the internet is providing lot of information and access to the remote suppliers. E-Commerce and E-Business is helping to make direct purchase from the manufacturers to get the items worldwide.

(iv) Local or Distant Suppliers

The problems associated with distant supplies is that the cost of transportation, packing**,** insurance, sales tax and octroi etc**.** are high and the repair and maintenance become difficult by such suppliers. Therefore, it is always preferred to select local suppliers to purchase the materials provided their performance and prices are comparable to distance suppliers.

(v) Small or Big Suppliers

There are various types of companies and manufacturers in India for example, large-scale manufacturers, medium scale, small scale and mini-scale manufacturing concerns. Each one is having its own advantages and disadvantages for supplying their products. Large-scale

manufacturers find large potential buyers. They supply goods at cheaper cost. The small-scale manufacturers however render more attention to their clients and ensure about quality of items and delivery time.

Delivery Terms

The prices of the material are the one quoted in the quotation and mentioned in the purchase order after negotiations. The cost of transportation, taxes, insurance, handling and delivery are also sufficiently large and they are added to calculate the cost of material. The ordering and inventory carrying cost are also the cost assigned to material cost.

The delivery terms are clearly stated in the purchasing order and the following terms are very important for getting the materials.

1. F.O.R. (Free on Rail)
2. F.O.B. (Free on Board)
3. C.I.F. (Cost, Insurance, Freight paid)
4. F.A.S. (Free Alongside Ship)

1. Free on Rail (F.O.R.)

The free on rail is the contract the buyer gets the title to the goods on final delivery, either at the rail-head or at the buyer's plant as per terms of contract. When terms and conditions of purchase clearly states the delivery at the Rail-head, the transportation are generally borne by the seller. F.O.R. seller plant means that buyer has to take the risk for loss or damage in transit and the sellers responsibility to deliver the goods in good condition at right time ceases after they are handed over to the Railways, the common carrier. The ownership title of the goods also passes to the buyer at the same time.

2. Free on Board (F.O.B.)

The free on boards is either at the buyer's plant or at the shipping point. The responsibility for transport of material should be clearly stated in the purchase contract. If it is at the shipping point, the buyer usually pays the transportation charges. If it is at the the buyer's plant the seller bears the transportation cost from shipping point to buyer's plant. If the goods are damaged in transit, the supplier negotiates the claim with the carrier, not the buyer. The buyer gets the title to the goods only when they are finally delivered at the shipping point or his plant as the case may be.

3. Cost, Insurance and Freight paid (C.I.F.)

It is commonly used in international trade, cost, insurance and freight paid contract price includes cost of materials, insurance and freight charges. The supplier is responsible for the goods and all the charges until they arrive at the port of destination. The buyer gets all claims for loss or damage in transit with carriers.

4. Free Alongside Ship (F.A.S.)

Free alongside ship is a contract used in international trade. With F.A.S. contract, the buyer designate port, berth and vessel and the foreign supplier is responsible for getting the goods to the ship and the buyer takes the responsibility thereafter.

Cancellation after Breach of Contract

If the supplier fails to deliver the materials by the agreed date of delivery or fails to perform an act as per terms and conditions of the purchase, he is deemed to have committed a breach of contract and the purchaser has the right to cancel the order. After cancellation he can sue for damages and loss suffered as a result of the non-compliance of the purchase contract. Non-delivery with in a specified date is a breach and cancellation of the order.

Supplier Evaluation and Performance Measurements

The selection of supplier is usually done by the purchaser by evaluation and finding performance measurement of supplier. The selection process consists of

(*i*) Need of supplier selection.

(*ii*) Identifying key-sourcing requirements.

(*iii*) Determining sourcing strategy.

(*iv*) Identifying potential supply sources.

(*v*) Determining method of evaluation and measurement of supplier.

(*vi*) Selection of supplier.

Supplier Evaluation Criteria

The evaluation of supplier is done through the weightage assigned by measuring their performance by purchase. The criteria are

1. Cost price 2. Quality 3. Delivery

The evaluation usually covers the following performance categories.

Various capabilities of suppliers are considered as management personnel, technological information system capability, electronic data interchange, EDI, bar coding, ERP and CAD/CAM and financial capability, cost and quality performance, production scheduling and control systems used in the company and policies adopted for long-term relationships.

Once the supplier is selected, the focus must shift from supplier evaluation to the continuous measurement of supplier performance. Supplier performance measurement includes the method and system to collect and provide information to measure rate or rank supplier performance on a continuous basis. The measurement decisions are based on the performance of various criteria. The quantitative variables lie in the following three categories.

1. Delivery performance: The buyer can evaluate the supplier who satisfies the quantity and due date commitments. The due date compliance help in measurement of delivery performance.

2. Quality performance: The buyer can compare the supplier quality and define supplier quality performance.

3. Cost reduction: Supplier's cost reduction and adjustment for inflation is a measure for cost reduction. The cost of items supplied by various supplier is important criteria of their evaluation.

Rating the Vendors

In order to compare the performance of various vendors, it is necessary to rate them. The rating of supplier (vendor) will be done on the following parameters.

(*i*) Quality performance

(*ii*) Delivery performance

(*iii*) Price performance

(i) Quality Performance

The supplier can be judged for quality performance from the view point of rejected lots. If a supplier has supplied 100 pieces and 10 pieces are rejected out of this lot, he has rating of 90%.

Weightage = Number of lot accepted × 100/Number of lot supplied

(*ii*) *Delivery Performance*

Delivery performance can be made in two ways

(*a*) Adherence to time schedule and (*b*) Adherence to quantity schedule.

(a) Adherence to time schedule

Number of deliveries made in time × weightage

Total number of scheduled delivery

(b) Adherence to quantity schedule

Quantity supplied × weightage/Scheduled delivery

(*iii*) *Price Performance*

Price is very important criterion for evaluating a vendor which is as = Minimum price offered × weightage vendor's price.

The best evaluation of supplier is by experience of purchase experts apart from the method described above.

Purchase Systems

Some of the purchase systems are given below.

(*i*) *Forward Buying*

It is commitment by an organization to buy in future usually for a year or so.

Forward buying is different from speculative buying where the motive is to make money out of price changes by selling the purchased items.

(*ii*) *Tender Buying*

Pubic undertaking and Government purchases are generally done by inviting tenders or quotations by advertising in newspapers.

(*iii*) *Rate Contract*

After negotiations, the seller and buyer agree to the rates of items. This system of rate contract is normally adopted by Government department and public sector organizations to make purchases at stabilized rates.

(*iv*) *System Contract*

It is the procedure to help buyer and seller to reduce administrative expenses . In this system, the original indent duly approved by competent authority is shipped back with the items and avoids the usual documents like purchase orders, material requisitions, letters and acknowledgements. It is useful for items with low-unit price and high consumption.

QUESTIONS

1. What do you mean by purchasing and supply chain management?
2. How does good purchasing system help the manufacturing organization?
3. Give the objectives of purchasing.
4. What are the functions of purchasing? Explain them.
5. What types of purchases are done?
6. Give the suitable structure of purchase and supply chain organization.
7. What are the essentials of successful purchasing?
8. What are the qualifications, duties and responsibilities of purchasing officer?
9. Give a good purchasing policy and purchasing procedure.
10. What are the advantages and disadvantages of centralized purchasing?
11. Explain the process of purchasing.
12. How the purchase requisitions are prepared? Explain the procedure of materials requisitioning.
13. How the tenders and quotations are prepared? Explain giving documents required for calling them.
14. What is a purchase order? How it is prepared?
15. Explain the purchase release and payments of purchases made.
16. What methods are used to purchase machines and equipments?
17. Explain F.O.R., F.O.B., C.I.F. and F.A.S.
18. How the suppliers are evaluated and their performance is measured?
19. Explain the various types of purchase systems.
20. Explain how the purchasing function can contribute to quality.

CHAPTER III

Stores Management and Control

Stores or Warehouses

The space, room and the building where various types of materials, semifinished, finished goods and items purchased and manufactured in the organisation are kept temporarily or for sufficient time till they are removed to supply for production and sale or used for consumption is called a Store or Warehouse. Finished parts or products ready for shipment and sale are called *stock* and they are separately stored in a place called *stockroom*. Each and every type of material needs a separate place, bin or container and a room to keep it and the type of store depends upon the type of material which is stored there. The position of stores is usually located near the production facility as indicated in the Fig. 1 below.

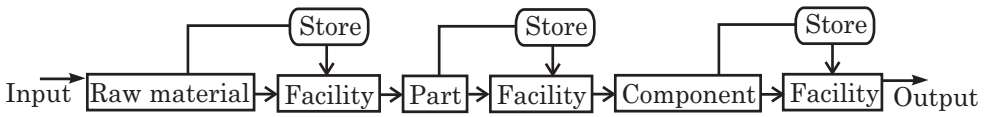


Fig. 1.

The part of material enters directly at the production facility after its purchase and rest is supplied to the stores. The part coming out from production facility, some of them enters the production centre or facility and rest are stored. In the same way, components produced at some facility are sent to assembly centre and rest are stored. Finally the output is the final product sent to stock or sell. This process of supplying and storing the various materials and parts is called Stores Management. As per the demand and requirement of materials at the production facility, the materials are supplied from the stores. The storage of materials maintains the continuity in production.

Classification of Stores

The stores are classified according to type of materials kept in it and they are also classified according to location

There are three types of methods of locating stores.

(1) Fixed location

(2) Random location

(3) Zoned location

1. Fixed location: It is suitable to locate the materials easily and delivery of materials at fixed location will take lesser time.

2. Random Location: The stores are randomly located.

3. Zoned location: This is the type of location where items of a particular product group are stored in a given zone or area.

The main criterion in deciding the type of location is to reduce the time of travel and keeping the material in the stores and withdrawing them with ease by the use of material handling equipment. Since in most of the manufacturing organisation, the availability of storage spaces are scares and therefore selection of location of store places need good stores planning for proper space utilisation and handling the materials.

The other way of storing is to keep the materials at one centralised place or near the place of their use at the production centre i.e., decentralised stores.

Centralised and Decentralised Stores

In small organisations, one store will be sufficient to store all the materials which can be supplied by this centralised place to the other places or requirments. But in large Industrial organisations since the production shop floors or workshops are lying at different place and sometimes located far away. So, the decentralisation of stores is necessary in such organisations. Sometimes, large centralised warehouses supply the goods to various other small warehouses located near the production centres.

Advantages of centralised store

1. The variety of goods can be supplied to all users from one small locations.
2. Minimum inventory will be there as store will have limited capacity specially the tools, fixtures, large parts and spare parts.
3. Less manpower will be required
4. Better control of materials is possible.
5. Materials located in small available space ensures economy in storage.
6. Large inventories are not there.
7. Receipts and inspection of materials can be efficiently organised.
8. Materials handling will be easy.
9. Wastage and deterioration of materials will be less.

Disadvantages of centralised storing

1. It may not be suitable for large manufacturing concern.
2. More staff will be required for shifting and transportation of the materials to various production units.
3. Wastage and shortage of materials may be there
4. Safety and maintenance of large amount of materials is difficult in large stores
5. Record keeping is difficult.

The disadvantages of centralised storing are advantages of decentralised storing and vise-versa.

Decentralised storing needs efficient planning of materials as well as location of

storing them. However, it is the convenience of the organisation to select any one type of storing system. But the type of materials like small parts as nut, bolts, screws, fixtures, chemicals, paints, gas cylinders, containers of flammable liquids like petrol, kerosene and lubricants they all have to be stored at separate places, whose requirments may be at many places. The types of store will definitely depend upon the types of materials stored such as

(*i*) Consumable materials

(*ii*) Raw materials entering the product

(*iii*) Chemicals, acids etc.

(*iv*) Inflammable and toxic materials like kerosene, petrol, diesel, lubricants, flammable liquids and gases

(*v*) Small parts like nut, bolts, screws, nails and fixtures

(*vi*) Hand tools and tools used for cutting machines

(*vii*) Machinery and equipments

(*viii*) Furniture

(*ix*) Office materials and stationery etc.

Stores Management and Store Keeping

The purpose of stores management is to device the activities of storing in such a way that the materials are received on one end, kept inside the storing room and issued to deliver at the production centre. All these activities are divided in these three systems. Receipt, storing and maintaining and issue are the three main functions of store keeping. Stores must be planned and organised in such a way to consider future developments and increase in demand and provision to store scarce materials.

Fig. 2.

Objectives of Store Keeping

The objectives of stores management is to assist the production department by procuring the required materials and goods and deliver them at appropriate time. It provides the service to all other departments along with production department to supply their requirements. The service provided by the stores is devided in four parts.

1. To procure and maintain the requirments of raw materials, components, parts, equipments, tools and other materials required for operations and processes and to store them.
2. To provide maintenance of materials, spare parts and office materials.
3. To store scrap, discarded and obsolete goods.
4. To receive and issue finished products as stock

Functions of Stores

1. To store the materials above safety stock and up to maximum capacity.
2. To see that essential materials required for production should not fall below the required minimum level. In such cases, it should remind the purchase department to expedite the purchase of such items to avoid shortages or stoppage of production.
3. To inspect and check the material after receipt and before storing it.
4. To arrange and store the materials systematically.
5. Distribute the materials promptly and maintain the flow of materials of production.
6. To maintain the materials efficiently, avoid wastages and thefts etc.
7. To keep up-to-date records of all incoming and out-going materials to match with the balance in the stores.

Organization of Stores

The storekeeper is the main responsible person to manage all the stores. The store is the link between purchase department and production department. It may be either in control of materials management or production department. The centralised stores are normally managed by materials management and decentralised or stores near the production centres are managed by the production controllers.

The main aim of stores organisation is to plan the storing of materials under effective supervision and control. The persons working in it have to efficiently receive, maintain and distribute the various items so as to use them at the minimum expenditure. The structure of organisation is given below in Fig. 3.

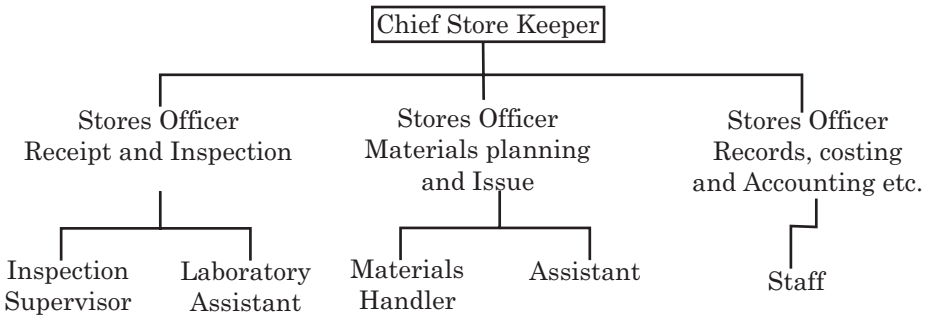


Fig. 3.

Duties and Responsibilities of Chief Storekeeper

(*i*) Planning the stores for its optimum utilisation.

(*ii*) Receiving all supplied materials, checking, inspection and recording them.

(*iii*) Storing proper materials in proper place, maintaining bin cards and stock cards and periodically checking them.

(*iv*) Receiving the requisitions from various facilities and departments and sending them to purchase department to order before shortages may arise.

(*v*) Receiving indents, scruitinizing, despatching and forwarding materials.

(*vi*) To prevent theft, unauthorised entry in the stores. Disposal of wastages, obsolete and unuseful materials. Return of bad quality materials supplied by the supplier.

(*vii*) Co-ordinate and correspond to all the departments so that they will have proper materials to maintain continuity in production processes.

(*viii*) Assist in inventory planning and inventory control.

(*ix*) The storekeeper is responsible for all the materials received in the stores, kept there and issued to various other departments. He should receive these materials of proper quantity after verification and proper authorisation as per specifications.

(*x*) To store the materials at proper place. Codification and classification of these materials is the responsibility of the storekeeper.

(*xi*) Proper issue of materials to various facility and production centres, to prevent thefts and damages, disposal of scraps, obsolete and unuseful materials, preservation and maintenance of materials is the responsibility of storekeeper.

(*xii*) It is the responsibility of storekeeper to correspond and supervise the stores workers co-ordinate the working in stores department and co-operate with purchase, production and all other departments of the organisation.

(*xiii*) To keep up-to-date records, checking and maintaining quality of materials is done by the storekeeper

(*xiv*) The stock valuation, verification, stock disposal and sales record keeping is also the responsibility of the storekeeper.

The duties and responsibilities of storekeeper are numerous as discussed above, but the systematic stores management will ease out and assist the authorities of organisation in materials control and avoid financial losses in materials.

Advantages of Systematic Storekeeping

1. Continuity in production
2. Receipt and issue of proper materials
3. Proper inventory control
4. Proper location and preservation of materials
5. Capital investment in materials can be reduced by under stocking
6. Quality control of materials and its proper utilisation
7. Better materials records avoids wastages and thefts etc.
8. Buffer stock avoids the shortages and stoppage of production. It will be regulated by analytical inventory studies and forecasting
9. Assisting all the departments in supplying their materials requirments
10. Saving in expenses required to order and store the materials by proper valuation

Qualifications of Storekeeper

The storekeeper should be a well-qualified graduate and experienced person. He should have complete knowledge of various types of materials, their specifications, properties and use. The qualifications the storekeeper should possess are given below

(*i*) He should be graduate in Science or Engineering.

(*ii*) He should have knowledge of materials management and storekeeping.

(*iii*) He should have taken training in stores handling.

(*iv*) Sound knowledge of his job is required.

(*v*) He must be honest and hard working.

(*vi*) He should have good memory and sound health.

(*vii*) He should be well acquainted with his duties and responsibilities.

(*viii*) He should have knowledge of prices of various materials.

(*ix*) He should be able to maintain the accounts of all the materials received in the stores and manage them

(*x*) He should be co-operative to everyone.

Types of Warehouses and Stores

Depending upon the type of materials to be stored, the warehouses are designed and located. The design of stores and methods of storing and withdrawing the materials will depend on how frequently the materials are received and stored inside the storing rooms and storing places and withdrawn from there.

Every organisation has to plan the type of warehouses according to their needs and production requirments and categories of materials purchased and stored.

The warehouses are classified in two categories

(*a*) Physical size and location of store

(*b*) Functional store

(a) Physical Stores

In physical consideration, the stores are located at various places and locations are of different sizes. Depending upon quantity and type of materials kept in them, their sizes will be determined.

They are as follows:

(i) Central Warehouses

It is located at one place and serves the various sub-stores or different plant of the factories. It is controlled by one storekeeper and his associates. In small organisation, centralisation of material receipt and supply will be advantageous. The finished products or stocks are also stored in central warehouses and supplied to various outlets depending upon their demands. In big plants also, the centralised warehouses can be located at a suitable place to supply the materials required to several manufacturing facilities which can be located all around the centralised store to reduce handling and better control of materials. The centralised stores are located at different places in the factories.

(ii) Temporary or Transit Stores

This type of stores are used to keep materials temporarily. The work in process inventories (WIP) or semi-finished goods are stored in such places for further processing.

(iii) Substores

This type of stores are located near the place of manufacturing, so that they can be immediately used up. The tools or equipments used to process the materials are also stored in sub store near the place of use.

(iv) Storing Sites

Large construction and fabrication projects needs bulk of materials of building construction like steel, cement, sand, stones and other fabrication materials. For such materials site stores, are built up near the project places.

(v) Departmental Stores

The organisations are having different departments and production centres. They have their storing places where all the materials required for that particular department will be kept to facilitate the working of department. These stores are called departmental stores. The big co-operative societies sell larger number of consumer items in these stores. Each of these stores sell particular type of consumer items like food grains, cosmetics, clothes, toys, washing and cleaning items and other materials of good quality at reasonable prices to the consumers.

(vi) Company Warehouses

Large companies which do not manufacture all the products which they sell like Bajaj, Tata, Birla, Hindustan Lever Limited, Modi, DCM, Baidyanath, Philips, Godrej and other group of companies but sell various products like textiles, garments, cosmetics, electrical and electronic appliances, chemicals, medicines and food products etc. have their big group stores located at one place as company warehouses. They serve all their selling units, located all over the country.

(b) Types of Functional Stores

They are the places where the materials of particular use are stored and supplied for further production operation and process.

They are classified as

(i) Raw Materials Stores

The materials like pig iron used to make castings, cotton used in textile mills, raw rubber, fabrication materials used to fabricate the parts are stored in the raw materials stores. They are purchased in bulk quantities and require large space. They also require trucks and other transportation equipments to supply to the place of production. They may be stored in the open places like open storeyards or in the sheds. Liquids, chemicals and gases are stored in large steel tanks or underground storing places with various types of safety devices attached to them.

(ii) Spare Parts Stores

The parts which are not manufactured in the plants but they are required for making the products used in assembly line. They are kept at separate places and stored in bins or racks. They are purchased from outside firms as semi-finished or finished products. The places used to store such items are called spare parts stores. The spare parts also include those items which are also used for maintenance and repair of machinery and equipments in the factory. Some of the items used as spare parts have to be stored carefully. They are given below

1. Electrical and electronic parts and instruments are stored in the dust-free and air conditioned rooms.
2. Welding rods are stored in moisture-free conditions.
3. Rubber parts like belts, packings, mounting pads, tyres, tubes are coated with talk powder and are kept in the dark rooms. Sun rays affect them.
4. Shafts, gears, bearings and tools are stored in water protective containers and they should be greased and painted to prevent rusting.
5. Screws, nuts and bolts, washers, fasteners, pipe fittings, rivets and auto parts are stored in shelves and bins properly maintained.

(iii) General Supplies Stores

Those materials not entering the product but are supporting items in manufacturing such as oils, lubricants, greases, paints, fuels, brushes, cleaning and washing materials, spirits, kerosene and detergents etc. are called *general supplies* and they are separately stored in general stores.

(iv) Stores for Tool Room Materials

Cutting and machining tools like workshop tools, grinding wheels, drills, reamers, single point cutting tools, blades, files, hammers, saws, pliers, screw drivers, jigs, fixtures and other special tools measuring instruments, cutting oils, abrasives, gloves and eye shields etc. are stored in tool room stores. They must be stored carefully to prevent from rusting and any chemical action.

(v) Packing Stores

Materials used for packing like, cardboards, wood boards, cartons, empty cylinders, boxes, bottles, various types of containers and other packing materials are stored in this type of stores.

(vi) Receipt Store and Quarantine Store

Receipt stores are those warehouses where the materials are received from vendors supplied from the railway stations, airports or docks.

The materials received here are kept till they are inspected. Quarantine store is place where materials received are sent for inspection which takes time. Till the inspection and verification is not complete, the materials are kept in the quarantine store. Quarantine means waiting for some time to inspect the materials.

(vii) Work-in-Process Store

The various types of parts and components are produced at different production facilities in batches and lots. The lots of one part produced is more for example 500 units and it is required at a time in 100 units only so the remaining 400 units are WIP inventory. They are temporarily kept near the production facility before being supplied for assembly or other production centre. This is called work in process inventories (WIP). The place where such type of items are stored is called work in process store. Sometimes spare parts stores are also used for storing WIP inventories.

(viii) Finished Products Stores

The finished products before being sold are kept as stock in the finished products stores. The distribution centres are also acting as finished products stores. The final products are also packed and finished at these places and package stores are also located here.

(ix) Stationery Stores

The office materials like files and other stationery items are kept here and they are issued to various departments.

(x) Bonded Stores

Bonded store is that where the goods on which custom or excise duty has not been paid are kept here.

(xi) Cold Storage or Refrigerated Store, Dehumidified and Flammable stores

The perishable materials like vegetables, fruits, meats, chemicals and medicines etc. are kept in the cold storages or refrigerated stores. The temperature in such stores is maintained between 32 and 50° F. The blood storage is also done in the refrigerated stores. The inflammable and toxic materials are kept in these types of special stores having fire proof and closed rooms where entries are restricted. The safety devices are used against fire and toxicity. They must be well protected against fire.

Dehumidifier stores are used for those materials which are kept in the moisture-free environment and kept in properly packed and sealed containers. The special precautions are necessary for preservation and safety of such types of stores particularly the atmospheric conditions and handling the materials.

(xii) Open Sheds and Open Yards Storages

These sheds or yards are used for storing large materials outside in open places. The materials like building materials, steel sheets etc. are kept here. The materials requiring protection from sun rays and rains are stored in sheds. The roofs are built without walls and materials are stored in such sheds. These sheds are also called *transit sheds* where bulk of materials received from ships like food grains, cement and fertilisers etc. are kept temporarily. The sheds are built outside the factories having good ventilation and large spaces to store bulk of materials required for production or other purposes of use.

Organising Stores

The stores are organised according to types of materials received in the organisation for storing and layout and location of stores.

The activities of stores department are as follows:

(*i*) Planning all the materials required for storing
(*ii*) Receipt of materials
(*iii*) Inspection and verification of all the materials received
(*iv*) Storing and issue of materials
(*v*) Preservation and maintenance of materials stored
(*vi*) Transport and materials handling
(*vii*) Record keeping of all the items
(*viii*) Stock taking and auditing
(*ix*) Inventory control
(*x*) Finished goods inventory packing and dispatching

(i) Materials Planning

All the materials required in the process of production must be identified and well defined by codification, nomenclature, specifications and standardisation. All the materials must have records in the stores department. The methods used to identify the materials required by the departments by codification and nomenclature is given in these chapters. The direct materials are also classified according to their cost, annual usage, imported materials and scarce materials. This analysis is very important for storing and inventory control. The details about these types of analysis is also given in the chapter, methods of classification and analysis of materials.

(ii) Receipt of Materials

The purchase department places the orders to purchase the materials and sends directly to stores department to receive it. All the materials purchased from vendors are received by the storekeeper. The materials delivered are inspected for the following aspects in the stores.

1. All the materials received are physically counted and measured for its quantity accurately and verified as per purchase order.
2. This verification is done quickly and efficiently without any delay.

After ascertaining the correct quantity of materials received, it is sent for inspection. Any delay or carelessness in the receipt section will make delays for inspection and inventory control section for further supply of materials to production facility and payment to supplier. Therefore, the receipt section must be very efficient and co-operative. The procedure adopted by receipt section for receipt of all the materials is as follows.

Receipt Procedure

(*i*) All the items received in the store which are delivered by the supplier or received from port, railways or road transport will have to be cleared and forwarded after checking

the quantity as per supplier invoice, challan, packing list and purchase order. The procedure followed for receipt of materials is as follows.

The materials delivered by a person bringing in the department delivers the challan and other documents as supplier's despatch note, consignment note, materials transport advise note and packing list giving the details of materials supplied. After checking the materials supplied, the delivery note is signed and checked in receipt section, stamped, its one copy is retained by receipt section and entered in Goods Receipt Register, also called Goods Inward Register. This register has the following entries as shown in the Fig. 4.

(1) Date and time of receipt

(2) Name of supplier

(3) Challan number

(4) Item description, quantity and value

(5) Reference of purchase order

(6) How supplied (R.R. no./ Truck carriage number)

(7) Reference of goods inward note

(8) Reference of rejection memo

Goods Receipt Register

Date of receipt.....

Challan number.....

Date.....

S.No.	*Description of item*	*Quantity*	*Value*	*Purchase order reference, rejection reference, carrier details*

Signature

Fig. 4.

(iii) Inspection and Verification

After receiving and counting the items received in the store they are to be inspected for correct quantity and quality as per specifications in the inspection department or laboratories.

In the inspection procedure after verification of goods if any discrepancy is found, it will be reported and if required the laboratory testing, dimensional measurements acceptance test or material composition test etc. are performed as specified in the order to assure the quality of the product for its acceptance or rejection.

For quality of the items, the supplier issues a certificate that delivered goods meet the specifications and quality as specified in the purchase order. Only periodic inspections are to be made of shipments for quality control. This practice is known as Quality Certification or Certified Quality Control. The purpose of this certification is to avoid duplication of inspection procedure, reducing cost of inspection and to accept suppliers responsibility to deliver quality goods. This also relieves the stores department to conduct rigorous inspections and test every time the material is received.

The various types of Statastical Quality Control (SQC) techniques are there to accept the lot sizes and samples of materials supplied by the supplier. Highly sophisticated and precise items and goods should have zero defects like defence or military supplies and aircraft items.

(iv) Storing and Issue of Materials

The types of methods used for storing depends upon the types of materials received in the store and how frequently they are issued. If the materials are required to be stored for longer time, their safety and security is important. The location of places to store the materials depends on various factors.

The classification of stores and the location is already discussed above. The storing and issue comprises the following activities.

1. After inspection transfer the materials directly to the storing places.
2. Transfer of materials to production facilities as per their requisitions.
3. Transferring the items to the departments requiring them.
4. Finished parts are directly sent to assembly section or for selling.

The methods used for storing and issue of materials are mainly classified in two ways.

(*a*) First In First Out (FIFO) method

(*b*) Last In First Out (LIFO) method

(a) First In First Out (FIFO) Method

In this method, the material stored first is issued first. For using this procedure, the following methods are used.

1. Double area system: In this particular method, two areas are used for each item to be stored and issued. The new lots of items are stored in second empty area and materials are issued from first area where previous old lot is stored. When first area is emptied, the material from second area is shifted to first area so that second area is emptied to receive the fresh materials.

2. Moving division system: In this method is the place selected for each item is more in area than required to provide space between new and old lots. The materials supplied first is placed first in right hand side area from where it is issued. The fresh lot is supplied in the second area on left hand side and shifted to right hand side when it is emptied.

3. Gravity feed system: The new materials are fed at the top of the containers or piles and removed from the bottom. The coal is handled in this way.

Methods of Storing the Materials

The materials will be stored depending upon its size, shape and weight. They are usually stored in

(*a*) Bins

(*b*) Shelves or racks

(*c*) Pallets

(*d*) Heavy lifts

(*e*) Containers

(a) *Bins*

The small items which can be handled easily are stored in bins. The items stored in bins are fast moving. The various types of bins are used depending upon the size of materials, the movable bins are also used. The loading and unloading the materials in the bins is normally done manually. The bin card is used to record the materials in bins.

Bin card: Bin card is attached to each bin, rack, shelf or any container of material storage. The material entering, leaving and balance in the bins are recorded on the bin cards and materials in the bins can be verified with these records.

In some of the stores, the bin cards are used in duplicate by the storekeeper. One card is attached to bins and other is kept by storekeeper for his ready reference. The maximum and minimum level of inventory to be kept in the stores place are also recorded on bin cards. A typical bin card used in the store is shown below in Fig. 5.

Bin Card

Bin no. ..... Minimum quantity .....

Name of the item ..... Maximum quantity .....

Ordering level .....

Date	*Quantity received*	*Quantity issued*	*Balance*

Checked by

Fig. 5.

(b) Shelves or Racks

The items which are large in size and heavy to be stored are kept in shelves or racks. Manual handling is not possible for large items, therefore, mechanical handling is used for storage and removal of items from racks. Shelves or racks are made either from wooden materials or metal plates. The various types of racks used are as follows:

1. Static racks: They can be prepared from pre-fabricated sections. Their heights and widths can be adjusted. Racks can be arranged back to back. They are designed to accommodate heavy materials.

2. Live racks: They are conveyors on which pallet loads are placed. Materials are loaded from one end and removed from the other end. It is economically used if the space available for it is fully used.

3. Drive through racks: In this type of storing the vertical and horizontal parts are similar to static racking. Pallets are loaded in to channels by sliding. The fork lift straight way keeps the materials in pallet position.

4. Honeycomb racks: This type of racks are designed from steel pipes, girders, and bars. The materials are stored by special type of over head travelling cranes operated by gantries.

5. Self-erected racks: The slotted angles are used to erect this type of racks and its sizes can be adjusted to suit the materials to be stored.

6. Pallets: They are specially designed platforms for stacking loads which can be moved by fork lift. The pallets are most suitable for stacking the small number of items which are frequently moved. The wide range of pallets of different sizes are build by steel over wood. They may be flat or loose items in cages can be placed. Fork lift trucks carries them.

The pallets are most suitable for storing and movement of materials which can be lifted easily by raising the pallets from storage areas.

7. Block staking: The heavy lifts can block the flow of materials. The separate storing arrangements are made for stacking them. The block are stacked one over the other and removed the same way. They may also be stacked on pallets.

8. Containers: Various types of containers are used to store the various types of materials. Particularly liquids and gases are stored in these containers. They may be closed or open containers.

Issue of Materials

The material is released or issued from the stores by Material Issue Requisition. The materials indents on stores are demands upon the storekeeper signed by authorised person to issue the material to the bearer of the requisition. The indent on stores are normally prepared in triplicate. These requisitions contain date, description of material, department requiring the material, job number, signature of indentor, storekeeper and receiver of the material. One copy of it is sent to the accounts department for costing. A typical type of material issue requisition is given below in Fig. 6.

Material Issue Requisition

Book no. ..... Indent no. .....

Department ..... Date .....

To,

The storekeeper

Please issue the following materials for the job number .....

S. No.	*Description of materials*	*Specification*	*Quantity demanded supplied*	*Stores ledger page no.*

Rate Cost Remarks

Number of items received .....

Receiver Indentor Storekeeper

Fig. 6.

Material Return

The material supplied in the department are sometimes not fully utilised so balance materials are returned back to store. After recording, they are returned by material returned note, which is written in triplicate. Two copies of this are sent to storekeeper and one copy is kept by the department. After receiving the material and checking, the storekeeper sends back one copy acknowledging the return of material to the department. The Material Returned Note is given below in Fig. 7.

Material Return Note

From Department ..... Serial number .....

Job number ..... Date .....

To,

Storekeeper

Please received the under mensioned materials

Signature

Description of material	*Reason of return*	*Quantity*	*Rate*	*Value*	*Store ledger page No.*

Bin card no. .....

Received

Signature .....

(Storekeeper)

Fig. 7.

Records of Store

For keeping the proper records of materials in the stores department and maintaining it, the various stores registers are used. With the use of computers now, the stores records are stored in various types of inventory files in the computers. The following types of registers are used.

(i) Inward and Outward Register

The materials received from the supplier by railway through Railway Receipt (RR). The entries of these RR is kept in inward register. The same material when goes out of the store, the entries are made in outward register. The material if despatched by Railways, the RR is sent to customer who receives it.

(ii) Receipt and Issue Register

These registers are of loose pages. All the materials received daily is entered in receipt register, inspected and than entered in the stock book. The material issued daily is entered in issue register. These registers are used for preparing stores ledger.

(iii) Stock Register

They are of two types

1. Consumable materials register
2. Non-consumable or permanent stock register

1. Consumable materials register: The materials which will be consumed and will not remain in store are entered in this register. One item will be recorded on one page. Its all the transactions are entered on the same page. The consumable materials are raw materials, coal, diesel, kerosene, lubricants, paints, varnishes, grease, cotton waste, screw, nails and nut and bolt etc.

2. Non-consumable or permanent stock register: All those items which will not be consumed and will remain in records till it is scraped or written off is entered in this type of register. They remain for permanent record. These items are machines and its accessaries, equipment, furniture, fittings, machine tools and hand tools etc. Each item is written on each page with all its specifications, costs etc. Some items which are used for some time say 2 to 3 years. After that they become surplus. Such items are removed from stock register and entered in the separate register called Surplus Items Register.

(iv) Suspense and Condemned Articles Register

The defective or excess items are entered in suspence register. The waste, obsolete and unrepealable and unuseful articles are entered in condemned article register. Such items will remain in these registers till they are not disposed off. After that they are removed from these registers.

(v) Loan Register

The materials which are not consumables are issued on loan temporarily after getting authorised slip. These materials are issued after recording in loan register and signature of receiver is taken in it. After receiving the materials back given on loan, the issue slip is returned.

(vi) Packages Register

The record of packages, empty containers and boxes are kept in this register. In this way, the records of all the items received in the store, kept as inventory and issued as per requisition from the store are to be maintained correctly and efficiently.

Valuation of Stock and Materials

The stock and materials stored as inventories in the store are having money value. They are the assets and working capital of the organisation. The materials and parts are purchased at different cost in the books of accounts. They are valued according to some method so that all the items have same price. The valuation would show the loss or profit to the company depending upon what cost is assigned to the inventories in the store. The materials and stock once entered in the store and kept, its value always increases because of various other cost which will be incurred in carrying them in the stores.

The method adopted for valuation of stock and items of inventory is approved by Board and valid for three years. The valuation of inventories will be controlled by proper valuation

of stock. For example, the car engine assemblies brought in to store in various months in an automobile company are valued as follows.

Month	*No. of car assemblies purchased*	*Price in Rupees*
July	200	40,000
August	150	45,000
September	125	55,000
October	250	50,000

The average value of all these assemblies in the month of November will be

$$\frac{200 \times 40000 + 150 \times 45000 + 125 \times 55000 + 250 \times 50000}{725} = \text{Rs. } 47{,}069 \text{ for each assembly.}$$

The various methods used for valuation of various types of materials are given as follows.

(1) First In First Out (FIFO)
(2) Last In First Out (LIFO)
(3) Highest In First Out and Next In First Out (HIFO and NIFO)
(4) Simple average method and weighted average method
(5) Fixed price method and standard price method
(6) Base stock method
(7) Actual cost method
(8) Current-value method
(9) Inflated-price method
(10) Replacement price method

(1) First In First Out (FIFO) Method

In this method, materials received first in the store are issued first out of the store. The materials are, issued at the actual cost without any profit or loss in valuation. This method is easy to use when the price of the material do not vary too much.

Application of the method

(*i*) This method is suitable when size and cost of material is large.
(*ii*) When large number of batches of materials do not remain in the stock.
(*iii*) It is used where the production is fast.

Benefits of the method

The method uses actual cost of the material for valuation and it is very easy to use. The only disadvantage of the method is that if large variation of prices are there, no consideration is given to current market prices. When the prices are falling, the material charged to

production is high and when the prices are rising, the material charged to production is low and replacement cost is high.

The example given below will make the use of this method and its benefits more clear.

Example

The colour picture tubes of television sets are received from different manufacturers in lots at different cost at different time as given below. They are issued to assembly shop using FIFO method. The price and quantity of these tubes are tabulated in the balance column as shown in the table below .

Item No. and Name: Colour picture tubes of T.V. sets

Date	*Receipt*			*Issue*			*Balance*		
	Quantity	*Price* (*Rs.*)	*Amount* (*Rs.*)	*Quantity*	*Price* (*Rs.*)	*Amount* (*Rs.*)	*Quantity*	*Price* (*Rs.*)	*Amount* (*Rs.*)
1st Jun	–	–	–	–	–	–	50	2500	1,25,000
10th Jun	150	3000	4,50,000	–	–	–	200	3000	5,75,000
15th Jun	–	–	–	50 50	2500 3000	1,25,000 1,50,000	100	3000	3,00,000
30th Jun	100	2800	2,80,000	–	–	–	200	2800	5,80,000
15th July	–	–	–	100 50	3000 2800	3,00,000 1,40,000	50	2800	1,40,000
2nd Aug	–	–	–	50	2800	1,40,000	Nil	Nil	Nil
8th Aug	100	2700	2,70,000	–	–	–	100	2700	2,70,000

(2) Last In First Out (LIFO) Method

In this method, the lot of material received currently is issued first and then the material is used from the last balance. The valuation of the material is done from the last batch received. It is opposite to FIFO method.

Application of the method

It is applicable when price variation is not high. It is used when the production is rapid.

Benefits of the method

The valuation of material is done at the current price and the production cost is based on this price. The disadvantage is that the old stock remains in the store and may lose its value or deteriorate.

The example of TV sets given above is explained below using LIFO method.

Example

Item No. and Name: Colour picture tubes of T.V. sets

Date	*Receipt*			*Issue*			*Balance*		
	Quantity	*Price* (*Rs.*)	*Amount* (*Rs.*)	*Quantity*	*Price* (*Rs.*)	*Amount* (*Rs.*)	*Quantity*	*Price* (*Rs.*)	*Amount* (*Rs.*)
1st Jun	–	–	–	–	–	–	50	2500	1,25,000
10th Jun	150	3000	4,50,000	–	–	–	200	3000	5,75,000
15th Jun	–	–	–	100	3000	3,00,000	50 50	2500 3000	1,25,000 1,50,000
30th Jun	100	2800	2,80,000	–	–	–	50 50 100	2500 3000 2800	1,25,000 1,50,000 2,80,000
15th July	–	–	–	100 50	2800 3000	2,80,000 1,50,000	50	2500	1,25,000
2nd Aug	–	–	–	50	2500	1,25,000	Nil	Nil	Nil
8th Aug	100	2700	2,70,000	–	–	–	100	2700	2,70,000

(3) Highest In First Out (HIFO) and Next In First Out (NIFO) Method

Both these methods are having some variations in valuation to the methods explained above. In Highest In First Out method, the highest price paid is valued first. As from given example of TV set colour picture tubes, the four prices are Rs. 25,00, 3000, 2800 and 2700 the highest value is Rs. 3000. It is valued first. Where as in Next In First Out method, the replacement value is taken into account. In the above example, the value of supply of picture tubes is Rs. 3000 on 10th Jun. but in next lot, it is reduced to Rs. 2800 so in the issue of it, the valuation is done @ Rs. 2800.

(4) Simple Average and Weighted Average Method

In this method of valuation, the average cost of material is charged for the production. Two types of averages are calculated.

(i) Simple Average Method

Whenever the material is issued the average cost is calculated. The disadvantage of this method is that every time the material is issued the average cost is calculated.

This method is explained by taking the same example of the TV set colour picture tubes as given above.

Item No. and Name: Colour picture tubes of T.V. sets

Date	*Receipt*			*Issue*			*Balance*		
	Quantity	*Price* (*Rs.*)	*Amount* (*Rs.*)	*Quantity*	*Price* (*Rs.*)	*Amount* (*Rs.*)	*Quantity*	*Price* (*Rs.*)	*Amount* (*Rs.*)
1st Jun	–	–	–	–	–	–	50	2500	1,25,000
10th Jun	150	3000	4,50,000	–	–	–	200	2875	5,75,000
15th Jun	–	–	–	100	2875	2,87,500	100	2875	2,87,500
30th Jun	100	2800	2,80,000	–	–	–	200	2837.50	5,67,500

The average value changes when change in price occurs. When the price fluctuations are rapid, the average price valuation is a useful method for small period of span.

(ii) Month End Average Method

In this method, average cost of material is calculated at the end of each month. In the example given above for colour picture tube of TV sets the average cost of it at the end of the month will be

$$\frac{50 \times 2500 + 150 \times 3000 + 100 \times 2800}{300} = \text{Rs. } 2850$$

(iii) Weighted Average Method

This method is similar to simple average method. Here the total quantities and total cost are considered where as in simple average method, only total costs are considered.

(iv) Periodic Simple Average and Weighted Average Method

In simple average and weighted average methods, the value of issue prices are calculated on issues and receipt basis where as in this method average is worked out at periodic intervals by dividing the total prices of the materials received during this period by the number of prices used in this period.

For the example given above of the colour picture tubes of TV sets the prices in the three months period Jun, July and August are 2500, 3000, 2800 and 2700. Periodic Simple average will be

$$\frac{2500 + 3000 + 2800 + 2700}{4} = 11000/4 = \text{Rs. } 2750 \text{ for three months.}$$

(5) Fixed Price and Standard Price Method

The value of materials are predetermined and their price is estimated for a fixed period of time say, one year. The material is charged at this fixed price or standard price. This method is also known as *standard price method*. The records of materials for their receipt and issue are done for their quantity.

This method is used when the variation in the prices of materials are negligible.

(6) Base Stock Method

In this method, the materials are issued at their cost. A fixed stock of material is always carried at the original cost and the minimum stock is a safety stock. This method is similar to FIFO method. The base stock is not always the old stock, it may be fresh stock but its valuation is recorded as old one.

(7) Actual Cost Method

In this method, the actual cost of purchase of material is charged when it is issued. This method is used for the materials which are purchased for specific purpose for example, spare parts, jigs and fixtures and tools etc. stored.

(8) Current Value Method

In this method, the materials are valued at the current market price and purchase price is not considered. This is useful to value the materials as per recent market conditions but many a time it is difficult to ascertain exact market price.

(9) Inflated Price Method

In this method, the charges for the materials are slightly inflated or increased. Some percentage of purchase price is added to it so that the value of material is inflated to recover the wastage and other cost incurred to store it.

(10) Replacement Price Method

In this method, the materials are valued at the replacement price.

Layout of Stores

The layout planning of stores is very important for the following reasons:

(1) Easy receipt, handling and issue of materials.

(2) Maintaining continuity in flow of materials. It should have minimum movement.

(3) The space for storing and handling the materials should be fully utilised.

(4) Proper places are selected for storing proper type of materials.

(5) Location should be such that minimum time and labour will be necessary to locate and get the materials.

(6) Rearrangement of storage can be done easily if necessary.

(7) Unloading platforms for quick receiving and disposal must be built at suitable height.

(8) Layout should be economic and efficient.

The methods of storing and layout must be such that it will eliminate wastage, erosion, rusting and deterioration. For that proper preservation, safety and inspection process must be used to prevent all these things.

Looking to the above considerations necessary, the following types of layouts are suggested:

(1) Straight through flow

(2) Straight line flow

(3) Layout of work element

(1) Straight Through Flow

It is simple layout. The item enters from one door, they are placed in straight rows. They will be picked from rows and move in one direction along the stores bay. Different types of stores will be arranged in every row and around that sufficient movement spaces will be provided. The large warehouses for the agricultural materials will have this type of arrangements. The centralised stores of industry will also have this layout (Fig. 8).

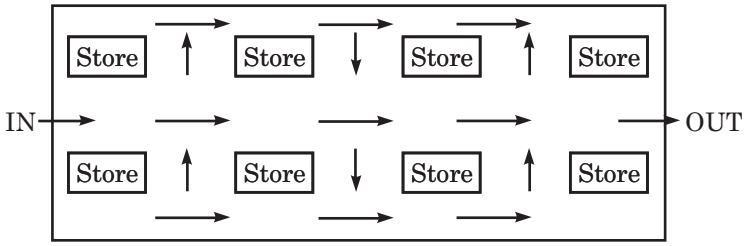


Fig. 8. Straight through flow

(2) Straight Line Flow

In this layout, the stores are arranged according to items incoming and outgoing from each of the storing places. They are arranged in such a way so that straight line flow of material is done. This arrangement is shown below. The small items are normally stored in such stores (Fig. 9).

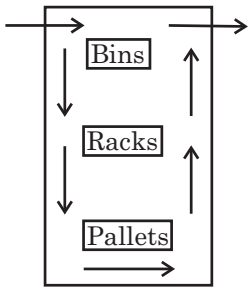


Fig. 9. Straight line flow

(3) Layout of Work Element

The stores are arranged according to work element grouping together for that particular work. These types of arrangements are flexible enough to arrange for slow moving, medium moving and fast moving items. The layout can be changed easily (Fig. 10).

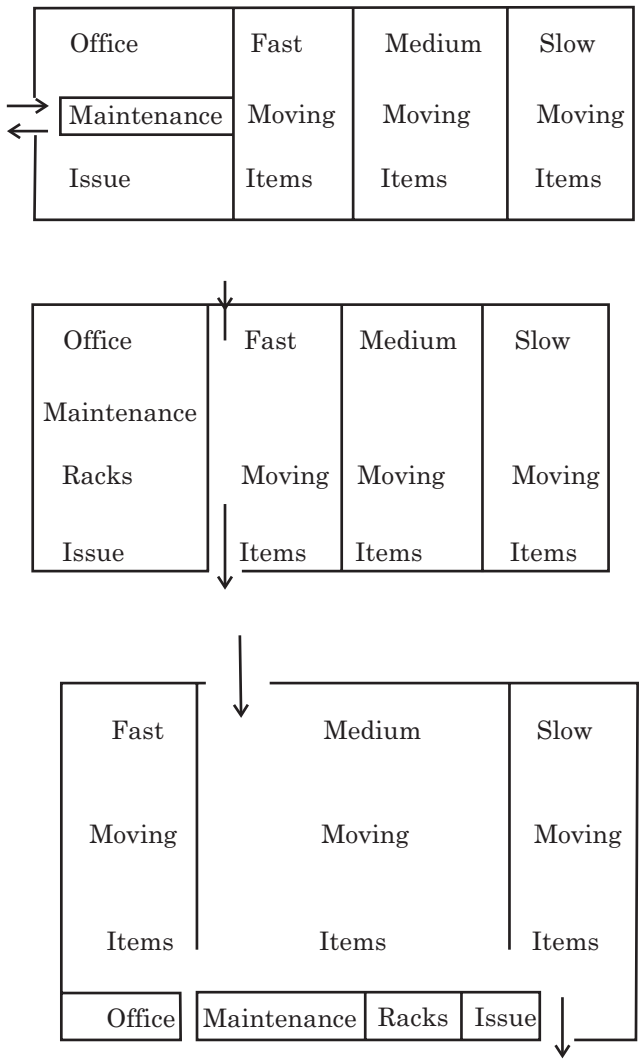


Fig. 10. Layout of work element

The equipments used in the layout of the stores are bins, racks, pallets, almirahs, tote pans, boxes and containers. The bins are used for storing the small, easily handled and general purpose items. These items are fast moving items. Racks are used to hold big and heavy items and will be moved using mechanical devices. Pallets are specially designed equipment to store bags, boxes and regular shaped heavy items. Box or post pallets are suitable for storing irregular-shaped items. Stands are used to store bars, tubes, sheets and plates of metals. Almirahs and cabinets are used to store expensive items which require dust free atmosphere. Depending upon the space available for stores location, the various types of equipments described above will be specially designed to make the layout effective, flexible and convenient for the stores department to control all the inflow and outgoing materials efficiently.

Preservation of Materials and Protection of Stores

The various types of materials stored will be affected by atmosphere and environment. These types of materials must be preserved by keeping them in proper environment which will not affect them. The materials will be affected and deteriorate in the following ways:

(*i*) Fruits, vegetables and some of the agricultural products deteriorate with time and they have short life. They can be stored and preserved for only few days. These types of materials must be carefully stored and the quantity to be stored should be such that it will be consumed before spoilage. Some chemicals can be preserved for few months.

(*ii*) Cement is affected by dampness. Steel plates and other iron products are corroded. Some of the materials are affected by dust particularly electronic devices. These types of materials must be protected from the things which deteriorate them.

(*iii*) Stationery, cloth, paper, wood and plywood are affected by dampness, white ants and moths. Anti treatment against white ants must be done where ever these types of materials are stored.

(*iv*) Rats, insects etc. eat away the food grains, wheat, rice, cereals, clothes etc. Bamboos, timber and wood are affected by *ghuns*.

(*v*) Drugs and chemicals are spoiled by light, air, heat etc. They must be preserved against them. Rubber goods are also affected by these things and they become hard after some time without use, therefore they must be consumed before their expiry periods.

(*vi*) Some types of liquids give out fumes and gases which may be toxic or flammable. The great precautions must be taken for preserving and use of such materials. They may be fertilisers, insectisides and other chemicals used. Battery cells are also deteriorating. If they are kept with other materials, they may spoil them. Battery cells must be stored in dry place and preserved properly.

(*vii*) Many a gases like petroleum gas, chlorine, sulpher dioxide, oxygen, hydrogen are preserved in gas cylinders. The proper types of cylinders are used and they are kept seperately after checking for leakages etc. Inflammable liquids are stored very carefully away from fire places and hot atmosphere.

Since most of the materials as discussed above deteriorate because of the atmospheric conditions and seasonal changes, therefore, these materials must be preserved in such a way that these effects are as less as possible and they must be protected. Some of the important protection methods necessary in every store are as follows:

1. Protection of store against fire: The stores must be located in fire-proof rooms. The fire fighting equipment like fire estinguishers, water and chemical sprinklers and inert gases are used against fire. The fire alarms and other safety devices should be used in the stores against fire. While doing welding in the store, precautions must be taken so that it will not be the cause of fire or burning any other material.

2. Dust protection: Closed and dust-free enclosers should be used in the stores. Cleaning and good housekeeping is necessary in the stores. Air conditioners prevent dust to enter in the stores. Wherever ventilation is necessary specific type of ventilators are used so that dust should not enter in the storerooms.

3. Maintaining proper environment: Proper air conditioning in the storerooms avoids dampness. Dehumidifiers maintains dryness in the stores. When the materials are kept outside, in the storeyards and sheds they must be protected against excessive exposure to light, heat and rains by building proper type of sheds.

4. Protection against corrosion: Those materials which are corroded by atmospheric moisture should be protected against corrosion by painting, coating or greasing by anti corrosive chemicals particularly machine parts, bearings and gears etc.

5. Fast-deteriorating materials should be used immediately and their storage should be limited. Overstocking of deteriorating materials should be avoided. Proper type of containers and storage places are necessary to keep deteriorating items. Their expiry time is to be mentioned on these containers. These items should be handled carefully.

6. Prevention of theft is very necessary in every stores department. Unauthorised persons should be prevented from entering in to the stores. The guards should check all the persons going out of the stores.

The stores are assets of the company. the use of proper preservation methods and protection of stores avoids lot of wastages of materials and goods. While planning the stores layout and location one of the important criteria is preservation of inventory and protection of all types of materials against atmosphere.

Auditing the Stores Materials

All the materials received in the stores and kept as inventory must be audited time to time as a materials management system to keep proper records. It must be followed to account the receipt, issue and balance of materials and goods. The system may be handled manually or by computer database. Today, the various softwares have been developed to use computerised materials management system for keeping all records accurately and it is very helpful for auditing the stores records.

The standardization, simplification, classification, coding and identification of materials are very necessary in a materials management system for storage and handling the materials. Store control is provided by properly recording the receipt and issue of materials and its physical verification. The following things are recorded in a systematic stores management system.

(*i*) Using suitable codes and nomenclature of the materials.

(*ii*) Classification of different items received in the stores.

(*iii*) Rates of each item and their total cost and quantity.

(*iv*) Dates and quantity of receipt and issue of materials.

(*v*) Names of suppliers.

(*vi*) Standards and specifications of the materials.

(*vii*) Methods of preservation, time of expiry and life of materials use.

(*viii*) Location of storage place of various items.

Some fool-proof methods of verification of all these records and stock taking must be used to physically control and check the inventories of all the materials and goods stored. If the discrepancies are discovered, its causes must be found out, errors should be corrected and

persons who are responsible must be informed and warned about this so that in future this thing will not be repeated. The control must be exercised by the stores supervisors and unauthorised entry of any person in the stores must be prevented.

Verification of Materials

The physical verification of materials will be done by two methods:

1. Periodic counting the items
2. Continuous counting the materials

(1) Periodic Counting the Items

The inventory will be verified by counting each item kept in the store once or twice in a year by a person other than those who are working in the stores department or the team whom the verification work is assigned. Before verification, the stores persons should keep their records up to date. The following preparations for stores verification are necessary.

(*i*) Good housekeeping and location of all the material in their places

(*ii*) Bin cards must be kept at bins with records.

(*iii*) Every one in the store must be well informed about verification work to keep their up to date records available in time.

(iv) Reporting all the verification work to the management.

(2) Continuous Counting Method

In this method, the inventories are counted continuously throughout the year physically to keep the regular records of all the items and materials. This checking work will be assigned to a team of persons who will continuously verify the stores items. They are properly trained for that. This method though avoids discrepancies and errors in materials storage, but delays in normal work of material receipt and issue. Many a time it may not be possible to continue the continuous checking of the materials throughout the year.

Security of Stores

The security of stores is very important against theft, pilferage and accidents. The security arrangement will depend upon types of materials and their costs. Security requirements vary from organisation to organisation. The system of security arrangement is decided on location of stores and value of materials stored there. Hazardious and inflammable materials must be kept away from other materials and protected against fire. These materials should have proper containers to store them, so that they should not leak and pollute the atmosphere.

Materials Accounting

Every material received in the store has money value. The cost of the material is determined by its price and storing cost. The price is obtained from the purchase orders but the storing cost is determined by proper accounting of various costs involved in processing,

handling, maintaining and storing the items. In order to account this money value of materials in hand at any time, the quantity of materials must be known and value is assigned to them. For material accounting, the records which are kept by the stores department are as follows:

(*i*) Records of quantity of materials and items

(*ii*) Records of regular receipt, issue and balance of materials

(*iii*) Cost involved in storekeeping

The documents required for these records are

(*a*) Materials received note

(*b*) Stores ledger

(*c*) Bin cards

(*d*) Stock identification cards

(*e*) Material requisition slip

(*f*) Material return slip

(*g*) Material transfer note

(a) Material Received Note

This document is prepared when materials are received after proper verification and inspection by authority. The information in the material received notes are recorded from supplier invoices, bills and challans. After approval from accounts department, the materials or goods will be taken into stock. The materials received note is prepared as given below in Fig. 11.

Material Received Note

Date .....

No. .....

Material received at .....

Name of the supplier .....

Address of the supplier .....

Description ..... Code no. .....

Quantity .....

Purchase order no. ..... Date .....

Remarks .....

.....

Received by .....

Checked by .....

Inspected by .....

Approved by .....

Fig. 11.

(b) Stores Ledger

The materials and goods received by materials received note after approval are entered in Store Ledger for record. This is a permanent record of all the materials received, issued and kept as inventory in the store. The entries are also written in the bin cards. The stores ledger records are as given below in Fig. 12.

Stores Ledger

Description of the material	Maximum stock .....
Code no.	Minimum stock .....
Bin no.	Purchase order .....

Received				*Issued*			
Date	*GPN no.*	*Supplier*	*quantity Rate price*	*Date*	*MPS no.*	*To whom*	*Quantity Rate price*

Balance .....

Remark .....

Fig. 12.

(c) Bin Card

The daily transaction of materials stored in the bin or racks are recorded on the bin card attached to them. The materials received, issued and balance are written on the bin cards. These informations are transferred to stores ledger and can be used for verification of the materials.

Bin Card

Description	Bin no. .....
.....	Maximum quantity .....
.....	Minimum quantity .....
Code no.	Recorder quantity .....
Stores ledger folio	

	Receipt	*Issue*	*Balance*
Date	*GRN No. Quantity*	*Date MRN No. Quantity*	*Quantity*

Fig. 13.

(d) Stock Identification Card

For identification of the materials and goods in the store, stock identification cards are kept in the store in every bin or rack. The information which are given in these cards are:

(*i*) Description and code no. of materials

(*ii*) Bin card No. and stores ledger folio

(*iii*) Specifications

(*iv*) Any other information necessary to identify the materials

Stock Identification Card

Name of item .....

Code number .....

Description .....

Specifications .....

Bin card No. ..... Stores ledger folio .....

.....

Fig. 14.

(e) Material Requisition Slip

The materials issued by the stores department to the various other departments and production centres on receipt of material requisition slips and quantity of materials issued is entered on it. Three copies of material requisition slips are prepared by issuing department. It is shown below in Fig. 15.

Material Requisition Slip

Copy to Production/Stores/Accounts No. .....

Date .....

Material required for .....

Job or product no. .....

Code no.	*Description*	*Quantity required*	*Quantity issued*	*Rate*	*Amount*	*Remarks*

Required by Received by Issued by

Signature Signature Signature

Fig. 15.

(f) Material Return Slip

The excess materials which are not required by the department or production center and they can not be kept in the department are returned to the stores. These materials returned are send by materials returned note to the stores after signed by the proper authority. It is given below in Fig. 16.

Material Returned Slip

Returned to ..... No. .....

From ..... Date .....

Product or Job no. .....

Code no.	*Description*	*Quantity*	*Rate*	*Amount*	*Remarks*

Returned by signature

Received by Signature

Stores Dept. .....

Accounts Dept. .....

Signature

Fig. 16.

(g) Material Transfer Note

When materials are transfered from one department to other department or one production centre to other, they are recorded on material transfer note. One copy of the material transfer note is sent to stores department for record and other copy is sent to accounts department for accounts purposes. This is given below in Fig. 17.

Material Transfer Note

Transfer to ..... No. .....

Product or Job no. ..... Date .....

From .....

Product or Job no. .....

Code no.	*Description*	*Quantity*	*Rate*	*Amount*	*Remarks*

Returned by Received by Stores Dept.. .....

Accounts Dept.. .....

Signature

Fig. 17.

QUESTIONS

1. What do you understand by Stores Management and Control?
2. What is a Store or Warehouse?
3. Give the classification of Stores.
4. What are the advantages and disadvantages of Centralised and Decentralised stores?
5. What are the objectives of good storekeeping?
6. Explain the suitable organisation of store.
7. Give the advantages of systematic storekeeping.
8. What are the qualifications of a storekeeper?
9. Enumerate the various types of warehouses and stores.
10. How will you organise various activities of stores management?
11. Give the different methods of storing and issue of materials.
12. Differentiate between First In First Out (FIFO) and Last In First Out (LIFO) methods of issuing the materials.

13. Describe the various types of materials storing system.
14. Describe the various types of materials storing system.
15. Describe the suitable methods of record keeping the materials in the stores and various types of stores registers.
16. Give the different methods of valuation of stock and materials.
17. Explain LIFO, FIFO, HIFO and NIFO.
18. Describe different methods of costing the materials.
19. How will you do layout planning of stores?
20. Describe various types of layout of stores.
21. How will you do preservation of materials and protection of stores?
22. How will you do auditing of stores materials?
23. What are the methods used for materials accounting?
24. Describe bin cards and stock identification card.
25. Differentiate between material requisition slip, material return slip and material transfer note.

CHAPTER IV

Standardization, Simplification, Classification, and Coding of Materials

Standardization and Simplification of Materials

Standardization

Setting up standards for quality, quantity, sizes, performance, service and materials of any product made for consumer and the process used in any industrial organization is called standardization. Standardization helps in evaluating the quality performance and value of a product, process or service. The International Organization for Standards (ISO) is set up for standardization of any product or process of any organization. According to ISO, ISO 9000 is the process for registration for quality standards internationally accepted to produce standard items. This is developed in Europe in 1987. The ISO 9000 criteria are recognized as the required quality standards for the European Union (EU) and many other parts of global market place have adopted these standards including India. It has some limitations. The criteria address only standards related to the quality assurance, which include variables related to process control, design, documentation, supplier control and assessment. They provide an indicator that the supplier has complied with process requirements. There is no way guarantee that the supplier produces quality products or services that actually meet customer requirements. Registration ensures that a quality system is in place but provides no absolute measures of quality results or customer satisfaction. Therefore, ISO has completely modified ISO 9000 process in 2001.

Dr. Walter A. Shewhart first introduced quality control technique to be used in industry through statistical method called SQC (Statistical Quality Control) technique. Standardization and quality control go hand in hand.

The quality control is necessary in various manufacturing stages including design of product. The product quality will be established by

1. quality at design of product stage.
2. quality at the production stage.
3. quality in the function and performance of the product.

The standardization of product is also done at all these stages. The close tolerances in the design stage are for better design but may not be economic to produce. The standardization

selects the tolerance values accepted in economic production process. The requirement of customer is also the factor considered in standardizing the product.

There are no written and acceptable standards but customer creates them. Large-scale consumption of products leads to mass production and standardization sets the quality in mass production of products and interchangeability of parts. Statistical quality control techniques are used for controlling the quality performance of mass production items and set the standards of sizes, types, dimensions, operational characteristics and life of products.

ISO 9000 consists of series of process quality standards but not the product quality standards. The product quality is a result of process quality. ISO 9000 is a series of standards ISO 9001, ISO 9002, ISO 9003 and ISO 9004. ISO 9000 simply provides guidelines for using ISO standards. ISO 9004 is an internal quality management document that provides help in implementing ISO 9001 through ISO 9003. ISO 9003 is least restrictive of the three primary standards requiring conformance only to final inspection and test standards within a production environment ISO 9002 requiring the same standards as ISO 9003, also includes standard requirements for purchasing, production and installation capabilities. ISO 9001, which requires every thing that ISO 9003 and ISO 9002, requires. It also includes standard requirements to ensure conformance in design and servicing a full range of manufacturing and support activities. The Total Quality Management (TQM) concept is followed by ISO 9000 which describes and defines the fundamental nature of work process necessary for an organization. It is a critical first step in implementing TQM system in the organization and recognizes discrepancies between what employees are doing and what the documentation stage is being done. It helps in removing discrepancies of employee's action, documentation and re-engineering the process.

Suppliers can have many benefits from pursuing ISO registration and customers are also benefited to buy ISO certified products. Since ISO 9000 is accepted as a common standard of quality assurance, it has been adopted by various industries in India and other countries like USA and European countries for their production.

Aims of Standardization

(*i*) In order to manufacture standard products all the tools, equipments, materials and processes used in it should be standardized.

(*ii*) All the machines used for production and operation should be standardized.

(*iii*) To specify quality of the product and maintain it.

(*iv*) Aims of standardization at the International level of marketing is to make and import and export goods and services which are having standards internationally accepted. The cooperation in scientific and technological development is needed for this.

(*v*) The goods produced to sell at national level or locally should also have the quality standards.

(*vi*) To achieve economy in cost, labor and material used in production.

(*vii*) Standardization ensures maximum convenience in use of products by simplification, rationalization and interchangeability of parts and components.

Advantages and Disadvantages of Standardization

Advantages

(*i*) It delivers better quality of products.

(*ii*) Automation in manufacturing makes the product economic to produce.

(*iii*) Reliability and performance of product is improved.

(*iv*) Overall economy can be obtained in production.

(*v*) It makes purchasing easy and selection of materials of particular specification and availability is ensured.

(*vi*) Management of production is easily controlled and higher efficiency can be achieved.

(*vii*) Customer satisfaction improves.

Disadvantages

(*i*) The cost may sometimes be increased in adopting standardization and manufacturing quality products.

(*ii*) Sometimes more rejection may be there because of lack of maintenance in highly mass producing companies.

(*iii*) There may be restriction to freedom of choice.

(*iv*) If the customer-demanded items are produced, it is difficult to standardize the choice.

Scope and Area of Standardization

The scope and area of standardization is very large. All types of business and commodities need standardization. The standard things are valued more and are reliable.

Standardization of Materials and Items

The standards of materials, parts, components and any items are referred in terms of definite specifications. They are also used for design of parts as ISI or International Standards. These specifications also define the mechanical, chemical, physical and any other properties and characteristics required for good performance of items. For checking and inspection purposes, these specifications of various properties are required. They also provide uniformity in items. Suppliers and purchaser would be negotiating and making the contracts based on these standard specifications. Those materials and items deviate from these specifications are called *rejected items* and will be send back to supplier by purchaser. The manufacturers are recognized by production of standard parts and specify the names, codes, surface finish, dimensions and other standard spare parts like nut-bolts, screws, bearings, gears, packing and other items giving the specifications approved by Bureau of Indian Standards or other international standard institutions.

Benefits of Standardization to the Organization

1. Purchase department will be benefitted in selecting the standard items supplied by suppliers.

2. The supplier will have large order to supply standard parts and therefore they can be produced economically.
3. Mass production of standard parts ensures their availability in the market.
4. Less inventories of standard parts benefit less investment in them and budget on materials can be better utilized.
5. Repair and maintenance is easier with standard spare parts. They need not to be stored in large amount and for longer time.
6. Company can offer after sales and service in a better way at lower cost.
7. The purchase and store department will have confidence to purchase good-quality items if they order standard materials.
8. Maintaining records of standard items is easy.
9. There is reduction of variety of items.

The standardization reduces variety in manufacturing as well as in inventory of materials. Reducing the variety of manufacturing, the parts reduces capital investment. This is very advantageous to small-scale manufacturers. The different small-scale manufacturers can produce different standard parts at much cheaper cost for the requirement of making standard machines or components for large industrial organization. The large organizations will have continuous supply of standard parts from these small manufacturing units or ancillaries. Thus, the system can operate on Just-in-Time manufacturing principle.

The classification and codification will be easier if standard items are carried in inventory. The inventories will be reduced to great extent. For example, there are large varieties of paints of different colors are available in the market. If the colors of the product are standardized the variety of paints to be purchased and stored will be reduced and quality paints can be used in painting the parts.

Classification of Standardization

The various products and services are classified according to their standards. His classification of standards can be as follows.

(*i*) Material standards: The raw materials used in production are standardized for their quality and characteristics.

(*ii*) Parts standards: They are standardized for their physical characteristics and performance. They are known for their technical specifications.

(*iii*) Equipment standards: If the parts and components used to make the particular equipment are standardized, the equipment made by them will also be a standard product.

(*iv*) Process standards: The various manufacturing methods and operations are standardized for economy in production and making them efficient.

(*v*) Safety standards: They are the rules and regulations formed to operate the machines and prevent any accidents. They are for the safety of human beings and other things in the organization. The safety standards and rules must be followed very strictly in every organization for the benefit of all.

(*vi*) Office standards: The administration work in the offices is also standardized to follow prescribed office procedures to avoid delays in work and to properly control it by the authority.

Levels of Standards

The standards adopted for various things are also different and their level depends upon their use. About five different levels of standards are used in routine operations.

(*i*) Individual standards: It is laid down by the individual person, builder, corporate body or a Government department for their own specific purchases or work, such as furniture house building, fabrication or road construction.

(*ii*) Company standards: It is prepared by various departments of a company together to carry out their work or purchase of various items in the company.

(*iii*) Industry standards: The trading association or industrial professional bodies prepare the standards for common interest of a group of industries or trading organizations for marketing their products are called Industry Standards. They have common agreement to produce these standard products to deliver to customers.

(*iv*) National standards: The National Standard Organization establishes the National Standards. It may be Government department or recognized by the Government. This organization in India is called Indian Standard Institution (ISI) or Bureau of Indian Standards.

(*v*) International standards: Those countries who are co-operating in international trade imports and exports of goods amongst each other are using international standards like ISO 9000. They have an agreement to purchase and sell their products manufactured in that country as per international standards.

Simplification

Variety reduction using standardization leads to simplification. It means elimination of unnecessary things not essential for functioning an equipment, elimination of variety of items used for a particular purpose and making and using few standard products.

The simplification brings economy in manufacture by reducing inventory and variety in materials and operations. It is beneficial to manufacturer, businessman and customer all together.

Advantages of Simplification

The advantages of simplification by reducing the complexity in the product and in its manufacturing processes and reducing the number of different products produced of some type are obtained by manufacturers, traders and users.

(i) Advantages to Manufacturer

1. In elimination of manufacturing those products, which are not profitable.
2. In reducing variety of products, their size and types reduces the complexity in manufacturing processes.
3. If variety is less, large lots of same product are produced using special types of machine tools.

4. Manufacturing cost is reduced by reducing the production of variety of products.
5. Inventories are reduced and capital involved in storing large variety of items can be used for increasing plant capacity.
6. Quality of less variety of products can be improved by using precision methods of manufacturing.
7. Technology improvement is possible.
8. Training of workers is easy. Skilled workers produce less variety of items more efficiently and productively.
9. There will be less wastages, obsolescence and scrap.
10. Manufacturing cost is reduced by reducing variety in products.
11. Better market control and prompt delivery of products is achieved by increased production.

(ii) Advantages to Traders and Businessman

1. Less variety of items are to be kept by traders.
2. Less money is inversted by businessmen in one type of product. They can sell more number of products and different products.
3. Selling becomes easy if variety of products is less.
4. As selling expenses are reduced in keeping less variety of products and less handling expenses, profit of the traders will be increased.
5. Large show rooms will not be required and storage spaces will also be reduced.
6. Stores records, accounting and office work will be less.

(iii) Advantages to Consumers

1. Standard and simplified products are available at cheaper rates.
2. Good quality products will be available.
3. After sales service given by supplier will be better and repair cost will be less.
4. Reliability and performance of standard and simplified products are also high.

Difference between Simplification and Standardization

This difference is given below:

(*i*) Standardization means setting up standard measurements in the form of specification for the size and shape of the product and defining performance of it as quality, reliability, functionality of product produced by standard operations and methods.

(*ii*) Simplification means reducing the complexity and variety in manufacturing types of products and stopping the production of non-saleable items.

Because of reducing sales of large variety of watches made by HMT, they have simplified their production to produce less models of watches at reduced cost. The Philips company is making the standard electrical and electronic items at higher cost compared to locally made or imported items. Though these non-standard items are available at cheaper cost but their

life will be less. The imported equipments if fail, their spare parts will not be available at cheaper cost. They will also be not available so easily to repair them.

Rationalization

Rationalization is the method to eliminate waste of materials and reduce the labor using scientific technique of simplification of operations of manufacturing, improvement in transportation systems, standardization of materials and products.

Many industries in Japan, England and Germany adopted rationalization. Rationalization first started in Germany after First World War. It removes all the duplication work and loss of economy by removing wastages, inefficiencies and variety of production.

Adopting the Following will do the Rationalization

(*i*) Simplification: It will rationalize any industry by making the few types of products more efficiently and profitably.

(*ii*) Intensification: Identifying the existing operations, machines and labor work to increase production. Utilizing all the resources fully without any wastage. Running the machines at higher speeds thereby increasing production. Working the employees for larger time will intensify the existing capacity to produce more at a lesser cost. This is called rationalization.

(*iii*) Automation: Adoption of automation increases production and reduces its cost. Large-scale production in any industry will be possible by adopting automation and mechanization of machines. It increases productivity and profitability. Rationalization can be achieved by automation.

(*iv*) Standardization: Adopting standardization in production and reducing variety rationalization is achieved. Using standard materials, processes, machines and efficient employees will produce the standard quality products. It eliminates wastage of materials, labor and utilizes time and all other resources. This is called Rationalization in industries.

There are several advantages of rationalization. They are standard quality production, better utilization of resources, reduction in cost and incentives to workers for getting better wages. There are also some disadvantages of rationalization for those industries, which cannot afford to adopt modernization and automation. If the industries cannot stand in competition to sell their products at cheaper rate, they will not survive. The unemployment may be there because of automation. Excess production will create difficulty for small industries to sell their production.

In India, it is difficult to adopt rationalization because of the changes and investments the industries have to make and unemployment problems faced critically. It will be done gradually as compared to other countries.

Classification and Codification

All the industries and other organizations require different type of materials, goods and items for manufacturing the products and providing the various types of services to their customers. These materials and goods are to be identified by the purchase and stores

department for supply to the various facilities of production and other departments in the organization so that materials management can function most efficiently. In order to identify, supply and store all the materials and goods properly, the classification and coding them systematically is essential part of materials management. Using proper methods of classification and coding the materials helps all the departments in locating, requisitioning and handling them in the organization. It also helps materials management people to select proper suppliers to purchase the proper materials at appropriate time.

Classification of Materials

The materials can be classified in different ways as given below.

(*a*) Those materials and parts that are used as direct materials for production. They are raw materials, parts, semi-processed materials, components, sub-assemblies, assemblies, spare parts and finished products.

(*b*) The other type of materials will be indirect material used to support the production systems. They will be tools used for machining like cutting tools for lathe, milling cutters, drills, hand tools as files, hammers and measuring tools.

(*c*) Jigs, fixtures and various types of dies and equipments used to hold the jobs and tools required for production work.

(*d*) There can be several type of supporting materials required for different purposes in manufacturing as mechanical, electrical and electronic processes. The example is various types of nut-bolts, screws, washers, wires, electrical fittings, resistors, capacitors, printed circuit boards and bulbs etc.

(*e*) Various types of chemicals, lubricants, binding materials, paints, packing materials, coolants, oils, fuels, cotton waste, cleaning materials, grease protecting materials and washing materials etc.

(*f*) The office materials, paper, stationary and computer materials like floppies, printers, CDs, laboratory materials and inspection and checking items can be classified in separate categories.

The various types of materials and items as stated above can be placed in separate categories, groups and subgroups depending upon their nature and use.

Advantages of Classification of Materials

(*i*) The various departments can prepare their requisitions giving the proper identification number and codes to their requirements.

(*ii*) Stores department will separate all the requisitions and put the materials in a group to prepare purchase orders.

(*iii*) The purchase orders will be further scrutinized by the purchase department after separating the various categories of materials so that the tenders and quotations will be prepared for selecting the suppliers of a particular group of materials and items.

(*iv*) The classification and coding is very helpful when materials are purchased and received in the receipt section of stores for correct identification of them as per purchase orders to verify them.

(*v*) Inventory of materials will be easily located, recorded and stored if properly classified. The bin cards and stock cards can be grouped according to particular group of materials. Inventory control of items becomes easy when they are classified in particular category. Materials can be kept in stores according to their category. Their classification and code numbers will do receipts and issues of materials and their entry in stock registers.

(*vi*) The classification of materials is very useful for accounting purposes. The allocation of funds and budgets for different categories of materials are separately prepared.

The different organizations classify and code their materials required differently. They prepare the manuals and catalogues when they use different coding systems. These manuals and catalogue contain various information about the materials used, such as code number, name, use, characteristics, prices, suppliers and manufacturers names and addresses. Materials management department also keeps the different catalogues, manuals, journals of various categories of materials of other firms and suppliers to facilitate in purchasing them.

Codification

The code numbers can identify the various materials used in any organization. The codification is defined as giving a symbol or a numerical code to a particular item. This number or symbol is the unique code number of the item. After classification of different items in the store in to sub-groups and groups according to their characteristics and use for exact identification of that material or item a code is allotted. This code can be a number or symbol consisting alphabets and numbers together.

For example, the blue color for painting iron parts is used and its code number can be Pb2054.

The suppliers or manufacturers also use their trade names and numbers for the items, which they sell. But these trade names or brand names of companies are many a time confusing. They supply various items in the trade names.

For example, Bajaj company sell large variety of goods by its trade name and symbol.

Therefore, to avoid the confusion and to purchase, store and supply to production department a specific item of required quality and characteristics the materials management identify every item by a unique code. All the organizations follow some method of standard coding system. There are different types of coding systems used to suit different firms depending upon the type of materials they are using and selling. Whichever method is used for coding, it should be flexible and simple to adopt. It should not be confusing.

Advantages of Codification

The systematic coding has number of advantages for purchase, stores and production department. It is the part of materials management activity.

(*i*) The long names and description of items need not to be repeated every time when an item is referred by code.

(*ii*) It helps in accurate identification of a particular item.

(*iii*) Duplication of material is avoided.

(*iv*) It helps in standardization of materials and products and reduces variety of them.

(*v*) The storing of materials, sorting and documentation becomes easier.

(*vi*) It helps in location of materials.

(*vii*) It helps in accounting and costing.

(*viii*) It is useful for purchase department to select suppliers.

(*ix*) It is useful for communication of information about materials.

Disadvantages of Codification

(*i*) The mistakes may be there in writing codes and it is difficult to find out correct codes.

(*ii*) Codes may be misunderstood.

(*iii*) When large number of codes is used for different materials, there may be confusion and it may be difficult to locate the materials without knowing the codes.

Stores Vocabulary

When large number of materials have been given codes, it becomes difficult to remember them. For easy reference, the organization is publishing the codes and names of materials in books. This publication is called Stores Vocabulary. The stores vocabulary may be published in number of volumes of books when large number of materials are required in the organization. Number of volumes of books may be categorized depending upon group of materials required in the organization.

For example, in the Railways, the categories of materials required are in lakhs.

System of Codification Used

The various types of systems of codification used in the materials management are as follows.

(*i*) Numerical system

(*ii*) Alphabetical system

(*iii*) Mnemonic system

(*iv*) Alpha-numeric system

(*v*) Decimal system

(*vi*) Color codification

(*vii*) Kodak system

(*viii*) Brisch system

(*i*) Numerical system: The numerical system of codification uses only numbers as codes of various materials kept in the stores. It is a simple method and most of the organizations use this system of codification. It is also easily understood.

To represent different groups of items, simple numbers are used. The block numbers are used to represent materials belonging to each of these items as sub-groups and a dash (-) or stroke (/) symbol is used in between the numbers to represent particular material in the sub-group.

Simple number: Either one number 0 to 9 is allotted to each item of a group. If total items in a group are more than 10, then two numbers 00 to 99 are allotted and so on.

Block number: The material of same characteristics or having similarities are sub-grouped as one item. These materials of sub-groups will be coded as block number. The block can be of three or more numbers for example 1–1000 or 1001–2000 etc.

Symbol Dash (-) or stroke (/): It is used in between numbers to represent the material belonging to sub-group. These various methods of numerical system of codification are given below.

Items	*Simple number*	*Block number*	*Dash or Stroke number*
Raw materials	0	1 – 100	
Cutting tools	1	101 – 150	
Metals	2	151 – 200	
Packing materials	3	201 – 300	
Stationary	4	301 – 500	
Fittings	5	501 – 600	
Electric parts	6	601 – 700	
Tools	7	701 - 800	
Fixtures	8	801 - 900	
Finished products	9	901 - 999	
Raw materials			
Wood	0	1 – 10	0 – 001
Teak wood	0	1	0 – 001/1
Plywood	0	2	0 – 001/2
Cutting tools	1	101 – 150	
Lathe tools	1	101	1 – 001/1
Milling cutters	1	102	1 – 102/2
Drill bits	1	103	1 – 103/6
Reamers	1	104	1 – 104/8
Metals	2	151- 200	
Cast iron	2	151 – 160	0 – 151
Grey cast iron	2	152	0 – 152/1
Malleable cast iron	2	153	0 – 153/2
Electric parts	6	601 – 700	
PVC wires	6	601	
Cable wires	6	605	
Bulbs 40 watt	6	610	

(*ii*) Alphabetical system: In alphabetical system the 'Alphabets' are used as symbols or codes to identify the items of stores. Group of items according to their nature and use are allotted an alphabetical starting code and other alphabets are used to identify exact items. This is shown individually below.

Item	*Code*
Raw material	A
Wood	B
Plastics	C
Paints	D
Greases	E
Varnishes	F

This system will be suitable when the number of items in the store will be less. While coding by alphabets, the duplication of symbols should be avoided.

(*iii*) Mnemonic system: This coding system also uses alphabets but the group of items according to their nature and use are allotted an alphabetical starting code from their names and other alphabets are used to identify exact item. This is given below. Use of starting alphabets as codes helps in memorizing the codes.

Groups	*Items*	*Codes*
Raw materials		RM
	Wood	RM – WD
	Plastic	RM – PL
	Paints	RM – PA
	Greases	RM – GR
	Varnishes	RM – V
Fittings		FT
	Nut-Bolts	FT – NB
	Screws	FT – SC
	Washers	FT – WA
	Keys	FT – KY
	Pins	FT – PN

(*iv*) Alpha-numeric system: The alphabets and numbers together are used in this system of coding. The group of items is coded by alphabets and subgroups and items of these groups are coded by numbers to identify the exact item. This system has advantage of both alphabetic and numeric system. The numbers used also give specifications like size, length, breadth, thickness, height, volume and weight etc. Alpha-numeric coding is given below:

Group	*Items*	*Specifications*	*Code*
Raw materials of furniture	Wood	Various sizes	RM-WD-1-100
	Steel	Various sections	RM-ST - !01-150
	Plywood	Different type	RM-PL-151-200
	Sunmica sheets	Different sizes	RM-SM-201-250
	Plastics	Different sizes	RM-PT-251-300
	Rubber	Different parts	RM-RB-301-350

(*v*) Decimal system: This system of codification is similar to numeric system. In this system, 10 units of decimal numbers 0-9 are used. Some significance is attached to every digit. Normally 7-8 digits are sufficient to give all characteristics of items. For example, first, second and third digits give class, group and sub-group of items. Fourth to eighth digits specify type, size, grade, shape and condition. The number before the decimal point represents sub-assembly or class of items. One digit coding system is given below:

	Class	Group	Subgroup	Type	Size	Grade	Shape	Condition
Digits	0	1	2	3	4	5	6	7

One-digit decimal system

If for any particular class characteristics more than 10 sub divisions are required then one digit decimal system can be substituted by two-digit decimal system. For example, for type, size and grade, more than 10 divisions are required then decimal is used after every two digits for type, size and grade to codify 100 items in each from 00-99 as shown below:

	Class	Group	Subgroup	Type	Size	Grade	Shape	Condition
Digits	0	1	2 .	00	11	2	3	4

Two-digit decimal system

The decimal codification system is flexible to extend it but becomes complicated by using decimal points at various places. If the decimal point is wrongly inserted or omitted in the code, the whole system will give wrong codes and confusion will create for other departments. Therefore, it is necessary to put decimal at correct place by understanding its significance by stores person. The example of decimal codification for cycle-wheel assembly is given below:

Cycle wheel assembly	16
Rim	16.01
Tire	16.02
Tube	16.03
Valve	16.04
Hub	16.05
Spokes	16.06

(*vi*) Color codification: Along with the numbers used for coding the materials and parts, they are also marked by colors to identify them physically. Many a time in counting the similar items and separating them color-coding will be very helpful. Color-coding easily identifies small parts. The various cables and wires of different colors are used in electrical fittings to identify their polarities. Color codes are also used in foundries to identify different patterns and metals.

Pattern colors: There is no universally-accepted standard for representing the pattern surfaces by different colors. The practice varies with different countries and sometimes with different manufacturers in the same country. The practice followed for color codes for pattern surfaces and core boxes are given below.

1. Red: Surface to be machined
2. Black: Surface to be left unmachined
3. Yellow: Core prints
4. Red strips on Yellow base: Seats for loose pieces
5. Black Strip on Yellow base: Stop offs
6. Clear or no color: Parting surface

(*vii*) Kodak system: Kodak system of coding is developed by Eastman Kodak Company of New York, U.S.A. It is a numerical system of codification, which uses 10 digits 3-4-3 (XXX-XXXX-XXX). The classification of items in first group is based on purchase category depending upon source of supplies and not on characteristics of items. Alphabets are avoided to facilitate handling on punch card and computer recording. All materials are divided into major classes of 100 basic classification numbering 00-99. This forms first two numbers of the code. Each class is further divided into10 subclasses, arranged alphabetically, this is third digit. Each kind of material in this subclass is assigned two-digit numbers as 00, 10, 20, 30, 40, ……..90. In this way, five digits are assigned. Sixth and seventh digits are for type of materials and eighth and ninth digits are for their sizes. The last tenth digit is to accommodate any minor variation in the items. If there are more types and sizes are to be accommodated, the allocation of digits can be changed without disturbing nearby items.

Kodak system is very flexible and accommodation to absorb ten times any type and ten times any sizes of items is possible. The allotment of digits is given as below:

Class	Subclass	Kinds	Types	Sizes	Minor variations
XX	X	XX	XX	XX	X
			Kodak system		

This will be explained by the following example:-

First step: Preliminary classification

Items	*Codes (first two digits)*
Raw materials	00-10
Parts	11-20
Components and products	21-30
Subassemblies	31-40
Electrical equipments	41-50

Contd...

Items	*Codes (first two digits)*
Mechanical equipments	51-60
Laboratory equipments	61-70
Office stationary and other materials	71-80
Furniture and fixtures	81-90
Miscellaneous items	91-99

Second step: Sub-classification.

Items	*Codes (first two digits)*
Mechanical equipments	51-60
Lathe tools	51
Milling machine tools	52
Drilling tools	53
Shaper tools	54
Hand tools	55
Other cutting tools	56
Jigs	57
Fixtures	58
Abrasives and grinding wheels etc.	59

Third step: In a subclass, further classification is done as follows:

Kinds of tools	*Class*	*Subclass*
Lathe tools	51	
Single-point cutting tool	51	0
Turning tool	51	1
Boring tool	51	2
Threading tool	51	3
Drilling tool	51	4
Knurling tool	51	5
Chamfering tool	51	6
Grooving tool	51	7
Facing tool	51	8
Form tool	51	9

In this way, the classification will be coded up to tenth digit. Size is the important consideration. Kinds and types are assigned as follows.

Digits assigned to kinds	*Digits assigned to types*
510 – XX XX – XXX	510 – XXXX – XXX
510 – 00 XX – XXX	510 – 0 0 0 0 – XXX
510 – 10 XX – XXX	510 – 0 0 1 0 – XXX
510 – 20 XX – XXX	510 – 0 0 2 0 – XXX
510 – 30 XX – XXX	510 – 0 0 3 0 – XXX
510 – 40 XX – XXX	510 – 0 0 4 0 – XXX
– – – –	– – – –
– – – –	– – – –

Eighth and ninth digit will form the size of the item and the tenth digit is for minor variation. For example, the drilling machine drill bit of 5-mm size will be coded as follows:

530 – 1020 – 051

530 for drilling machine general type

10 for kind of drilling machine

20 for vertical type

05 is size of drill and

1 for H.S.S. drill bit

(*viii*) Brisch system: Brisch system used for codification is similar to numerical system where 7 digits numerical code is used to code the items. First of all the items purchased in the organization are divided into various classes as given below:

Items	*Codes*
Raw materials	0
Parts	1
Components and products	2
Subassemblies	3
Electrical equipments	4
Mechanical equipments	5
Laboratory equipments	6
Office stationary and other materials	7
Furniture and fixtures	8
Miscellaneous items	9

The classes or groups of similar items without any overlapping and confusion are further divided into items of similar characteristics.

After classifying materials of similar characteristics they are again sub-divided in to a lower classification as per their size and specifications etc. The objective of this is to use less number of codes to accommodate large variety of items with no ambiguity or confusion. Less than 7 digit code can also be used in Brisch system as per need of codification.

The following code is used for the assembly of a car wheel.

5 3 2 6 0 4 1

Cataloguing: Codification gives code numbers or symbols to items purchased for production and stored in the organization for their identification. Cataloguing is the method of stocking spare parts of various equipments like vehicles, various machines material handling and other equipments. All such items required as spare parts and equipments are listed in the catalogues.

QUESTIONS

1. What is Standardization?
2. Why standardization of materials is necessary?
3. Describe the methods used for standardization.
4. Differentiate between standardization and specification.
5. What do you understand by the term identification of materials?
6. Give the benefits of standardization to the organization.
7. What is simplification and variety reduction?
8. What are the advantages of simplification?
9. Explain Rationalization. Why rationalization is necessary to develop industries in India?
10. Give the classification of materials.
11. Define codification of materials.
12. Name the types of methods used for codification and discuss them.
13. Give the advantages of classification of materials.
14. Give the advantages of codification of materials.
15. Discuss the Numerical and Alphabetical methods of codification.
16. Describe Kodak system of codification.

CHAPTER V

Forecasting

Introduction

Every organization needs the market for selling their product or services. These sales depend on demand. The demand for a product or service depends upon customer requirements and needs and it can change. The organization has to plan its production according to these changes and fluctuations of demand in the market. The estimate of demand for sales of a product or service will be based on previous record and present trend.

Forecasting is the method of accurate determination of these demands of sales. It estimates the quantity of production on the basis of forecasted demand. It involves past and present data and after its analysis, the management is able to forecast the future requirements and decides the quantity and capacity of production and operations. The schedules are prepared on these production plans and the raw materials. Parts and components are purchased and stored accordingly. The method used for forecasting must be able to accurately give the values of demand and sales of company so that there will not be greater fluctuations or deviations of sales from these forecasted values. It is therefore necessary to analyze the demands and sales of a product of a company based on market using some of the methods of forecasting continuously and use one which forecasts to a correct decision.

Forecasting not only plans the quantity of production and sales but also is necessary to plan material requirements, schedule of production, operations and manpower etc.

Sales Forecasting and Estimating

The estimation of future sales of a product manufactured by an industrial organization will be done on the basis of present and past data of the sales of the product. This estimation is done using the mathematical techniques called *sales forecasting*. They are used for future planning of production, inventories and other resources of the organization so that full capacity utilization of resources is possible.

The purpose of sales forecasting and data analysis for future estimation of sales are:

1. To take decisions on production quantity and volume.
2. To gather information about demands for different products.
3. It is a starting point for budgeting.
4. The inventory policy is affected by sales forecast.

5. It is required to plan for the future of the plant as a whole.
6. To know the future trends in product development.
7. The pricing policy may also be affected by market research.
8. The results of market research is useful for the purpose of sales control and evaluating sales progress.

It is always asked 'Is forecasting a Black Art?' and what restricts consumption?

The answer is:

(*i*) The product and its limitations.

(*ii*) The consumer and his potential buying power.

(*iii*) Competition, value and utilities.

(*iv*) Saturation.

(*v*) Distribution and promotion.

(*vi*) State of business.

(i) The product and its Limitations

The development of the product by simplification, standardization, quality control of materials and operations will improve its sales.

(ii) The Consumer and his Potential Buying Power

The consumer and his potential buying power depends on the earnings and overall development of the nation, industrialization and employment situations. It will decide about type of consumer and his opinion, attitude and taste about purchases based on his buying power.

(iii) Competitions, Value and Utilities

Analysis of competition is based on value and utility of a product that how it is competing for a share in the market. Whether it has direct competition with similar products or indirect competition with other products or services. The ratio of its utility to price is to be found out.

(iv) Saturation

The law of diminishing utility states that beyond a certain rise in consumption of an item demand tends to decrease as the supply increases. Selling to satisfy demand after saturation changes in the product sales which indicates introducing new product or variety to avoid monopoly.

(v) Distribution and Promotion Methods

The fast and timely distribution of products at the time of high demand is necessary to promote sales. Effectiveness of distribution, advertising, other sales promotion techniques and better terms of sales benefit the producers and businessmen.

(vi) State of Business

Pricing policies, service facilities and customer approach is always helping in the business.

The future expansion and development of the organization is also depends on this. The type of forecasting used for this is as follows.

Types of Forecasting

1. Short-term forecasting
2. Long-term forecasting

1. Short-Term Forecasting

When the sales forecasting is done for three months to one year, it is called short-term forecasting. Some of the items like perishable materials, vegetables, food products and some of the consumer items are forecasted daily, weekly or monthly. The demands of these products fluctuate in short period of time.

Benefits of Short-Term Forecasting

(*i*) The fluctuating demands in short periods will be predicted and the inventories of materials have to be kept to meet these fluctuations.

(*ii*) Reduce the investment on cost of large amount of materials and to machines.

(*iii*) To arrange the finances and control the cost.

(*iv*) To decide the short-term sales.

2. Long-Term Forecasting

When the sales forecasting is done for long period of time such as five years or more than five years, it is called long-term forecasting. For construction of buildings and plants of large manufacturing organization and large project works of Government, the long-term forecasting is done. Military organizations, satellites launching, ship building, railways construction and petroleum refineries works use long-term forecasting.

Benefits of Long-term Forecasting

(*i*) The future developments and expansion programs are based on long-term forecasting.

(*ii*) For economic development of rural and other areas where industrial activities are less, the long-term planning and forecasting is necessary.

(*iii*) To meet long-term financial requirements of large manufacturing organization, long-term forecasting is used.

Applications of Sales Forecasts

The various uses of forecasts are:

(*i*) To acquaint with the market trends and fluctuations, it is necessary to know the sales forecasts from market data.

(*ii*) The E-business and marketing today provide current information about the sales data of different products. This influences the current sales of every firm. The forecast of every firm should be based on this.

(*iii*) Sales forecasting is used for financial budgeting and estimating the sales resources required for it.

(*iv*) The various items have fluctuating demands, which depend upon market conditions, seasonal variations and customer requirements. They may be short-term variations and long-term variations. To adjust the production of items to suit this fluctuation which will only be known by proper forecasting.

(*v*) Sales forecasting helps in using proper sales promotion techniques for those items, which are having less sell. It saves selling cost through proper advertisement.

(*vi*) Forecasting of price fluctuations controls the inventory and stores to stock the various items at proper time purchased at lowest possible price.

(*vii*) Overstocking and shortages can only be avoided by proper forecasting of production, which helps management to take correct decisions in production planning.

(*viii*) For establishing any new venture in business, sales forecasting is always used for marketing the products and setting the goals and objectives of business

(*ix*) The factors, which are controllable in business, will be analyzed with the help of company's past and present records of sale. Further sale will be forecasted on the basis of this analysis. This will co-ordinate all the activities of business.

(*x*) Accurate sales forecasting is a management tool used for development expansion, diversification and profit maximization in their business.

The application of forecasting methods thus helps in marketing and sales promotion, materials management and purchasing, financing and planning various resources of any organization to expand their business and meet the objectives. In order to accomplish this, it is necessary to use various methods of forecasting. Some of these methods are discussed below.

Methods of Forecasting

Since the forecasting is the basis for planning the production for sales and future expansion of the business, the various methods of predicting the demand of various products in the market and its share, the organization can use different methods of forecasting available to analyze the past records and future trends.

To use the proper method of forecasting, the experience and good judgment is necessary about market and trend of business. This is to be supplemented with the scientific and mathematical models of forecasting techniques, which gives the proper results of statistical data. The use of computers and the software of forecasting methods is helping to get these results quickly and accurately to predict the future sales. The forecasting will be used for the new product for a company, which is just launching its product. The methods, which will be used, for these types of product to forecast its demand will be based on market surveys or old data if available for similar type of product. The forecasting is also used for the products, which are already in demand, and the company will be developing to enhance the production.

The methods used for forecasting the new products are:

(1) Survey of customers

(2) Comparisons with existing products in demand

(3) Market research

(4) Market trials through sales agencies.

The methods used for forecasting the existing established products whose demands are already there in the market and they can also be used for new products as well are:

(1) Time series analysis

(2) Trend analysis

(3) Opinion-based method

(4) Causal method

(5) Market research

Planning is done with foresight and action to see that things come out to be true happenings. Forecasting techniques and methods selected for planning must be such as to make it as accurate as needed. The various methods given above are discussed as follows.

(1) Survey of Customers

This method is used for development of new products. There are two types of surveys can be done to know the requirements of customers.

(i) Direct Survey Method

In this method, the customers are directly approached to know what they want to buy in near future and how much.

The sample survey of customers is done from different areas to know their liking. Taking into consideration the various factors like economic conditions, social, religious and habitual aspects of purchasing. This method has some of the advantages as follows.

(*a*) Buyers liking may be irregular and changing.

(*b*) The customers may not be able to select the particular thing properly from various alternatives. They may have more than one choices.

(*c*) Economics and other factors will not allow the customers to buy the things of their choice.

(ii) Indirect Survey Method

The customer's purchasing habits and choices will be obtained from the market retail and wholesale shops. Sales representatives and agents. This method will give the actual sales of particular type of products in the market and customer requirements.

(2) Comparisons with Existing Products in Demand

If the new product is to be developed and launched for sale in the market, it should be compared with the existing established product of similar type. In competitive way, through advertisement and sales promotion it can be substituted by customers for their use provided that its price may be less and more attractive.

The role of salesman is very important in this method as he has better knowledge about customers' liking.

(3) Market Research

The various market conditions, political, social and economic environment are studied for product design and development. The various factors, which are to be considered to promote the sales of new product, are analyzed from the data available from the market and then the product is manufactured to suit the customers of different markets.

(4) Market Trials Through Sales Agencies

How the customers prefer a particular product to buy and use will be tried through the trials from some sales agencies or directly supplying the new product to customers. Gradually if the sales increase, the product will be manufactured in more quantity.

The salesman's estimate from his area is better in his opinion to sell that product and it may be launched.

For new product, all such trials from various areas are collected and the final estimates are analyzed. For the products, which are already established for that also, the salesman estimates are revised to consider the following factors in future sales:

(*i*) Design changes required in the product.

(*ii*) Changes in the prices because of design changes , material changes and improved processes used to manufacture the product.

(*iii*) Techniques used for forecasting are projecting the future based on the past historical data and they are also called *projection methods of forecasting,* for established products the time series analysis is useful. It may be used for new products as well if available data are limited. All other methods given above can also be used for forecasting the existing established products as well.

(1) Time Series Analysis

Time series analysis is based on historical data for demand changes with respect to time. Demand is expressed as a series of data, which varies with time. The time series analysis is basically divided into two methods as given below:

(*i*) Smoothing methods

(*ii*) Decomposition methods

In time series analysis, the data of sales in units, quantities or rupees are available as dependable variable with respect to time, daily, weekly, monthly or yearly.

The factors, which affect the demand variations, are:

(1) Random changes

(2) Trend

(3) Seasonality

(4) Cyclic changes

Seasonal variations are short-term variations but its effect is more than cyclic variations. Cyclic variations are long-term oscillations about a trend line. Trend line will have to be drawn for long-period variations. There is no method to know about random variations. They may be referred to as noise, residual and irregular in terms of statistical techniques of forecasting. For long-period variations to forecast the demand, the following points are taken into consideration.

(*i*) New sales promotion methods, advertisements and competitive strategies adopted,

(*ii*) Better economic environment may be created due to employment.

(*iii*) Increased population needs more supply of goods but it reduces purchasing capacity of people.

There are several techniques used in time series analysis of forecasting. They are discussed below:

(*i*) Smoothing Methods

This method removes the random factors, which changes the demand by using weight age to smooth out the past series of data over time. The trends are projected by appropriately correcting the data. The seasonal changes are properly determined.

(1) Moving Average Method

The different techniques used are:

(*i*) Simple average technique

(*ii*) n-period moving average technique

(*iii*) Weighted n-period moving average technique

(2) Exponential Smoothing Method

(3) Least Square Method

(*ii*) *Decomposition Methods*

Each component of time series, which changes the demand randomness, trend, seasonality and cycle, is broken in separate factor and multiplying it separately to demand changes.

In smoothing method, the single pattern of demand in every period is considered, while in decomposition method, each component of demand is taken and they are all assembled together. The effect of variation of demand is considered for the following two types of changes.

1. Long-period variations
2. Short-period variations.

The experience of salesman, sales manager and sales executives for sales forecasting is very necessary particularly for new products. The following methods of forecasting using mathematical and statistical month-wise or year-wise changes are analyzed.

The various methods used to forecast the demand of sales are given below.

(1) Moving Average Method

(*i*) *Simple Average Technique*

The simple arithmetic average of a set of observed values of sales for n-period is calculated and it is used as forecast for the n+1th period in the immediate future.

The average demand for *n* period is = D_{avg}

$$D_{avg} = \frac{D_1 + D_2 + D_3 + \cdots\cdots + D_n}{n}$$

Forecast for n+1 period is $F_n+1 = D_{avg}$

Standard deviation $\quad S.d. = \frac{(D_{avg} - D_x)^2}{n}$

(ii) n-period Moving Average Technique

The forecast for a particular period mostly depends on some near past values. The old data mostly do not predict the proper forecast for n+1 period is calculated from previous *n* period average value n-period moving average

$$k = t$$

$$D_{n+1} = \frac{1}{n} \sum Dk$$

$$k = t - n + 1$$

i.e., $D_{n+1} = \frac{D_1 + D_2 + D_3 + \cdots\cdots + D_n}{n}$; where k = 1 to n

If one-year data are available then 1 to 6 months moving average will be used for 7th month, 2 to 7 months moving average is used for 8th month and so on.

$$D_7 = \frac{D_1 + D_2 + D_3 + D_4 + D_5 + D_6}{6}$$

$$D_8 = \frac{D_2 + D_3 + D_4 + D_5 + D_6 + D_7}{6}$$

The number of period selected for moving average depends on

(1) What is forecasted

(2) Characteristics of demand

(iii) Weighted n-period moving average

In this method, different weights are given to different periods as compared to simple moving average where equal weights are given to all the periods.

D_{n+1} = Weighted *n*-period moving average

$D_{n+1} = W_1D_1 + W_2D_2 + \ldots\ldots\ldots\ldots\ldots + W_nD_n$

Or $D_{n+1} = \sum_{k=1}^{k=n} WkDk$

(2) Exponential Smoothing

In the simple exponential smoothing method, only forecasted and actual demand of current month is necessary to forecast the demand for next period. Forecasted demand for n+1 period will be F_{n+1}.

$$F_{n+1} = LD_n + (1–L)\ F_n$$

where D_n = Actual demand for nth period

F_n = Forecasted demand of n + 1 period

L = Weightage given to current periods actual demand observed, its value varies from 0 to 1.

The disadvantage of moving average method is to store large amount of demand data for number of periods. The exponential smoothing average is same as weighted moving average if (1–L) is multiplied to L in the next period and so on.

$$F_{n+1} = LD_n + L\ (1 - L)\ D_{n-1} + L(1 - L) \times 2D_{n-2} + \ldots\ldots$$

It is important to select the value of *n* from 0.1 to 0.3 provided smaller values of L means less weightage is given to current demand to eliminate random error and large value of L means more weightage is given to current value of demand having less randomness.

Relation between simple moving average forecasting and exponential smoothing forecasting is given by the value of weightage L which can be found as

$L = \frac{2}{n+1}$; Where n is taken as number of periods.

As the weight attached to successive older observations decreases by the constant factor (1-L), the method is called *exponential-smoothing method*.

(3) Least Square Method

In this method, a trend line is fitted which is called the *line of best fit*. This line passes through the points in such a way that the sum of squares of the deviations of the actual points above and below the trend line is minimum. The sum of positive and negative deviations on either side of the line of best fit will be zero. The sum of deviations of various points on either side of the line is equal to zero.

The sum of squares of these deviations will be least and therefore this method is called *least square method of forecasting*.

Its advantages are that this method always gives some results. Trend value can be obtained for all the years. It gives most satisfactory results.

Its disadvantage is that it is not flexible, if more data is added, all the calculations are done again.

A straight line fitted in the least square method is given as

$$Y = a + bX \qquad ...(1)$$

Where Y is the dependent variable of sales in rupees or volume of demand and X is the independent variable in terms of unit of time as day, week, month or year. a and b are unknown constants to be determined from the given data of X and Y.

To determine values of a and b, the equations to be solved are obtained by summing equation (1)

$$\sum Y = na + b\sum X \qquad ....(2)$$

Multiplying X to equation (1) and summing

$$\sum XY = a\sum X + b\sum X^2 \quad ...(3)$$

Where n is number of values of X and Y

$$\sum X\sum Y = na\sum X + b(\sum X)^2 \quad ...(4)$$

$$n\sum XY = na\sum X + nb\sum X^2 \quad ...(5)$$

$$\sum X\sum Y = n\sum XY = b(\sum X)^2 - nb\sum X^2$$

$$b\{(\sum X)^2 - n\sum X^2\} = \sum X\sum Y - n\sum XY$$

$$b = \frac{\sum X\sum Y - n\sum XY}{\{(\sum X)^2 - n\sum X^2\}} \quad ...(6)$$

Substituting this value in (2)

$$\sum Y = na + \frac{\sum X\sum Y - n\sum XY}{\{(\sum X)^2 - n\sum X^2\}}\sum X$$

$$= na + \frac{(\sum X)^2\sum Y - n\sum X\sum XY}{\{(\sum X)^2 - n\sum X^2\}}$$

$$na = \sum Y - \frac{(\sum X)^2\sum Y - n\sum X\sum XY}{\{(\sum X)^2 - n\sum X^2\}}$$

$$na = \frac{Y(\sum X)^2 - n(\sum X)^2\sum Y + n\sum X\sum XY}{\{(\sum X)^2 - n\sum X^2\}}$$

$$a = \frac{\sum X\sum XY - \sum Y\sum X^2}{\{(\sum X)^2 - n\sum X^2\}} \quad ...(7)$$

When deviations are taken from middle value, $\sum X$ will be equal to zero

Substituting this value of $\sum X = 0$

$$a = \frac{\sum Y\sum X^2}{n\sum X^2} = \frac{\sum Y}{n} \qquad b = \frac{n\sum XY}{n\sum X^2} = \frac{\sum XY}{\sum X^2}$$

$$a = \frac{\sum Y}{n} \quad ...(8)$$

$$b = \frac{\sum XY}{\sum X^2} \quad ...(9)$$

This is called *least square method* because the value of deviations of points from the line $Y = a + b X$ is minimum and the constants a and b can also be found out by minimization of these deviations as follows

$$\text{Min } \sum(Y - y)^2 = \text{Min } \sum(a + bx - y)^2$$

Differentiating this with respect to a and b partially and equating them to 0

$$d/da\ \sum(Y - y)^2 = 0 \text{ and } d/db\ \sum(Y - y)^2 = 0 \quad ...(10)$$

$$d/da\ \sum(a + bx - y)^2 = 0 \text{ and } d/db\ \sum(ax + b - y)^2 = 0 \quad ...(11)$$

$$d/da\ \sum(a^2 + b^2x^2 + y^2 + 2abx - 2bxy - 2ay) = 0 \quad ...(12)$$

$$d/db\ \sum(a^2 + b^2x^2 + y^2 + 2abx - 2bxy - 2ay) = 0 \quad ...(13)$$

Solving these differentiations we get

$$\sum(2a + 2bx - 2y) = 0 \quad \text{and} \quad \sum(2bx^2 + 2ax - 2xy) = 0$$

$$an + b\sum x - \sum y = 0 \quad \text{and} \quad b\sum x^2 + \sum x - \sum xy = 0$$

$$a = \frac{\sum y - b\sum x}{n} \quad \text{and} \quad b\sum x^2 + \frac{(\sum y - b\sum x)}{n}\sum x - \sum xy = 0 \qquad ...(14)$$

Solving equation (14) we get the value of a and b as follows

$$a = \frac{\sum X \sum XY - \sum Y \sum X^2}{\{(\sum X)^2 - n\sum X^2\}} \qquad ...(15)$$

$$b = \frac{\sum X \sum Y - n\sum XY}{\{(\sum X)^2 - n\sum X^2\}} \qquad ...(16)$$

Curve fitting is the method of finding linear or non-linear relationship between dependent variable y (demand or sales in forecasting) and *x* is time-dependant variable. It is helpful in causal methods where demand is depending on some factor and also in time series analysis of decomposition method where trend line is obtained for forecasting from demand data.

Two types of curve fitting will be used

1 Straight line using least square method

$$y = ax + b$$

2 Parabola or quadratic curve

$$y = a0 + a1\sum x + a2\sum x^2$$

The equations used for solving the values of a0, a1 and a2 are

$$\sum y = a0 + a1\sum x + a2\sum x^2$$

$$\sum xy = a0\sum x + a1\sum x^2 + a2\sum x^3$$

$$\sum x^2y = a0\sum x^2 + a1\sum x^3 + a2\sum x^4$$

For n values of observations for least square parabola. If origin is taken at the middle of the period $\sum x = 0$ and $\sum x^3 = 0$ then the above equations will become

$$\sum y = a0n + a2\sum x$$

$$\sum xy = a1\sum x^2$$

$$\sum x^2y = a0\sum x^2 + a2\sum x^4$$

(ii) Decomposition Method

The variation of demand can be based on trend, cyclic, seasonal and random variations.

The demand can be broken down into these components and it can be determined as the product of these four factors as

$$D = T \times C \times S \times R$$

where D = Demand

T = Trend variation

C = Cyclic variation

S = Seasonal variation

R = Randomness

Trend Variation

The long-period demand either increases or decreases according to some linear or non-linear trend. Linear trend can be simple straight line moving upward or downward or geometric straight-line trend.

A study of company's sales records is indispensable for forecasting if the pattern of sales repeats. To fit a straight line to a given scatter it is called *regression line* and expressed as Y = a + bX. This trend is given in figure below.

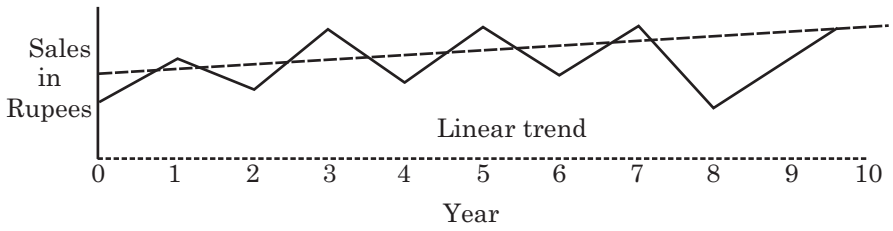


Fig. 1. Sales record linear trend

There can be non-linear trend as shown in Figure below.

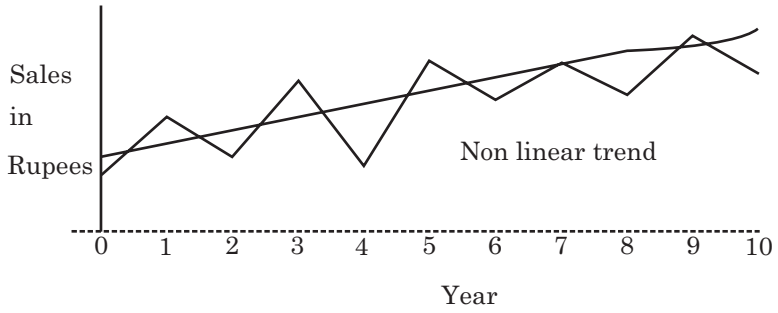


Fig. 2. Sales record non-linear trend

Cyclic Variation

The cyclic variations as an index in decomposition method occur as short-period changes and periodic variations. These variations may be regular or irregular.

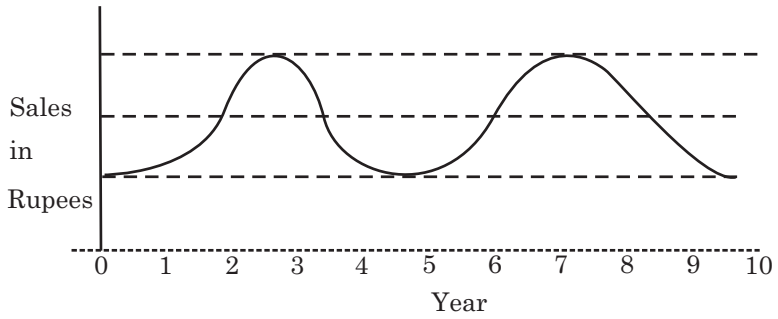
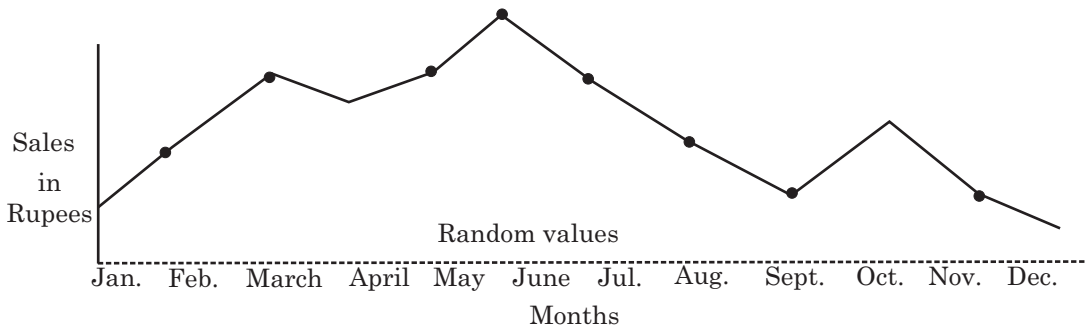


Fig. 3. Cyclic Variation

Seasonal variations

The seasonal variations occur because of changes in climate, such as sales of Icecream and Coolers increase in summer. Umbrella and Raincoats are sold more in rainy season and Woolen clothes are sold more in winter. Normally seasonal variations are periodic and regular but when sudden changes in weather occur, the demand varies abruptly and rises very fast.

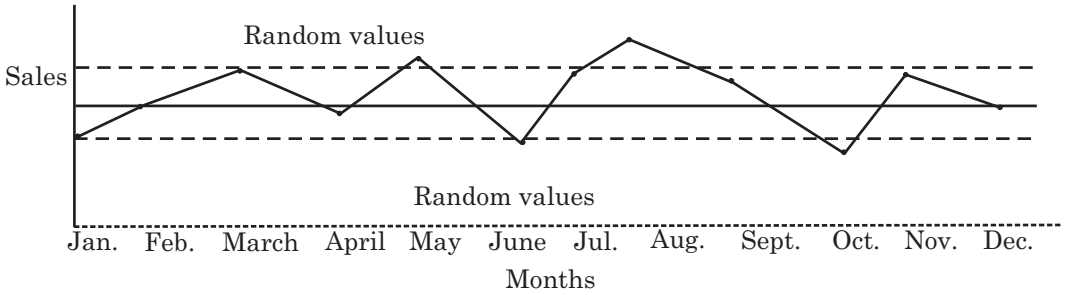


Festival sales increase is just like seasonal increase in demand of particular items.

Diwali, Holi, Christmas and Id festivals increase demand of sweets, clothes, colors, candles and utensils.

Randomness

These variations are erratic and irregular. The random values of demand are eliminated from demand data when large values or small values from average values are removed and new values of average demand are calculated to determine the forecasted demand.



If the large demand data are available, the moving average of those demands are taken whose periods are equal to periods of seasonal cycle.

The ratio of demand to moving average will be

$$\frac{D}{MA} = \frac{T \times C \times S \times R}{T \times C} = S \times R$$

This eliminates seasonality and randomness. The plot of D/S over time reveals the Trend-cum-Cycle.

Time Series Analysis

Smoothing Method and Moving Average Method

Example 1: The monthly sales of scooters in an automobile shop are given below for one year. Find the sales forecast for the first three months in next year using,

(*i*) Simple average method, also find average and standard deviation.

(*ii*) Three months, four months and five months moving average.

(*iii*) Compare them and plot the values.

Month	*Sales*	*Month*	*Sales*
1	12	7	21
2	18	8	42
3	24	9	15
4	28	10	08
5	36	11	20
6	30	12	10

Solution: X_{ave} = Simple average = $1/n \sum X$

$= (12 + 18 + 24 + 28 + 36 + 30 + 21 + 42 + 15 + 8 + 20 + 10)/12$

$= 264/12 = 22$

S.d. = Standard deviation = $\sqrt{(\sum (X_{ave} - X)^2 / n)}$

$= \sqrt{((22-12)^2 + (22-18)^2 + (22-24)^2 + (22-28)^2 + (22-36)^2 + (22-30)^2 + (22-21)^2 + (22-42)^2 + (22-15)^2 + (22-8)^2 + (22-20)^2 + (22-10)^2)/12}$

$= \sqrt{(10^2 + 4^2 + 2^2 + 6^2 + 14^2 + 8^2 + 1^2 + 20^2 + 7^2 + 14^2 + 2^2 + 12^2)/12}$

$= \sqrt{(100 + 16 + 4 + 36 + 196 + 64 + 1 + 400 + 49 + 196 + 4 + 144)/12}$

$= \sum\sqrt{1210/12} = \sqrt{108.3} = 10.08$

Average is = 22 and standard deviation is = 10.08

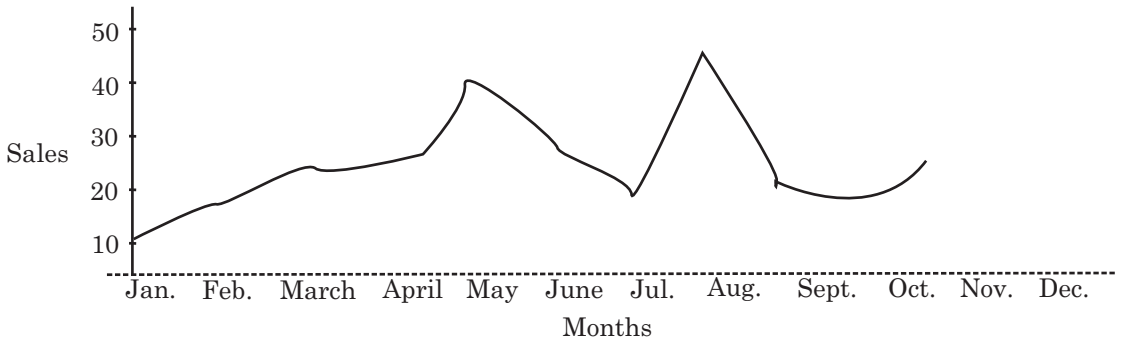
Month	*Sales*	*3 months moving average*	*4 months moving average*	*5 months moving average*
1	12			
2	18			
3	24			
4	28	18		
5	36	23.3	20.5	
6	30	29.3	26.5	23.6
7	21	31.3	29.5	27.2
8	42	29	28.75	27.8

Contd...

Month	*Sales*	*3 Months moving Average*	*4 Months moving Average*	*5 Months moving Average*
9	15	31	32.25	31.4
10	08	26	27	28.8
11	20	21.6	21.5	23.2
12	10	14.3	21.25	21.2
		12.6	13.25	19
		14.8	12.81	14.4
		12.3	14.01	15

Forecast for New Year

Moving averages			
Month	*3 months*	*4 months*	*5 months*
1	13	13	19
2	15	13	14
3	12	14	15



Weighted Moving Average and Exponential Smoothing Methods

Example 2: The fan blades made by a fan manufacturing company for six months in a summer season are as follows:

Months	*Fan blades made*
Feb	428
March	640
April	1025
May	830
June	745
July	582

(*i*) Calculate the forecast for the next year using 4 months moving average

(*ii*) Calculate weighted moving average for next 6 months, Feb to March taking weight ages as 0.1, 0.1, 0.2, 0.2, 0.3, 0.1

(*iii*) Calculate the forecast for next year by using exponential smoothing, taking the value of L for 3, 4 and 5 months

Solution (*i*)

Month	*Fan blades*	*4 months moving average*
Feb.	428	
March	640	
April	1025	
May	830	2923/4 =731
June	745	3240/4 = 810
July	582	3182/4 = 796
		2953/4 = 738

Forecast for next Feb. = 796 and March = 738

Simple average is 4250/6 = 708 fan blades

(*ii*) Weighted moving average

$$D_n = W_1D_1 + W_2D_2 + \ldots\ldots\ldots + W_6D_6$$

$$= .1 \times 426 + .1 \times 640 + .2 \times 1025 + .2 \times 830 + .3 \times 745 + .1 \times 582$$

$$= 42.6 + 64 + 205 + 166 + 223.5 + 58.2$$

$$= 759.5 = 760 \text{ forecast is 760 fan blades}$$

(*iii*) For three months L = 2/*n* +1 = 2/4 = 0.5 for 4 months L = 2/5 =0.4 and for 5 months L = 2/6 = 0.33

Forecast using 3 months period $F_{n+1} = L\ D_n + (1 - L)\ F_n$

$F_{n+1} = .5 \times 582 + .5 \times 719 = 291 + 359.5 = 650.5 = 651$

Simple average $F_{n+1} = .5 \times 582 + .5 \times 708.3 = 291 + 354 = 645$

Using 4-months period

$F_{n+1} = .4 \times 582 + .6 \times 796.8 = 232.8 + 478.08 = 710.88 = 711$

Simple average $F_{n+1} = .4 \times 582 + .6 \times 708.3 = 232.8 + 424.98 = 657.78 = 658$

Using 5-months period

$F_{n+1} = .33 \times 582 + .66 \times 764.4 = 175.56 + 467.48 = 680$

Simple average $F_{n+1} = .33 \times 582 + .66 \times 708.3 = 175.56 + 467.48 = 643$

Example 3: The computer sales of a company for last 6 years are given below. Calculate the forecast for sale of computers for all seven years using

(*i*) Simple exponential smoothing using L for 2, 4 and 5 months

(*ii*) Least square method

Year	*Sales of computers*
1996	128
1997	236
1998	354
1999	581
2000	862
2001	1055

Solution: Demand = D Forecast = F, L for 2 months = 2/2+1 = 0.66

For 4 months =2/4+1 = 0.4 for 5 months = 2/5+1 = 0.33

1996 $D_1 = F_1 = 128$

1997 $F_2 = LD_1 + (1 - L) F_1 = 128$

1998 $F_3 = LD_2 + (1 - L) F_2 =. 66 \times 236 + .34 \times 128 = 155.76 + 42.24 = 198$

$= . 4 \times 236 + .6 \times 128 = 94.4 + 76.8 = 171$

$= .33 \times 236 + .67 \times 128 = 77.88 + 84.48 = 162$

1999 $F_4 = LD_3 + (1 - L) F_3 = .66 \times 354 +. 34 \times 198 = 233.64 + 65.34 = 299$

$= .4 \times 354 + .6 \times 171 = 141.6 + 102.6 = 244$

$= .33 \times 354 + .67 \times 162 = 116,82 + 107 = 224$

2000 $F_5 = LD_4 + (1 - L) F_4 = .66 \times 581 +. 34 \times 299 = 383.46 + 98.67 = 482$

$= .4 \times 581 + .6 \times 244 = 232.4 + 146.4 = 379$

$= .33 \times 581 + .67 \times 224 = 191.73 + 147.84 = 340$

2001 $F_6 = LD_5 + (1 - L) F5 = .66 \times 862 + .34 \times 482 = 568.92 + 159.10 + 728$

$= .4 \times 862 + 6 \times 379 = 344.8 + 227.4 = 572$

$= .33 \times 862$

2002 $F_7 = LD_6 + (1\text{-}L) F_6 = .66 \times 1055 + .34 \times 728 = 696.3 + 240 = 936$

$= .4 \times 1055 + .6 \times 572 = 422 + 343.2 = 765$

$= .33 \times 1055 + .67 \times 509 = 348.15 + 335.94 = 684$

(*ii*) *Least square method:* The year 1999 is chosen as 1 year, other values are tabulated as below.

Year	*X*	*Y*	X^2	*XY*
1996	–3	128	9	–384
1997	–2	236	4	–472
1998	–1	354	1	–354
1999	+1	581	1	581
2000	+2	862	4	1724
2001	+3	1055	9	3165
	$\sum X = 0$	$\sum Y = 3216$	$\sum X\ 2 = 28$	$\sum XY = 4260$

$Y = a + bX$ $a = \sum Y/n = 3216/6 = 536$ and $b = \sum XY/\sum x^2 = 4260/28 = 152$

Straight line fit is $Y = 536 + 152X$

Forecast for 2002 is $= 536 + 152 \times 4536 + 608 + 1144$

Example 4: The yearly sales of Bicycle of a company for last five years are recorded as follows. Find the forecast of sales of Bicycle for 2003 year using least square method . Also find out the trend line.

Year	*Sales of Bicycle*
1998	8000
1999	15000
2000	21000
2001	23000
2002	32000

Solution

Year	*X*	X^2	*Yx1000*	*XY*	*Year*	*X*	X^2	*Yx1000*	*XY*
1998	1	1	8	8	1998	-2	4	8	-16
1999	2	4	15	30	1999	-1	1	15	-15
2000	3	9	21	63	2000	0	0	21	0
2001	4	16	23	92	2001	1	1	23	23
2002	5	25	32	160	2002	2	4	32	64
	15	55	99	353		0	10	99	56

$Y = a + b\ X\ \sum Y = na + b\sum X$ $99 = 5a + 15b$ $297 = 15a + 45b$ ...(1)

$\sum XY = a\sum X + b\sum X\ 2\ 353 = 15a + 55b$ ...(2)

Solving (2) – (1) $56 = 10b$, $b = 5.6$ $99 = 5a + 5.6 \times 15$ $5a = 99 - 84 = 15a = 3$

Line of fit is $Y = 3 + 5.6X$, Forecast for 2003 is $Y = 3 + 5.6 \times 6 = 3 + 33.6 = 36.6 = 36600$

When for the year 2000 $x = 0$, $Y = 5a + bX$ $99 = 5a$, $a = 19.8$

$\sum XY = a\sum X + b\sum X^2$ $56 = b \times 10$, $b = 5.6$

Line of fit is $Y = 19.8 + 5.6X$, Forecast for 2003 is $Y = 19.8 + 16.8 = 36.6 = 366000$

Forecast obtained from both lines of fit for the year 2003 is = 36600 bicycles.

Example 5: The sales of a product and its demand index are given below for last 10 months. Find the relationship between sales and demand index of the product. If the demand index for the 11th month is 30, find the forecast of sale.

Solution: The values are tabulated as follows:

Month	*Demand index* X	*Sales x 100* Y	X^2	XY
1	10	1.2	100	12
2	12	1.5	144	18
3	14	2.5	196	35
4	16	3.1	256	49.6
5	18	3.7	324	66.6
6	20	4.4	400	88
7	22	5.6	484	123.2
8	24	6.9	576	165.6
9	26	7.4	676	192.4
10	28	8.5	784	238
	190	44.8	3940	988.4

$Y = na + b\sum X$ and $\sum XY = a\sum X + b\sum X^2$

$44.8 = 10a + b \times 190$ ...(1) $988.4 = a \times 190 + b \times 340$ ...(2)

Multiply (1) by 19 and subtracting from (2) $988.4 - 851.2 = b \times (3940\text{-}3610) = b \times 330$

$330b = 137.2b = 137.2/330 = 0.415$ $10a + 190 \times .415 = 44.8$ $a + 19 \times .415 = 4.48a = 4.48\text{-}7.885a = -3.405b = 0.415$

Trend line is $Y = -3.405 + 0.415X$ for 11th month $X = 30$ $Y = -3.405 + 0.415 \times 30 = -3.405 + 12.45 = 9.045$ $Y = 9.405$.

Sale in 11th month having demand index as 30 is 904.5

(iii) Opinion-Based Method

This method is based on the experience of persons who are expert in marketing and sales. Opinion based method uses the behavior of the people, which decides the demand. It recognizes the type of analysis for quantity demanded by the people based on best judgment of experts and market knowledge. The study of behavior pattern for demand is necessary in this method.

The forecasting is therefore related to both past data, trend and opinion of the experts.

(iv) Causal Method

When the forecast of demand is not dependent on past historical data or any trend then it is to be found out that what are the factors on which the demand changes. The causal method determines the causes or reasons for change of demand. In this method, we try to find out the factors, which causes the demand variations, and then establish a relationship between the demand and these factors.

Some of the factors which changes the demand may be

1. Growth in population
2. Increase in income

3. Seasonal factors
4. Competition in market
5. Festivals
6. Flooding the markets with products and goods

The competition and flooding the market with products and goods affect the demand in negative or inverse way. The various causal methods used for forecasting are

(*i*) Regression and correlation analysis.

(*ii*) Econometric models

(*iii*) Input-output analysis

(*iv*) End-use analysis

The method of regression and correlation analysis used for forecasting will only be discussed below.

Regression and Correlation Analysis

In this analysis, dependable variable Y i.e., demand is estimated from the equation related with some of the independent variable X1, X2, X3, and X4 etc. and their constant coefficients a0, a1, a2, a3 and a4 are multiplied to them. These variables are related as linear relationship known as regression equation as given below.

$$Y = a0 + a1X1 + a2\ X2 \quad ...(1)$$

This is the linear regression equation a0, a1 and a2 are called *partial regression coefficients*. The linear regression equation given above represents the relationship between dependent variable Y which may be demand depending on independent variables X1 and X2 as some factors. It is a three-dimensional plane.

The equations, which are used to find out the values of coefficients a0, a1 and a2 etc., are given below.

$$\sum Y = a0n + a1\sum X1 + a2\sum X2 \quad ...(2)$$

$$\sum YX1 = a0\sum X1 + a1\sum X1^2 + a2\sum X1X2 \quad ...(3)$$

$$\sum YX2 = a0\sum X2 + a2\sum X1X2 + a2\sum X2^2 \quad ...(4)$$

The regression equation can be extended as generalized regression equation for more number of variables as

$$Y = a0 + a1X1 + a2X2 + a3X3 \quad ...(5)$$

$$\sum Y = a0n + a1\sum X1 + a2\sum X2 + a3\sum X3 \quad ...(6)$$

$$\sum YX1 = a0\sum X1 + a1\sum X1^2 + a2\sum X1X2 + a3\sum X1X3 \quad ...(7)$$

$$\sum YX2 = a0\sum X2 + a1\sum X1X2 + a2\sum X2^2 + a3\sum X2X3 \quad ...(8)$$

$$\sum YX3 = a0\sum X3 + a1\sum X1X3 + a2\sum X2X3 + a3\sum X3^2 \quad ...(9)$$

From the data available for Y, X1, X2 and X3, the values of a0, a1, a2 and a3 regression coefficients can be found out to find the regression equation which can be used to find out the values of Y with given values of X1, X2 and X3.

Correlation

The statistical tool, which is used for finding relationship between two or more variables in one single figure, is known as correlation. It is average relationship between two or more variables established. When all the values of variables satisfy a regression equation exactly, then the variables are called *perfectly correlated variables*. In actual practice, the points of data are scattered about the line of fit or plane of fit. In all such cases, we will be defining fit with a measure of correlation.

The total variation of Y is defined as $\Sigma(Y - Y_{avg})^2$. The total variation can be divided by two terms as follows.

$$\Sigma(Y - Y_{avg})^2 = \Sigma(Y - Y_{est})^2 + . \Sigma(Y_{est} - Y_{avg})^2$$

The first term $\Sigma(Y - Y_{est})^2$ on the right side of this equation is called as Unexplained Variation.

The second term $\Sigma(Y_{est} - Y_{avg})^2$ on the right side of this equation is called as Explained Variation.

If there is no correlation, the best estimate of Y for given value of X would be Y_{avg} the mean value of Y (dependent variable) and X (independent variable). In this case, Y will be perfectly correlated and all the values of Y and all the values of Y will lie on the line of fit. When the actual values of Y_{avg} are different from estimated value Y_{est} the variation is unexplained by regression line.

Coefficient of Correlation

The square root of the ratio of explained variation $\Sigma(Y_{est} - Y_{avg})^2$ to total variation $\Sigma(Y - Y_{avg})^2$ is called *coefficient of correlation r*. The coefficient of correlation *r* is a dimensionless quantity whose value varies from –1 to +1.

Coefficient of Determination

The ratio of explained variation $\Sigma(Y_{est} - Y_{avg})^2$ to total variation $\Sigma(Y - Y_{avg})^2$ which is equal to r^2 is called Coefficient of Determination. The coefficient of determination is the fraction of the variation in the dependent variable Y, which is explained by the regression line fitted by the given data of X1, X2 and X3 etc..

The values of coefficients, *r* (coefficient of correlation) and r^2 (coefficient of determination) are the measure of correlation. *r* signifies –ve and +ve values of correlation and r^2 signify the proportion of explained variation. Correlationship analysis is an additional technique, which can be used to forecast sales. The forecast based on time series analysis may have error and it should be supplemented by correlation analysis.

One type of business or economic activity generates the business in other fields. New house buildings, population growth, employment generation, rise in income, climatic conditions, education, sex, entertainment and nationality are some of the factors which decides the forecast for sale of items like consumer goods, furniture, building materials and automobiles etc.

Logarithmic Straight line or Exponential Method of Sales Trend Measurements

Many a time the linear relationship or straight line fit may not be proper to fit in the data of sales trend. A smooth curve may be a better fit.

The equation of the curve, which may be fitted, is of exponential type as Y = ab*X. Taking log on both sides we can change this exponential equation into logarithmic form which can be solved by least square method.

$$\log Y = \log a + \log b * X$$

Or $\log Y = \log a + X \log b$ on logarithmic paper, it will be straight line. In order to find out the values of a and b, these equations will be converted as

$$\sum \log Y = n \log a + \sum X \log b$$

$$\sum X \log Y = \sum X \log a + \sum X^{*2} \log b$$

If point is selected such that $\sum X = 0$ then the solution will be

$$\log a = \frac{\sum \log Y}{n} \text{ and } \log b = \frac{\sum X \log Y}{\sum X^{*2}}$$

Example 6: XYZ Company has the following sales of its product; find out the forecast for the year 2003 using logarithmic straight-line method.

Year	Sale (Rs. x 1000)	Year	Sale (Rs. x 1000)
1996	95	2000	170
1997	120	2001	340
1998	230	2002	405
1999	205		

Solution: - The values are tabulated as follows.

Year	*X*	*Sale Y x 1000*	X^2	*logY*	*XlogY*	*Forecasted values*
1996	–3	95	9	1.977	-5.931	103.27
1997	–2	120	4	2.079	-4.158	128.53
1998	–1	230	1	2.361	-2.361	159.95
1999	0	205	0	2.311	0	199.06
2000	1	170	1	2.230	2.230	247.74
2001	2	340	4	2.531	5.062	308.32
2002	3	405	9	2.607	7.821	383.70
	0	1565	28	16.096	2.663	

$$\log a = \frac{\sum \log Y}{n} \text{ and } \quad \log b = \frac{\sum X \log Y}{\sum X^2}$$

$$\log a = 16.096/7 = 2.299 \qquad \log b = 2.663/28 = 0.095$$

$$a = 199.06 \qquad b = 1.244$$

The equation for forecasting is logY = loga + Xlogb logY = 2.299 + 0.095X

Forecasted values for the various years are calculated as

1996 log Y = 2.299 + 0.095 × (–3) = 2.299 – .285 = 2.014 Y = 103.27

1997 log Y = 2.299 + 0.095 × (–2) = 2.299 – .19 = 2.109 Y = 128.53

1998 log Y = 2.299 + 0.095 × (–1) = 2.299 – .095 = 2.204 Y = 159.95

1999 log Y = 2.299 + 0.095 × (0) = 2.299 = 2.299 Y = 199.06

2000 log Y = 2.299 + 0.095 × (1) = 2.299 +.095 = 2.394 Y = 247.74

2001 log Y = 2.299 + 0.095 × (2) = 2.299 + .19 = 2.489 Y = 308.32

2002 log Y = 2.299 + 0.095 × (3) = 2.299 + .285 = 2.584 Y = 383.70

2003 log Y = 2.299 + 0.095 × (4) = 2.299 + .38 = 2.679 Y = 477.52

Regression line is log Y = 2.299 + 0.095 X and forecast for 2003 is = 477000 Rs.

Example 7: The sales of washing machine in a shop for last five years are given. Find the forecast for sixth year using parabolic curve method and its trend.

Year	*Sales*	*Year*	*Sales*
2002	325	1999	150
2001	240	1998	80
2000	430		

Solution: The equation for parabolic curve is $Y = a0 + a1X + a2X^2$

when X = 0 Y = a0

The normal equations are

$$\sum Y = na0 + a1\sum X + a2\sum X^2 \quad ...(1)$$

$$\sum XY = a0\sum X + a1\sum X^2 + a2\sum X^3 \quad ...(2)$$

$$\sum X^2Y = a0\sum X^2 + a1\sum X^3 + a2\sum X^4 \quad ...(3)$$

When middle point is origin $\sum X = 0$ the above equations are reduced as follows

$$\sum Y = na0 + a2\sum X^2 \quad ...(4)$$

$$\sum XY = a1\sum X^2 \quad ...(5)$$

$$\sum X^2 = a0\sum X^2 + a2\sum X^4 \quad ...(6)$$

These values are tabulated as follows

Year	*X*	*Y*	*XY*	X^2	X^2Y	X^3	X^4	*Forecasted sales of washing machine*
2002	2	325	650	4	1300	8	16	298
2001	1	240	240	1	240	1	1	334
2000	0	430	0	0	0	0	0	308
1999	–1	150	–150	1	150	–1	1	218
1998	–2	80	–160	4	320	–8	16	66
		0	1225	580	10	2010	0	34

$$1225 = 5a0 + a2 \times 10 \quad ...(1)$$

$$580 = a1 \times 10 \; a1 = 58 \quad ...(2)$$

$$2010 = 10 \times a0 + a2 \times 34 \quad ...(3)$$

Multiplying (1) by 2 and subtracting from (3) we get

$(34 - 20)\ a2 = (2010 - 2450)\ 14\ a2 = -440\ a2 = -440/14 = -31.4$

Substituting value of a2 in (1) $1225 = 5\ a0 - 314$, $5a0 = 1225 + 314 = 1539$, $a0 = 307.8$

The equation is $Y = 307.8 + 58X - 31.4\ X^{*2}$

Forecast for 2003 will be $Y = 307.8 + 58 \times 3 - 31.4 \times 9 = 307.8 + 174 - 282.6 = 199.2 = 200$

Forecast values for five years are calculated as follows

2002 $Y = 307.8 + 58 \times 2 - 31.4 \times 4 = 307.8 + 116 - 125.6 = 298.2$

2001 $Y = 307.8 + 58 \times 1 - 31.4 \times 1 = 307.8 + 58 - 31.4 = 334.4$

2000 $Y = 307.8 + 58 \times 0 - 31.4 \times 0 = 307.8$

1999 $Y = 307.8 + 58 \times -1 - 31.4 \times 1 = 307.8 - 58 - 31.4 = 218.4$

1998 $Y = 307.8 + 58 \times -2 - 31.4 \times 4 = 307.8 - 116 - 125.6 = 66.2$

(v) Trend Analysis

The trend is the estimated variation of sales demand which follows some curve fitted to the available data and further demand can be approximately predicted from these curves.

The various methods used for estimating the sales trend are:

(*i*) Free hand method, opinion-based method or inspection method

(*ii*) Method of average. They are

- (*a*) Selected point trend
- (*b*) Semi average trend
- (*c*) Moving average trend

(*iii*) Method of least square. They are

- (*a*) Straight-line trend
- (*b*) Logarithmic Straight-line trend
- (*c*) Parabolic trend

(*i*) Free hand or Inspection method: In this method, the free-hand curves are drawn by impressing the values of variations of data on graph sheets keeping the peak and trough values same. It gives initial judgment of trend and variations of demand. The opinion of experts is also useful in deciding the trend .The limitations of the method will be that exact trend can not be predicted and requires further exercise for better estimates.

(*ii*) Method of averages: This is already discussed in time series analysis. The average values of large number of data are the selective forecast of demand. In selective point method, the values of years so chosen which are considered to be most representative values.

(*iii*) Method of least square: In this method, the straight line or curve is fitted using the simple or logarithmic straight line or parabolic curve to give the best fit to the available

data and further forecast assumes to lie on these trend line or curve. This method is supposed to be most appropriate and important for forecasting. They are discussed above with examples solved on them.

(*iv*) Market research: The market is main area for demand fluctuations, collection of data and knowing the trend of the sales of different products. The changes in them are based on the various factors like socio-economic, political and business changes. The analysis of the market will always be the best way to know the sales of any item. It will predict the future demand. These things are already discussed earlier.

Selection and Procedure for Forecasting

For selection of a forecasting method, the following things are necessary:

1. Accuracy of data. The data should be accurately available.
2. Cost of evaluation of data and forecasting should be economic.
3. The method used for forecasting should be simple and easily adopted. It should be easy to understand.
4. Result-oriented technique should be adopted and it should give quick and timely results.

For selecting the procedure of the forecasting, the following points are useful.

(*i*) The proper method of forecasting should be selected.

(*ii*) Whether short-term or long-term forecasting is necessary will be decided before selecting the method of forecasting.

(*iii*) Collect the data as much as required for forecasting.

(*iv*) Decide the length of period for which demand may not change much.

(*v*) Use proper statistical method and find the forecast results.

(*vi*) Select the time for forecast.

(*vii*) Avoid the complexity in using forecasting and use only those factors which affects more in demand fluctuations.

(*viii*) For forecasting the demand for new products the analysis must be carefully done.

Example 8 The number of students taking admission in a school is dependent upon the following factors. 1. Distance of the school, 2. Fees charged, 3. Facility available. The bus facility available with the school. There are two variables fees charged and facility available. These factors are given for numbers of schools in an area in the table below along with number of students admitted in these schools the data are collected from these schools. Assuming linear relationship between the students admitted and these factors find out the relationship amongst these factors with the given data.

School no.	*No. of students admitted (Y)*	*Facility available (XI)*	*Fees (X2)*
1	540	10	10
2	280	5	12
3	720	12	8
4	630	14	9
5	460	16	14
6	580	8	7
7	370	6	16
8	400	7	15

Solution

To establish the relationship between the variables let us assume

Y = Number of students admitted

X1 = Facility available

X2 = Fees charged

The regression equation will be

$$Y = a0 + a1\sum X1 + a2X2 \quad ...(1)$$

$$\sum Y = a0n + a1\sum X1 + a2\sum X2 \quad ...(2)$$

$$\sum YX1 = a0\sum X1 + a1\sum X1*2 + a2\sum X1X2 \quad ...(3)$$

$$\sum YX2 = a0\sum X2 + a1\sum X1X2 + a2\sum X2*2 \quad ...(4)$$

Y	*X1*	*X2*	*X1Y*	*X2Y*	*X1*2*	*$X2^2$*	*X1X2*
540	10	10	5400	5400	100	100	100
280	5	12	1400	3360	25	144	60
720	12	8	8640	5760	144	64	96
630	14	9	8820	5670	196	81	126
460	16	14	7360	6440	256	196	224
580	8	7	4640	4060	64	49	56
370	6	16	2220	5920	36	256	96
400	7	15	2800	6000	49	225	105
3980	78	91	41280	42610	870	1115	863

$$3980 = a0 \times 8 + a1 \times 8 + a2 \times 91 \quad ...(5)$$

$$41280 = a0 \times 78 + a1 \times 870 + a2 \times 863 \quad ...(6)$$

$$42610 = a0 \times 91 + a1 \times 863 + a2 \times 1115 \quad ...(7)$$

$$3980/8 = a0 + a1 \times 78/8 + a2 \times 91/8 \quad ...(8)$$

$$41280/78 = a0 + a1 \times 870/78 + a2 \times 863/78 \quad ...(9)$$

$$42610/91 = a0 + a1 \times 863/91 + a2 \times 1115/91 \quad ...(10)$$

497.5 = a0 + 975a1 + 11.375a2 ...(11)

529.23 = a0 + 11.15 a1 + 11.064a2 ...(12)

468.241 = a0 + 9.48 a1 + 12.252a2 ...(13)

Solving (11),(12) and (13) taking (12) – (11) and (12) – (13)

31.73 =1.4a1 – 0.311a2 ...(14)

60.989 = 1.67a1 – 1.188 a2 ...(15)

31.73 /1.4 =a1 – 0.311/1.4a2 ...(16)

60.989/1.67 = a1 –1.188/1.67a2 ...(17)

22.664 = a1– 0.222a2 ...(18)

36.52 = a1 – 0.711a2 ...(19)

Taking (19) – (18) 13.856 = – 0.489a2

a2 = – 28.335 a1 + 0.222 × 28.335 = 22.664 a1 + 6.2904 = 22.664

a1 = 22.664 – 6.29037 16.373

497.5 = a0 + 9.75 × 16.373 – 11.375 × 28.335 a0 + 159.63 – 322.31 = a0 –162.68

a0 = 497.5 + 162.68 = 660.18

Regression equation is Y = 660.18 + 16.373 X1 – 28.335 X2

The +ve value of a1 indicates that the number of students admitted will increase with increase in value of X1 the better facility.

The –ve value of a2 indicates that the number of students admitted will be reduced if the X2 the fees will be increased.

We can calculate the value of Y number of students admitted if X1 and X2 are given.

For example, X1 = 20 and X2 = 10 then Y = 660.18 + 16.373 × 20 – 28.335 × 10 = 660.18 + 327.46 – 283.35 = 704 students

Number of students admitted = 704.

QUESTIONS

1. What is Sales Forecasting? How is it useful for planning the production?
2. How many types of forecasting are used?
3. Differentiate between long-term and short-term forecasting. Give their benefits.
4. What are the applications of forecasts?
5. Give the various methods of forecasting. Explain them.
6. What is Time Series Analysis?
7. Explain the smoothing method of forecasting.
8. Explain the decomposition method of forecasting.

9. What is moving average method of forecasting? How many types of moving average methods are used?
10. Write short notes on following methods of forecasting.
    (*i*) Exponential smoothing method
    (*ii*) Least square method
    (*iii*) n-period moving average technique
    (*iv*) Weighted n-period moving average
11. What are the factors, which affects the forecasting?
12. Explain the following types of variations of sales.
    (*i*) Trend variation
    (*ii*) Cyclic variation
    (*iii*) Seasonal variation
    (*iv*) Randomness
13. What is causal method of forecasting?
14. What is opinion-based method of forecasting?
15. How does market research help in forecasting the demand and production of an item for sale?

16 How will you select a procedure for proper forecasting?

Examples

1. The sales of a product are given for last 7 years. Find the forecast of its demand using 4 and 5 months moving average and exponential smoothing method for 8th year.

Year	*Sales*
1996	56
1997	88
1998	102
1999	187
2000	254
2001	385
2002	462

2. Find the forecast of sales for 8th year using least square method, simple average and standard deviation of the data given in the Example 1 above and also the equation of straight line of fit.

3. The sales and demand index of a product sold by a company are given below. Find the relationship between sales and demand index of the product. Also find the forecast for 7th year if the demand index is 50.

Year	*Sales*	*Demand index*
1997	104	10
1998	215	14
1999	264	18
2000	375	25
2001	546	32
2002	720	40

4. The number of patients admitted in the hospital depends upon its distance from the house and expenses required. The data for five such hospitals are given below. Find the relationship between these factors with number of patients admitted. If the distance of the hospital is 10 km and Rs. 3000 expenses are there, find the number of patients likely to be admitted in the hospital.

Hospital No.	*No. of patients admitted*	*Distance in Km*	*Expenses in Rs.*
1	250	4.2	2300
2	175	1.8	4800
3	360	2.8	3500
4	450	8.6	1700
5	530	6.3	2000
6	620	12	1500

5. Sales of refrigerator in winter are given below. Find the forecast of its sale in the next winter using logarithmic straight line method and parabolic curve method for two months, Oct. and Nov. Find the equations for both the methods.

Month	*Sales of retrigerator*
Oct.	325
Nov.	536
Dec.	243
Jan.	188
Feb.	374
March	58

CHAPTER VI

Inventory Planning

Introduction

Every organization requires some type of materials for production, business or day-to-day use. Storing these materials, which may be raw materials, used to make the product, materials in process, parts, components, and finished products. Sub-assemblies and assemblies directly entering in to the production and final product, indirect materials used for maintenance etc. like fuels and lubricants, any general purpose materials and equipments. All of them are stored for future use. These stock of materials stored are called Inventories.

Definition

Stock of goods, which must be carried and stored in order to ensure smooth and efficient running of affairs of production and business, is called Inventory. All these materials and goods have value and cost and they are the assets purchased and used to produce the products or sold to carry out some service and business to earn the profit for an organization. The materials as inventory are stocked to maintain the operations and processes in production and business. Its purpose is for transaction, precautions against shortage and speculation. The transaction is to synchronize inflow and outflow of materials as a precautionary measure for safety against demand increase and supply and speculation against rise in price.

Necessity and Reasons for Inventory

1. The demand and supply of materials fluctuate and therefore the production is to be controlled as per the demand fluctuations. The excess production is stocked as inventory for future sales. Materials are stored to meet the production fluctuations in the organization.
2. The business people stock the materials as inventory for speculation, rise in price or shortage occurring because of sudden rise in demand.
3. Inventories are valuable assets and the different parts and components are made in a lot. They may be more than requirements because the production in a lot is more economic. They are to be kept as inventories temporarily till next lot is produced after its consumption. The materials planning necessitates inventory planning and storing them.

4. Marketing and production planning requires purchase and inventory planning decisions for an organization to control expenses and finances. The amount of inventory plays an important role in materials decision to control purchase of materials.
5. To get the purchase benefits, discounts, reduced transportation and ordering cost the bulk purchase may be economical. Inventory of such materials are stored for longer time.

Functions of Inventories

The functions of inventories are:

1. The materials must be available in time for production.
2. The production should go on continuously and the stores supply all the materials required for production.
3. The marketing and purchasing takes time and inventories ensure the organization to handle them efficiently.
4. It helps in planning the production and consumption of its stock.
5. Inventories stabilize employment in the organization.
6. Reduction in cost of materials and inventory control reduces the cost of product.
7. Inventories of raw materials, parts, components, work in process etc. are required to meet the demand of production and to maintain line balance of assembly work.
8. The efficient store keeping and materials management is possible only by efficient inventory planning and control.
9. Planning inventory reduces and utilizes the working capital of organization properly.
10. The inventory prevents the stock out and shortages and discounts are available for large purchases.

Types of Inventories

The various types of inventories are classified according to the function for which they are required. Only those types of materials and items are purchased and stored in the organization to keep as inventories, which are frequently required for production. Either it directly enters in the product or necessary for production. Other types of materials which are not frequently required for production, they are purchased and consumed. They may not be kept in stores as inventories. The classification of inventories will be as follows.

(*i*). Inventories of direct materials referred to as Bill of Materials (BOM). It consists of raw materials and production inventories, parts, components, subassemblies, assemblies and finished goods.

(*ii*). Inventories of indirect materials are spares, tools, general supplies, stationeries, fuels, lubricants and maintenance materials. They are given as follows.

1. *Raw Materials and B.O.M. Inventories*

Raw materials are purchased from outside either from manufacturer or suppliers. These

materials enter in to the product. They are essential and stocked according to their functions. Functionally inventories can be stated as

(*a*) Movement inventories

(*b*) Lot size inventories

(*c*) Anticipation inventories

(*d*) Fluctuation inventories

They will be further classified and stored according to their volume, quantity, cost and category. The raw materials will be further converted into parts and components.

2. *Production Inventories*

They are parts, components and semi finished products stored at various places and supplied as per requirements of demand in production.

3. *Work-in-Process Inventories*

These are the parts, components and other items stored during production processes at various facilities and departments of production waiting to be assembled. For example, in a car manufacturing several parts of engine, gear assembly, wheels, sheet metal parts, body etc. are manufactured at different centers and stored as work-in-process inventories and supplied to assembly section as per requirement of assembly shop.

4. *M.R.O. Inventories*

They are the maintenance, repair and operating supplies. These M.R.O. inventories are consumed for production operation and generally do not become the part of product. For example, grease, oil, lubricant, cutting fluids , machinery and plant spares, tools, jigs, fixtures, cleaning liquids and chemicals etc. are M.R.O. inventories.

5. *Finished Goods or Product Inventories*

These inventories are final finished products ready for shipment to sale or temporarily stocked before being sent to market and sold. The complete vehicle as scooter, motor cycle or car is the finished product inventory of an automobile industry.

The inventories can also be classified according to their functions as stated above. They are:

1. Movement or transit inventories: The inventories move from one place to other. They are called movement or transit inventories. The amount of these inventories will be

$I = i.\ t$ where I = Inventory in transit, i = rate of inventory movement per unit time and t = time of movement

2. Lot size inventories: The materials are purchased in a lot to economize the cost of placing the purchase order and carrying them in store. The product is also produced in lot quantity to economize cost of set-up and production. The discount on purchase is obtained if the material is purchased in a particular amount or a lot size. This inventory of materials is called lot size inventory.

3. Fluctuation inventories: When the demand fluctuates and it is certain and unpredictable the inventory stock must be sufficient to meet the fluctuating demand. These

types of inventories are called fluctuating inventories. They may also be kept as safety stock.

4. Anticipation inventories: When the demand is known certainly, it is predictable or can be found out, the amount of purchase of materials or production quantities are very well planned. The inventory of materials are also planned to economize the cost of ordering and carrying them in stores. These planned inventories are also known as anticipation inventories.

Advantages and Disadvantages of Storing Inventory of Materials

Advantages

(*i*) Keeping inventory of materials will always allow the production to start at any time and continue it till they are exhausted.

(*ii*) In competitive situations, inventories are always necessary to supply emergency orders of product.

(*iii*) Large quantity purchases are profitable as large discounts are available. Transportation cost per item is reduced.

(*iv*) Cost of ordering is reduced, as frequent orders are not placed.

(*v*) In case of shortages or non-availability of materials, inventory helps in production and sales.

(*vi*) In case of inflation or rise in price of materials, large amount of inventory purchased at lower prices reduces cost of production and helps in production planning.

(*vii*) Increase in production when demand increases suddenly inventory helps for rapid production.

(*viii*) The continuity in production and taking the work from workers is possible only by keeping inventory.

Disadvantages

(*i*) The carrying cost of inventories will be more if materials are stored for longer time.

(*ii*) Unnecessary capital is invested in materials if large inventories are purchased and stored.

(*iii*) The safety of materials and its maintenance may be costly. The insurance charges, rent of stores and other cost of storage are involved in inventory such as cost of holding and record keeping the materials in stock.

(*iv*) Wastage, pilferages, deterioration and obsolescence of materials and parts with time will unnecessarily be unprofitable to organization.

(*v*) In case of reduction in cost of items in inventories, there will be great loss to the company.

For all such disadvantages of keeping large inventories, it is always safe to plan the inventories and store the requisite quantities of materials. The proper forecasting, inventory planning and control techniques must be used to do so. Every industry and business firms face the problem of inventory planning and control. A medium size manufacturing organization

requires 5000 to 50,000 different materials and items, which are stored as inventories. The cost of warehousing and inventory carrying sometimes increases rapidly if they are not consumed in time. The management and control of inventories is therefore a basic function of materials management and is greatly concern to owners of every industry and business.

Inventory Planning

In every manufacturing organization, materials are to be kept as inventories. How much materials are to be stored and when they are required is the problem of store keeping, which will be solved by efficient inventory planning. Therefore, it is very important function of materials management how efficiently it will plan the inventories of the stores.

Objectives of Inventory Planning and Management

Since inventory planning and control is a very important function of an organization. Its objective is to make available all type of materials required in time to maintain a buffer stock and continue production schedule and business.

The following are its objectives:

(i)Ensure Availability of Materials

To maintain stock of all materials in store as inventories, so that it should be available to production department in time and required quantity. Production should not stop because of nonavailability of any material. The materials requirements planning is one of the important technique used today to plan the inventory of materials required for production.

(ii) Optimizing Inventory Levels

The quantity of inventory stored and materials purchased should have optimum level so that it must match production quantity and no shortages will be there.

(iii) Economic Ordering of Purchase Quantities

The cost of ordering and carrying the inventories must be balanced so that the quantity of materials purchased every time as an order should have benefits of market prices and discounts and they must be economic to purchase.

(iv) The Use of Capital Investment Must be Efficiently Done

Every organization wants to invest its capital efficiently in materials. It should not be held up without use. The excessive investment in inventories should be avoided by proper inventory control. The analytical models of inventory control will be used to solve these minimization problems of inventory cost.

(v) Minimizing the Wastage of Materials

There should be minimum or no wastage of materials. It is only possible through proper inventory control and good store keeping. The wastage of materials may be because of leakages, spoilages, not preserving properly, deterioration, obsolescence, theft and pilferages etc. They should be checked. The dust and rusting many a time deteriorates and spoils the materials. The cleaning and protection against them is necessary.

(vi) Service to Customers

The proper stock of goods and products in the store serves the customers better to fulfill their demands by ready sales of items to their satisfaction and needs. The proper sales forecasting is required to control the production and to maintain the availability of products in stock. It will also be objective of sales department and requirement of capacity planning the production. The production planning includes and integrates capacity planning and inventory planning. The materials and inventory planning is done using materials requirements planning which is called *MRP-I*. The integrative type of production for a manufacturing system is called *manufacturing resource planning* and referred to as *MRP-II*.

Storage and Movement of Materials

The complete MRP-II is supported by MRP- I to plan and supply all materials required for production most efficiently and effectively. It has sales forecasting, inventory planning and control as an essential materials management activity.

Requirement of Sales Forecast for Operations

The demand forecast data must be available in the form that can be translated into demands for materials, time in specific equipment classification and demands for specific labor skills. The nature of production-distribution system is shown in the figure below.

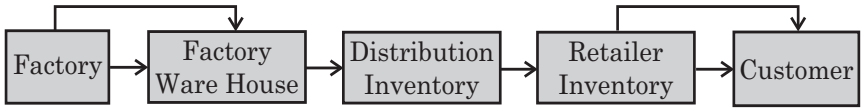


Fig. 9. System of Inventories

The various types of system inventories will be pipeline inventories, cycle inventories, buffer inventories and finished goods inventories**.** These inventories will be planned by the materials requirement planning system, which is computer-operated modern method of inventory planning and control.

Inventory Planning and Control Systems

In every manufacturing or trading concern, the planning and controlling of inventories of physical goods and materials required is of great importance. Raw materials and other parts waiting for dispatch as inventories in the stores or Work-in-progress should have perfect and up-to-date accounting.

In a production system designed either as a product layout (flow shops) or process layout (job shops), control of materials flow and its utilization is very essential. Finished components, semi-finished parts and raw materials move between departments and share scarce common resources. They are either queuing before machines as in-process inventory or waiting to be dispatched to the store, thus increasing production lead time to a great extent. The efficient inventory control for storing and issue of all these items with proper scheduled deliveries will only save the time and cost of inventories. The various types of inventory control techniques are developed for materials management department of any organization.

First of all, materials managers should be able to classify thousands of materials stored as inventories according to their cost, characteristics, quantities, priorities, and other factors to identify and use them. The classification based on these factors is called Selective Inventory Control Analysis of Inventory Management and Control. This analysis is discussed below.

Selective Inventory Control

Definition

The methods of inventory control vary from item to item which are stored as inventory. The items are selected on the basis of their values and priorities and other factors. Thousands of materials are purchased, stored and used during production processes every year in the company. Materials management department of the company has to transact and manage them for effective control and economic production. They will have to be classified and stored according to their cost, volume, use, and other factors of production and efficient inventory control. The methods used to classify these inventories of various items systematically are called Selective Inventory Control Analysis. The various methods of selective inventory control analysis used by materials managers are given below:

(1) ABC analysis
(2) HML analysis
(3) XYZ analysis
(4) VED analysis
(5) VEIN analysis
(6) SDE analysis
(7) FSN or MNG analysis
(8) GOLF analysis
(9) SOS analysis
(10) FAN analysis

The comparative study of all these methods is described below:

S. no.	*Selective inventory control techniques*	*Application*
(1)	ABC (Always , Better , Control) analysis	Yearly sales value of materials are considered, more valued but less quantity materials are A items, medium level B items and less-valued bulk items are C items.
(2)	HML (High, Medium, Low prices) analysis	Categorized as high, medium and low-unit price of materials.

Contd...

(3)	XYZ analysis	Classification is based on value of inventory items stored. High-cost inventory X items, medium-cost Y items and low-cost Z items.
(4)	VED (Vital, Essential, Desirable) analysis	Critically required items and equipments for production purpose.
(5)	VEIN (Vital, Essential, Important, Normal)	Same as VED analysis
(6)	SDE (Scares, Difficult to obtain, Easy to obtain) analysis	Availability and purchasing problems analysis are there for these materials.
(7)	FSN (Fast, Slow, Non-moving) or MNG (Government, Non-moving, Ghost items analysis	Movement from the stores and frequency of use items.
(8)	GOLF (Government, Open market, Local, Foreign materials) analysis	Supply sources and purchase strategies decided for these items.
(9)	SOS (Seasonal and Off-seasonal) analysis	Seasonal and nature of supply items.
(10)	FAN Failure analysis	Design, reliability and issue of spares.

All these analysis are described below:

(1) *ABC Analysis*

This is most popular inventory control technique adopted as Pareto's Law. H. Ford Dickie of General Electric Co. of USA developed it. In 1897, Italian economist Vifredo Pareto observed in Italy that large percentage of national wealth and income is lying in the hands of small percentage of population, which is still happening in India and thus distribution of wealth is unbalanced and therefore it is uneconomical situation. In industries also, large amount of capital is invested in purchase of costly items in small number. Eighty percent of the cost of materials purchased is required for only Twenty percent costly items.

For efficient inventory control in stores where the large number of materials are to be handled, the classification of them is necessary to take particular care of costly items, which are less in number. The ABC analysis is commonly used in most of the organizations to classify the materials according to their sales values. In this method, all the items of stores are classified in three groups as A, B and C as explained below.

(*i*) The quantity of each item used annually multiply by its unit sales price is sales value of that item. All such sales values of all the items are calculated and tabulated.

(*ii*) The items, its quantity sold and sales values are tabulated in decreasing order and the sales values are added item-wise and shown in next column.

(*iii*) The totals of quantity and sales values of all the items used annually are found out. The percentage sales values of each item is found out and percentage of quantity of each item is also found out. These two columns are added showing percentage of total sales values item wise and percentage of total quantity of sales.

(*iv*) Seventy percent of total sales value items will be listed in A category. Its percentage quantity used is found out.

(*v*) About 20 % of total sales value items will be listed in B category. Its percentage quantity used is found out.

(*vi*) Balanced about 10 % of total sales value items will be listed in C category . Its percentage quantity will be remaining balance. This procedure will be understood by the example given below.

Characteristics of ABC Items

A-Items

These items have 70% of sales value but less in quantity about 15 to 20%. The capital should not be blocked in these items. They can be ordered frequently and consumed immediately. The purchase of these items will be controlled by Director and cared most in the company. They are only 10 to 15% quantity-wise and require special attention in stores.

B-Items

They have about 20 to 25% sales value and same quantity to purchase. Since they are medium valued items therefore large inventory of them is not necessary. They can be ordered frequently but at the same time the quantity ordered should be such that it will be economic to purchase and its shortage should not be there. They are less valued than A items and quantity-wise about 15 to 25%.

C-Items

They have the least sales cost about 10%. They are required in large quantity about 50 to 60%. They can be purchased in bulk to avail large discounts and less price to pay. This will also reduce the cost of ordering and purchasing. They can be purchased once or twice in a year. They are least-valued items.

Advantages of ABC Analysis

(*i*) The inventory control of different categories of items will be better if costlier items are not stored for large period, which reduces capital investment.

(*ii*) The quantities of various categories of items are economically ordered and stored as per need. It saves the cost of ordering and carrying the inventories.

(*iii*) The purchasing of various categories of items become easy and discounts are also obtained on large purchase of items of C category.

(*iv*) Better record keeping of different categories of items helps in good inventory control

The ABC categories are based on value, usage and criticality of the requirement of items. The ABC is also referred as Always, Better, Control analysis. The graph of quantity

of items used and their usage value cost-wise is shown in Fig. 10 below. The ABC items are also indicated.

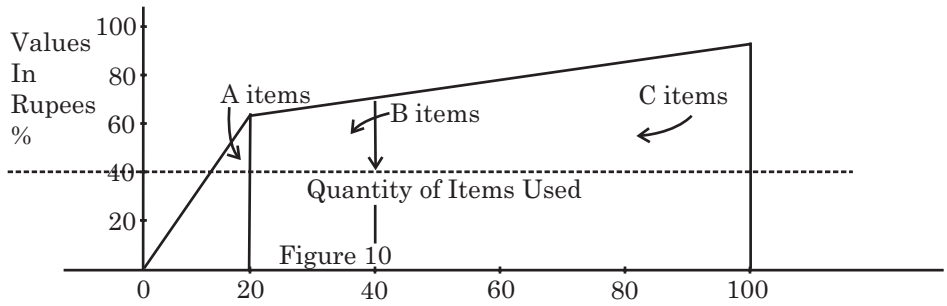


Fig. 10. Quantity of Items Used

In order to classify all the items in ABC Categories as per policy of materials manager and to show them on graph the following procedure is used.

Example 1: A company stocks the following items in its inventory.

S. No.	*Item code*	*Annual use (Units)*	*Unit cost (Rs.)*	*Amount usage (Rs.)*
1	X11	300	5.00	1500
2	X12	15	460.00	6900
3	X13	150	12.50	1875
4	X14	120	32.00	3840
5	X15	275	108.00	29700
6	X21	2000	1.50	3000
7	X22	45	960.00	43200
8	X23	30	120.00	3600
9	X24	180	3.50	630
10	X25	60	40.00	2400

(1) Calculate the values of annual use of each item.

(2) Rank items in descending order of value of annual use.

(3) Plot the results showing percentage of total value of annual use verses percentage of items.

(4) Divide the items in to ABC categories such that approximately

A-items constitute 70% B-items constitute 20% C-items constitute 10 % of total sales cost.

Solution: The various values asked in (1) and (2) about values of quantity, total usage and total cost month-wise are calculated and tabulated in the descending order of their values as follows.

S. No.	*Item code*	*Annual use (units)*	*Total use (%)*		*Unit cost (Rs.)*	*Amount usage (Rs.)*	*Total cost (Rs.)*	*Percentage of total cost*
1	X22	45	45	1.42	960	43200	43200	44.70
2	X15	275	320	10.08	108	29700	72900	75.43
3	X12	15	335	10.55	460	6900	79800	82.57
4	X14	120	455	14.33	32	3840	83640	86.54
5	X23	30	485	15.27	1.20	3600	87240	90.27
6	X21	2000	2485	78.26	1.50	3000	90240	93.37
7	X25	60	2545	80.15	40	2400	92640	96.64
8	X13	150	2695	84.88	12.50	1875	94515	97.80
9	X11	300	2995	94.33	5	1500	96015	99.35
10	X24	180	3175	100.00	3.50	630	96645	100.00

From the table, the various items in ABC categories are found out as:

A-items are X22 and X15 has total usage Rs. 96645 × 0.70 = 67651.50 which is nearer to Rs.72900. They are 72900/96645 = 75.43% and quantity of 320/3175 = 10.08 % is used.

B-items are X12, X14 and X23 total usage 87240/7200 =14340/96645=14.84%, they are 485 – 320 =165 = 5.19 %

C-items are remaining X21, X25, X13, X11 and X24 having total value 96645 – 87240 = Rs. 9405 Rs. 9.73 % and 2690/3175 = 84.72 %

The graph is plotted between percentage values and annual use and percentage of total cost as given below indicating all ABC items. See Fig. 11.

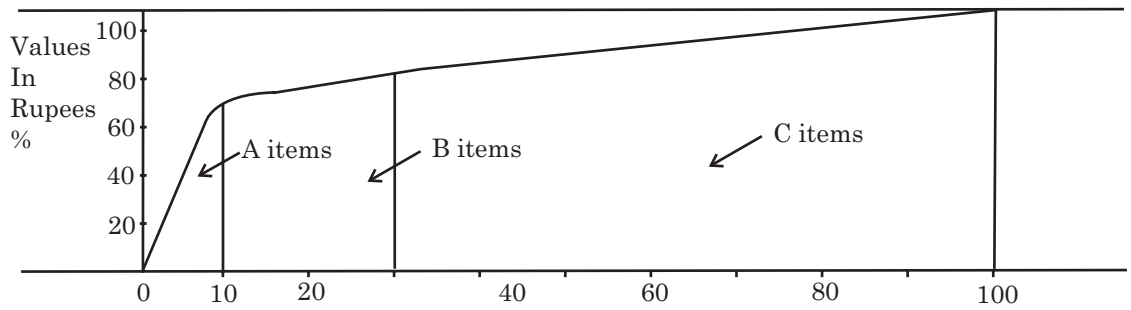


Fig. 11. Quantity of items used

(2) HML Analysis

In this analysis, the items are classified according to their unit value or rate.

H-items They are having highest cost per unit, for example, materials having the cost more than Rs. 10,000 per piece will be placed as H-item.

M-items They are the medium-cost items per unit say the items having the price between Rs. 2000 to Rs. 10,000.

L-items They are the least price items say less than Rs. 2000 per piece.

The quantity consumption or usage per year is not considered in this classification as is done in ABC analysis. Many a time, the categorization of items will be done using both ABC and HML methods together. For example, items belonging to A and H category will be cared most.

(3) XYZ Analysis

In this method, the classification is based on value of inventory stored.

X-items They are the items whose inventory value is highest. Maximum capital is invested in these items.

Y-items They are medium-value inventory items.

Z-items These items have least inventory values and therefore not reviewed frequently.

XYZ classification is either combined with ABC or FSN classification for better analysis of items.

VED, VEIN and SDE analysis

All these VED, VEIN and SDE analysis are done to classify the items as per their urgency of requirement, use and consumption

(4) VED Analysis

It classifies the items as follows

V-items It refers to vital or most essential items. The production will stop without them.

E-items They are essential items. The production will be disrupted without them.

D-items They are desirable items. The production will not suffer without them immediately. This type of classification is done mostly for spare parts and equipments and is used for a sizeable reduction in inventory.

(5) VEIN Analysis

In this classification of materials,

V-items stands for vital items.

E-items stands for essential items.

I-items stands for important items.

N-items stands for normal items.

VEIN classification is also done for machinery parts and items required for maintenance purposes.

(6) SDE Analysis

In this method of classification

S-items stands for scares items. They are either short-supply materials or few suppliers manufacture them. They may be imported items and their inventory must be in the store.

D-items stands for difficult to procure and manufacture items. Its availability is less.

E- items They are easily available and need not be stored.

(7) FSN and MNG Analysis

Both these analysis are same and used as per issue of items from the stores.

FSN Analysis may be made to weed out unwanted materials and parts.

F-items stands for fast-moving items. They are consumed very fast.

S-items They are slow-moving items consumed slowly.

N-items They are non-moving items.

This method will automatically reduce inventory cost. A part of material, which has been issued within three years, can be completely weeded out. If an item moves sparingly within this period its stock can be substantially reduced. Fast moving items pose no such problems.

MNG Analysis has

M-items They are moving items consumed time to time.

N-items They are non-moving items not consumed.

G-items They are Ghost items which has no transaction and nil balance in the store.

(8) GOLF

classification where,

G-items stands for Government items.

O-items refers to open market.

L-items stands for local items.

F-items stands for foreign materials.

The import is done through some State Trading Corporation. Government purchases are also done through some such agencies. Local and open-market items are easily available in the country.

(9) S-O-S Classification

Agricultural and some such items available or manufactured in a particular season as per seasonal demands are classified as

S- Seasonal items and O-S are off-seasonal items. The seasonal items are purchased and stocked in that season in which they are available and used.

(10) FAN Analysis

It is called failure analysis and is done for design and reliability of products and inspection before purchase is carried out.

(11) Combined Analysis

In order to control the high-cost items precisely and ordered on the basis of their priorities of requirements they are critically classified using two or more methods such as

using ABC and FSN, ABC and XYZ or HML and VED as combined analysis to store these items. This combination is described below.

The first combination is described between ABC and XYZ classification.

Second combination is described between HML and VED classification.

They are desirable items.

	X	*Y*	*Z*
A	Largest cost and high-value important items stored carefully	Largest cost and medium-value items ordered using EOQ	Largest cost and low value items stored in sufficient quantity
B	Medium cost and high-value items stored carefully	Medium cost and medium value ordered regularly	Medium cost less value stored sufficiently
C	Low cost and high-value items ordered in sufficient quantity getting discounts	Low cost and medium-value items always available in the store	Low cost and less-value items purchased once in a year in large amount
	V	*E*	*D*
H	High price vital items must be available in the store	High price essential items ordered frequently	High price desirable items economically ordered
M	Medium price vital items whose availability in the store is must	Medium price essential items always available in the store	Medium price desirable items ordered once or twice in a year
L	Low price vital items availability assured	Low price essential items stored in large number	Low price desirable items ordered once in a year

The following example will explain these types of analysis in better way.

Example 2: The various materials stored annually as inventory are given in the table below. Classify them in ABC-XYZ category and ABC-HML category together and suggest the methods of their ordering and storing for better inventory control. Use ABC classification of items as A-items 70%, B-items 20% and C-items 10% of total cost.

Materials	*Quantity* (*No.*)	*Price* (*Rs.*)	*Total cost* (*Rs.*)
M1	100	50	5000
M2	300	20	6000
M3	50	1000	50000
M4	80	500	40000
M11	210	140	29400
M12	1000	10	10000

Contd...

Materials	*Quantity in No.*	*Price Rs.*	*Total Cost Rs.*
M13	2500	5	12500
M14	20	400	8000
M21	120	800	96000
M22	125	240	30000
M23	40	80	3200
M24	200	310	62000

Solution : The various values are calculated and tabulated as given in the table below:

Materials	*Quantity (No.)*	*Total quantity*	*%*	*Price (Rs.)*	*Cost (Rs.)*	*Total Cost (Rs.)*	*%*
M21	120	120	2.53	800	96000	96000	27.26
M24	200	320	6.74	310	62000	158000	44.87
M3	50	370	7.80	1000	50000	208000	59.07
M4	80	450	9.48	500	40000	248000	70.43
M22	125	575	12.12	240	30000	278000	78.95
M11	210	785	16.54	140	29400	307400	87.30
M13	2500	3285	69.23	5	12500	319900	90.85
M12	1000	4285	90.30	10	10000	329900	93.69
M14	20	4305	90.72	400	8000	337900	95.96
M2	300	4605	97.05	20	6000	343900	97.67
M1	100	4705	99.18	50	5000	348900	99.09
M23	40	4745	100.00	80	3200	352100	100.00

	X	*Y*	*Z*
A – Items	M21, M24	M3	M4
B – Items	M22	M11	M13
C – Items	M12	M2, M1, M23	M14
	H	*M*	*L*
X – Items	M3, M21	M4	M24
Y - Items	M22	M11	M13
Z – Items	M14	M23, M1	M2, M12

Most valued items are M3 and M21 and they are to be cared most in the store. They must be ordered as per requirements. M2, M12 and M13 are cared least and may be ordered in bulk once in a year.

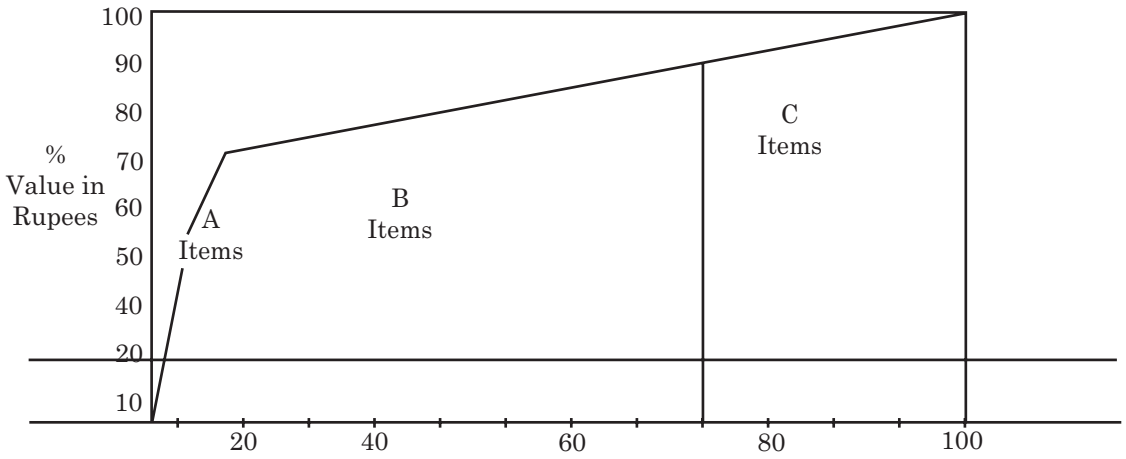


Fig. 12. Quantity of Items used in %

Example 3: Classify the various parts of a scooter in VED category.

Solution: V-Items of a scooter are all the engine parts like piston, cylinder, connecting rod, crank shaft, crank, gear assembly, clutch assembly and handle etc.

E-Items are engine body, covers, brakes, wheels, petrol tank, chain, head light and brake light etc.

D-Items are all other remaining parts like panels, gear and clutch wires, chain cover, indicators, all accessories and cables etc.

QUESTIONS

1. What is Inventory Planning?
2. Define inventory. Give its types and functions.
3. Why the inventories are necessary?
4. What are the advantages and disadvantages of storing inventories of materials?
5. Give the objectives of inventory planning and management.
6. What is materials requirements planning?
7. Give the difference between MRP-I and MRP-II.
8. Describe the method of materials requirements planning with example.
9. Give the structure of MRP system.
10. Explain the following terms (*i*) MRP (*ii*) BOM (*iii*) Item inventory (*iv*) Gross and net requirements.
11. What is Break Even Analysis? Why it is used?
12. Explain the following terms: Break Even Point (BEP), Margin of safety and Angle of Incidence.

13. What is the difference between fixed cost and variable cost?
14. How will you take *make or buy decision* in production system?
15. What are the strategies used to increase the profit of an organization? What is the effect of BEP changes?
16. What is the selective inventory control? Why it is used in inventory control?
17. Give the various analysis of selective inventory control techniques.
18. What is ABC analysis? How it is used? Describe it.
19. Describe the following types of analysis used in classification of items in inventory.
    (*i*) HML and XYZ analysis
    (*ii*) VED, VEIN and SDE analysis
    (*iii*) FSN, MNG, GOLF, S-O-S and FAN analysis.
20 What is combined analysis and how precisely items are classified by this method?

Examples

1. The toothpaste manufacturer wants to know the sales and profit to earn on this product. The fixed cost to manufacture it is Rs. 20000. Variable cost is Rs.10 per toothpaste tube. The sales are 5000 per year and its price is Rs.16. Find the BEP and sales to have profit of Rs.15000 per year. Suggest the various methods to increase the profit.

Ans. BEP = 3333, Profit = 10000 and Sales = 5833.

2. A firm has the following items in the store and its usage value and price are given below.

(1) Rank the items in descending order of value of usage.

(2) Divide the items in ABC category as follows

A-Items – 70% of usage cost B-Items – 20 % of usage cost and C-Items – 10 % of usage cost.

(3) Plot the graph of percentage usage and percentage quantity used.

(4) Quantities used in ABC categories.

Items	*Quantity used*	*Sales cost (Rs.)*
X11	50	120
X12	16	500
X13	175	15
X14	200	12
X15	350	10
X16	80	200
X17	40	800
X18	400	5

Ans. A-Items X17, X16, X12 Cost = Rs. 56000, 77% Usage = 136, 10%
B-Items X11, X15 Cost = Rs. 9500, 13.1% Usage = 400, 30.5%
C-Items X13, X14, X18 Cost = Rs. 7025, 9.9% Usage = 775, 59.5%

CHAPTER VII

Materials Requirements Planning

Introduction

Materials Requirements Planning (MRP -1) was introduced around 1960. The application of MRP to plan the materials in a production inventory control situations in a manufacturing concern I is used to achieve control over the flow of resources and to determine inventory needs. Implementation of this system requires the use of a computer. The procurement of a computer by small organization has now become economical and feasible as the cost of it is reduced and a suitable computer for any organization is available for its use. Therefore, this system of MRP can be used by small manufacturing organization as well to plan and control its production and inventories.

MRP System

Out of the seven important resources (7Ms) as given below. Materials is one, which requires lot of planning and controlling in the organization. The following are the important resources, which require proper planning and management in the organization.

1. Money
2. Materials
3. Manpower
4. Machines
5. Methods
6. Management
7. Matrix, which is system, facilities, plants and location etc.

The planning is done through human brains, his efforts and activities which control these resources optimally for some useful output. Today, computers are used for this purpose. The new methodology of materials planning system using computer is called materials requirements planning (MRP). Since it is first introduced in a production-inventory system in an organization, it is called MRP-I. Later on the other resources and complete manufacturing activities are planned and operated, assisted by computers. This method of computer-assisted planning and managing all the resources of manufacturing is called Manufacturing Resources Planning. It is now called as MRP-II system. The management information system called as

MIS is used to communicate information to managers to plan and control the resources which are transformed in to some utility output is now largely used as E-manufacturing and E-business system in most of the large manufacturing and business organizations. The information is recognized as resource and it is to maximize the utilization of other resources as manpower, money, materials, and machines. The manager attempts to minimize the amount of time during which resources are idle. To keep them functioning at their peak efficiency, they are fully utilized at critical time and contributes to give maximum output to organization. Manufacturing information system used on computer consists of Computer- Aided Design (CAD), Computer-Aided Manufacturing (CAM), Robotics and MRP. Using MRP, system controls all the materials.

Use of MRP by a Manufacturing Concern

MRP calculates item demand and time phases all inventory status data in time increments as fine as the user has specified. The variability of requirement over a fixed period of time is uncertain and the statistical methods to control this variability fails. The physical control over these requirements is difficult for complex manufacturing enterprises. For small manufacturing concern, it may be uneconomical because of record keeping and cost accounting.

This may sometimes lead to lack of control. The MRP system as explained below will indicate that this control is simplified and systematized by the use of computer. In practice, building buffer stock of work-in-process inventory between departments and between operations ensures a high utilization of production resources at the cost of a high investment in work-in-process inventories particularly in small discrete parts manufacturing enterprise. The MRP system developed here reduces this investment .

End product demand, which is either obtained from previous records or by forecasting, is called *independent demand* since it originates independently. However, the demand for subassemblies, components, parts and raw material stock is derived from the planned production levels of the end products. Production planning determines master production schedule for end products. The requirements for subassemblies, components and raw materials related to those end products can be simply computed. The demand for these items is dependent on the planned production of final products.

The three portions of MRP system are:

(*a*) Dependent demand of components

(*b*) Net requirement of component parts

(*c*) Lead time offsetting and time phasing of all these parts

The manufacturing routing sheets and product bill of materials describe the departmental routings and production lines to manufacture subassemblies and components. Using these database in conjunction with schedule of end-product requirements. it is possible to compute the timing of production of each component and part to meet the given end-product schedule. This computation is called Net Requirements and Time phasing. MRP computes the timing of all the subassemblies, components, parts and raw materials procurement. The quantity in stock or in inventory in any period is reduced from net requirement and the leadtime required to produce or receive the orders is offset to place the orders of requirements. So, obtained at this offset time schedule. This is done in such a way as to attempt to minimize work-in-process inventory.

The structure of MRP system is illustrated level by level in Fig. 1 given below. The master schedule, bill of materials, inventory transaction, requirement of service parts and spares are supplied to the MRP processor through various files.

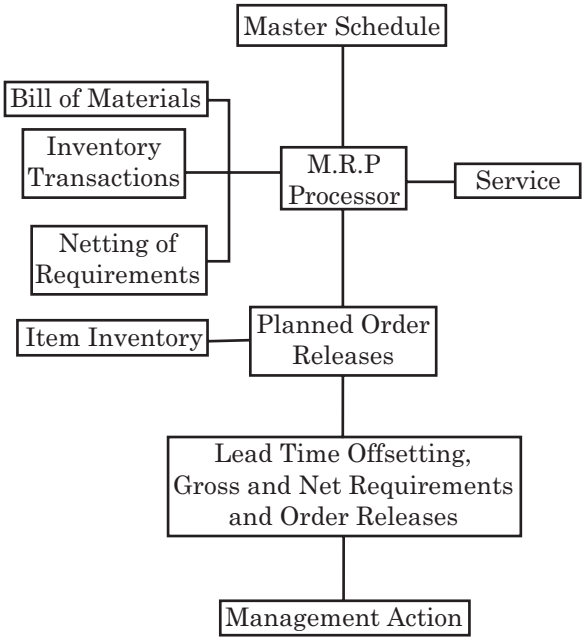


Fig. 1. M.R.P. Structure

Development of MRP

The end product demand is independently calculated either by sales forecasting or by orders received from the customers. The demand of product is scheduled for production, which is called Master Production Schedule (MPS). The materials are procured as per the MPS requirements of end products. The calculations of materials requirements at various levels of production are dependent demand items which enter at different subassemblies and components. This demand of items is obtained from bill of materials. In this way, all the materials and parts requirements are calculated and MRP system is planned and developed.

The following things are required for this.

(*i*) The complete production structure of final product called B.O.M. explosion.

(*ii*) The lead time required to produce or purchase the different items at various levels of production system.

(*iii*) End product demand and delivery schedule as MPS.

(*iv*) The materials and parts stored as inventory ready to supply.

(*v*) The purchase orders, which can be placed to procure the items, which are not produced.

In order to plan this and accomplish the function of inventory management, the following information is necessary.

(*i*) Record of independent demand or sales of items or end product.

(*ii*) List of all components and materials required to be sold or entering into assemblies of end product.

(*iii*) Identification of these components or materials by some part number.

(*iv*) Demand or quantity required of each material to manufacture end item.

(*v*) Quantity of each material procured and existing as inventory.

Computer Program

A computer program is developed as MRP processor, which calculates demand of each component and part. This is explained in the example for a Toy Car assembly in which five items are required to manufacture it. The item inventory file stores the inventory of these items and it is the input for finding the net requirements and time phasing of these requirements are obtained. The computations for this example are explained below for *toy car monufacturing model.*

Flow Chart

The computer program developed for MRP is explained by the flow chart shown in Fig. 2. given below. The program requires the following files and data to give the materials requirements:

1. *Bill of Materials File*

In bill of material explosion (BOM)

The end product is assigned level – 0 ,

Subassemblies assigned level – 1

Parts of subassemblies assigned level – 2

Components of these parts assigned level – 3 and

Raw materials assigned level – 4

2. *Item Inventory File*

Item inventory file supplies the quantity of each item in inventory and rest of the computations is done by MRP processor. The net requirements and time phasing of order to be released are the final output for suitable management action to take place. The Toy Car manufacturing is a small enterprise to demonstrate the MRP system but it is a useful model for the application and understanding this system.

The output of bill of materials file for which a computer program is developed and the output is shown in figure 5.as Toy Car assembly bill of materials.

The output of item inventory file is shown in figure 6. Number of parts required for five Toy Car end items. Number of parts in inventory as ON HAND and the net requirement of each part to get five final Toy Car assemblies are the outputs obtained from this program.

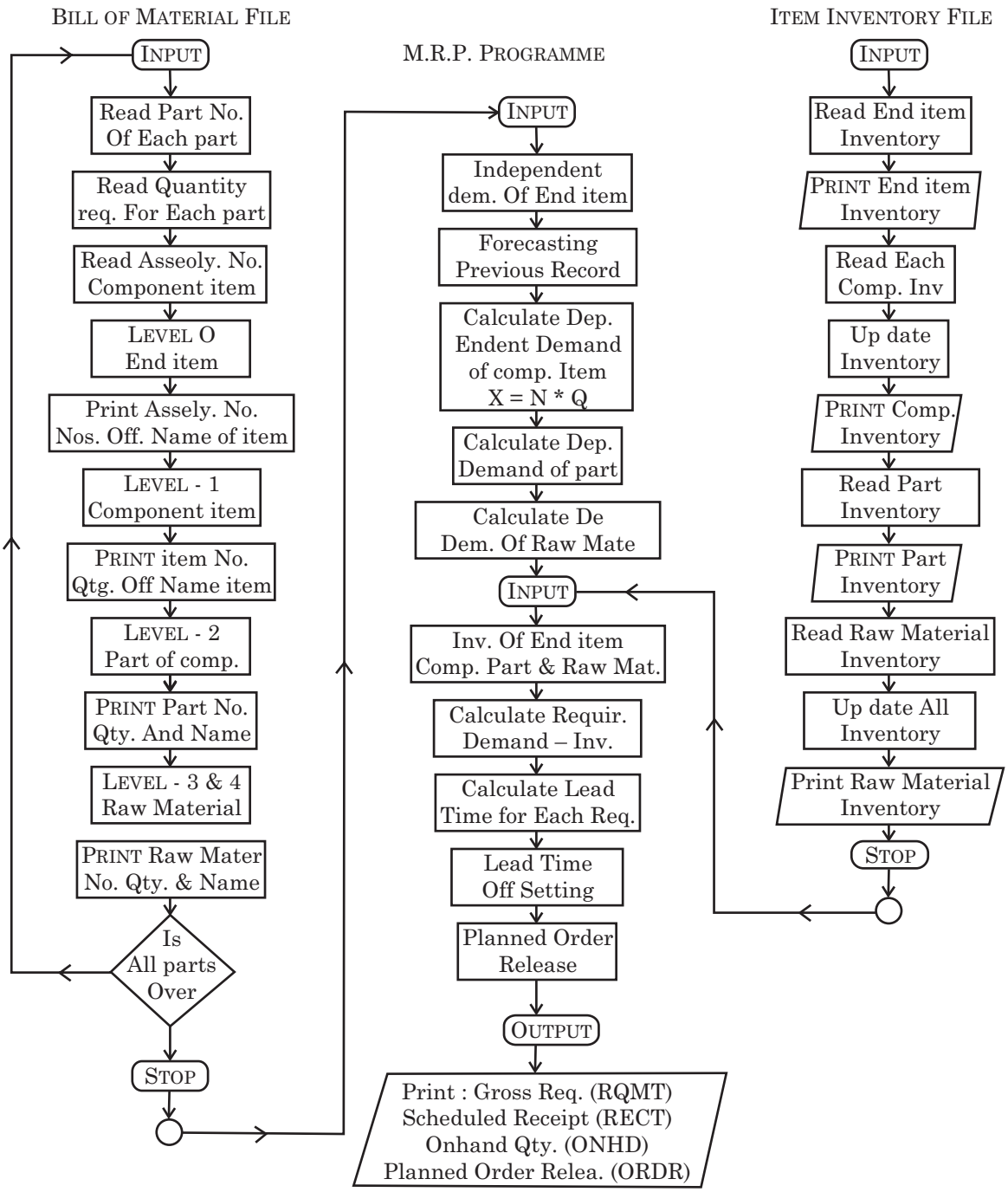


Fig. 2. Flow Chart for M.R.P.

Application of MRP System and its Computer Model

Application of materials requirements planning system model in a small manufacturing concern as an example of a case study is explained in details below.

The methods of MRP system are not new. However until recently, it has not been economically practical to employ these methods in small manufacturing concern. In large complex manufacturing enterprises also its use was not much encouraging. But the dramatic reduction in cost and availability of computer has made it possible for industrial managers to use this system which can store and retrieve large data and has fast computational capabilities, at the same time it is simple to use. Therefore, a simplified model developed here illustrates that any small or large-scale manufacturing company can adopt the MRP system.

The case study is developed for a single product however same can be extended for multi-product manufacturing as well.

Toy Car Manufacturing

The model is developed for MRP to be used in a small concern for manufacturing a Toy Car and the case study computer program has been developed as an application of MRP system in toy car manufacturing. The inventory planning is required for manufacture of toy car whose demand is independent and can be forecasted or predicted from previous records. The bill of materials calculates the requirements of components, parts and materials like case labels, packing case, car box, axles, plastic dye-red, plastic powder and plastic dye-black. If any spare parts or service items (like axles and packing cases) are separately added to each individual materials demand.

From the item inventory file, which is updated, time to time the inventory transactions of receipts and issues are fed to the MRP processor. The MRP processor gives the outputs which are called as the *planned order release* for which the suitable policy action can be taken by the management to purchase the various materials. The BOM and item inventory files along with service and spare parts files are processed by MRP programme as shown in Figs. 2 and 3.

Application of a Material Requirement Planning System Model in a Small Manufacturing Concern—A Case Study

Toy Car Components and Parts

In manufacturing of toy car its components are –

1. Body
2. Wheel and axle unit

(*i*) **Body –** It is made up of plastic dye red and plastic powder.

(*ii*) **Wheel and axle unit –** Four wheels attached to two axles (made of steel) are made from plastic dye black and plastic powder. The other parts are car box for putting toy car in it and a plastic case containing 24 car box packages and a label put on the packing case.

The notion of the dependent demand requires the following two assumptions: (1) The product is made of several things. (2) We want to make the product. This notion is fulfilled by BOM structure.

Bill of Material Structure for Toy Car Assembly

The simplest structure for toy car assembly is summarised as part list. Summarised bill of material however is too compact reveal the quantity of raw material needed for each component part (Fig. 2).

Toy Car Parts List

Assembly

Part no.	*Quantity*	*Description*
10001	1	Case lable
10002	1	Packing case
20001	1	Car box
50001	48	Axles
40001	24	Plastic dye-red
40002	216	Plastic powder
60001	96	Plastic dye-black

Fig. 3 : Summarised bill of material

Assembly	*Part no.*	*Quantity*	*Description*
1000			Toy car (case lot)
	10001	1	Case label
	10002	1	Packing case
	20000	24	Toy car package
20000			
	20001	1	Toy car package Car box
	30000	1	Toy car
30000			Toy car
	40000	1	Body
	50000	2	Wheel/Axle unit
40000			Body
	40001	1	Plastic dye-red
	40002	5	Plastic powder
50000			Wheel/Axle unit

Contd...

Assembly	*Part No.*	*Quantity*	*Description*
	50001	1	Axle
	60000	2	Wheel
60000			Wheel
	40002	1	Plastic powder
	60001	1	Plastic dye-black

Fig. 4. Bill of material explosion

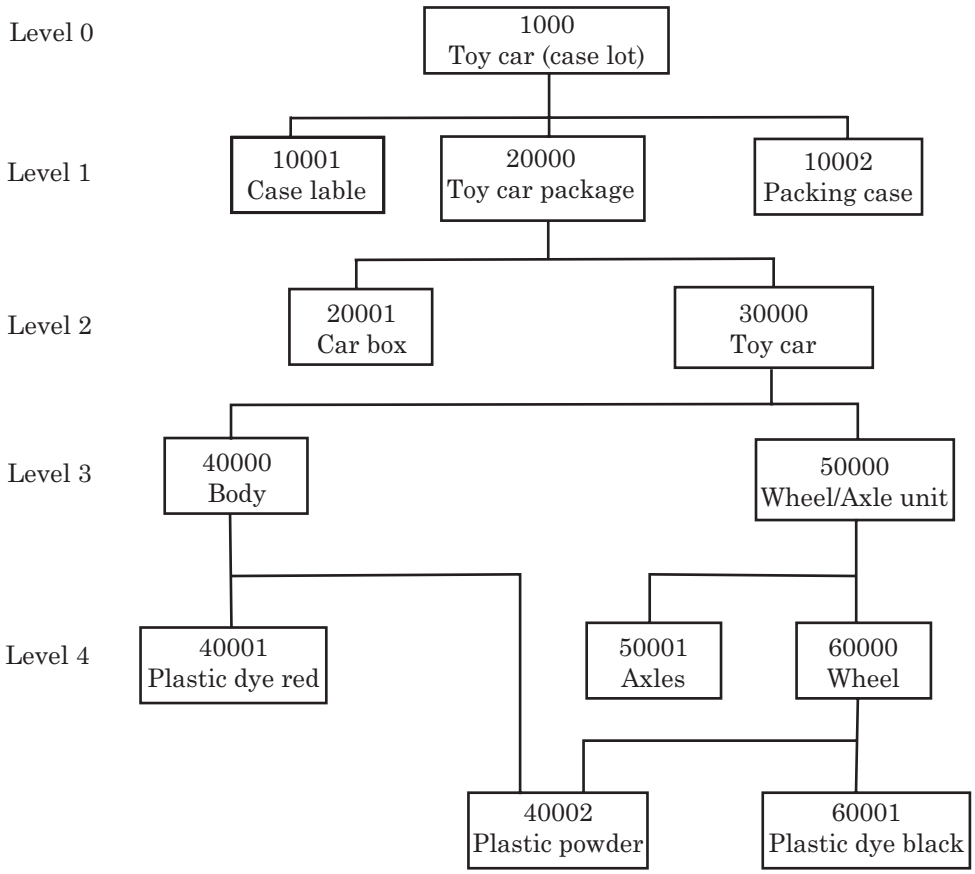


Fig. 5. Bill of material structure

The bill of material explosion is shown in Fig. 3. This gives the complete detail of each end item, component part, part list and raw material along with numbers for each assembly and part number. It also gives the level of each assembly at which it is made MRP is multi-level manufacturing system. End product assembly is given the lowest number, 10000 and it is also a lowest level and product zero level (can be given 1st level).

The alternative multilevel BOM structure of Toy Car assembly is shown in Fig. 4.

Net Requirements

The gross requirement for each part is obtained from BOM. The item inventory file where inventory On Hand of each part is supplied. The net requirement is obtained as below:

Package	
Gross requirements	24
On Hand	7
On Hand finished	5
Toy car	
Net required	12

The computer output of MRP programme lists the part list, part no., quantity required for 5 units of demand for toy car, on-hand inventory and net required.

Lead Time Offsetting

Assuming the toy car takes nine wheels to complete the assembly and the lead time supplied to computer for each item. The number of items available in each week in inventory for each part is supplied and updated every week in data file and these transaction of items is given as On-Hand inventory lead time, quantity available and week number.

Toy Car Assembly Bill of Material Toy Car Parts List Assembly 00099 (Toy Car Lot)

Assembly	*Part*	*Quantity*	*Description*
10000			Toy car (case lot)
	10001	1	Case lable
	10002	1	Packing case
	20000	24	Toy-car package
20000			Toy-car package
	20001	1	Car Box
	30000	1	Toy Car
30000			Toy Car
	40000	1	Body
	50000	2	Wheel/Axle unit
40000			Body
	40001	1	Plastic dye-red
	40002	5	Plastic powder

Cont....

Assembly	*Part*	*Quantity*	*Description*
50000			Wheel/Axle unit
	50001	1	Axles
	60000	2	Wheel
60000			Wheel
	40002	1	Plastic powder
	60001	1	Plastic dye-black

Fig. 6. Bill of Material File

Car Assembly and Part Requirements Assembly 00099 (Toy Car Lot)

10000, 5, 0, 0, 5
10001, 5, 0, 0, 5
10002, 5, 0, 0, 5
20000, 120, 0, 0, 120
20001, 120, 75, 75, 45
30000, 120, 5, 5, 115
40000, 120, 7, 12, 108
50000, 240, 0, 10, 230
40001, 120, 0, 12, 108
40002, 1080, 0, 80, 1000
50001, 240, 37, 47, 193
60000, 480, 0, 20, 460
60001, 480, 0, 20, 460

Description	*Part*	*Required*	*On-hand*	*Net*
Toy car case lot	10000	5	0	5
Label	10001	5	0	5
Case	10002	5	0	5
Package	20000	120	0	120
Box	20001	120	75	45
Car	30000	120	5	115
Body	40000	120	7	108
Wheel/Axel	50000	240	0	230
Red dye	40001	120	0	108
Powder	40002	1080	0	1000
Axle	50001	240	37	193
Wheel	60000	480	0	460
Black dye	60001	480	0	460

Figs. 7 & 8. Item Inventory file, Gross Requirement and Inventory

From these inventory transactions and net requirements each week, the following quantities are calculated each week.

RQMT – Gross requirment each week

RECT – Net requirement each week

ONHD – Quantity on hand each week (net requirment – receipts)

ORDR – Quantity ordered lead time before it is required

So that the end of planning period a specific number of end product is available to meet the required demand.

For manufacture of say 5 units of Toy car assembly packages (in this study unit be = 5000 toy car assembly packages) 9 weeks time is required. The complete computer output of net requirement and lead time offsetting is shown in Fig. 10. It indicates name and number of item, quantity in hand, lead time and RQMT (Gross requirement), RECT (Receipt), ONHD (Inventory on hand). ORDR (order released offsetting by lead time) so that at the end of 9 weeks complete assembly of 5 units of toy car assembly packages are available in stock to deliver to the customer.

The flow chart shown (Fig. 2) can also be used to develop a computer programme for large-scale complex manufacturing system for multiproduct.

Time phasing of Toy car parts in inventory

PART	OH	LT	TY	WK	TY	WK	TY	WK	TY	WK
20001	0	1	0	0	0	0	0	0	0	0
20001	0	3	25	1	0	0	0	0	0	0
20002	0	2	25	1	0	0	0	0	0	0
20003	0	1	0	0	0	0	0	0	0	0
20001	75	3	0	0	0	0	0	0	0	0
30001	5	1	3	2	5	4	0	0	0	0
40001	7	1	10	1	0	0	0	0	0	0
50001	0	1	0	0	0	0	0	0	0	0
40001	0	2	0	0	0	0	0	0	0	0
40002	0	1	90	1	90	3	90	5	90	7
50001	37	1	0	0	0	0	0	0	0	0
60001	0	1	0	0	0	0	0	0	0	0
60001	0	2	0	0	0	0	0	0	0	0

Fig. 9. Time Phasing of Items in Inventory

Lead time offsetting and Net requirements of Toy car parts

TOY CAR	Case	lot 10000		5	0	1			
00	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0		0	0	5
RECT	0	0	0	0	0	0	0	0	0
ONHD	0	0	0	0	0	0	0	0	5
ORDR	0	0	0	0	0	0	0	5	0
LABEL		10001	5	0	3				
20001	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0	0	0	5	0
RECT	25	0	0	0	0	0		0	0
ONHD	25	25	25	25	25	25	25	20	20
ORDR	0	0	0	0	0	0	0	0	0
CASE			10002	5	0	2			
20002	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0	0	0	5	0
RECT	25	0	0	0	0	0	0	0	0
ONHD	25	25	25	25	25	25	25	20	20
ORDR	0	0	0	0	0	0	0	0	0
PACKAGE			20000	120	0	1			
20000	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0	0	0	120	0
RECT	0	0	0	0	0	0	0	0	0
ONHD	0	0	0	0	0	0	0	120	120
ORDR	0	0	0	0	0	0	120	0	0
BOX			20001	120	75	3			
20001	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0	0	120	0	0
RECT	75	0	0	0	0	0	0	0	0
ONHD	75	75	75	75	75	75	45	45	45
ORDR	0	0	0	45	0	0	0	0	0
CAR			30000	120	5	1			
30000	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0	0	120	0	0
RECT	8	0	0	5	0	0	0	0	0

Contd...

ONHD	8	8	8	13	13	13	107	107	107
ORDR	0	0	0	0	0	107	0	0	0
BODY			40000	107	7	1			
40000	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0	107	0	0	0
RECT	17	0	0	0	0	0	0	0	0
ONHD	17	17	17	17	17	90	90	90	90
ORDR	0	0	0	0	90	0	0	0	0
WHEEL/AXLE			50000	214	0	1			
50000	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	0	214	0	0	0
RECT	0	0	0	0	0	0	0	0	0
ONHD	0	0	0	0	0	.214	.214	.214	.214
ORDR	0	0	0	0	214	0	0	0	0
RED DYE			40001	90	0	2			
40001	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	90	0	0	0	0
RECT	0	0	0	0	0	0	0	0	0
ONHD	0	0	0	0	90	90	90	90	90
ORDR	0	0	90	0	0	0	0	0	0
POWDER			40002	878	0	1			
40002	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	878	0	0	0	0
RECT	90	0	90	0	90	0	90	0	0
ONHD	90	90	180	180	608	608	518	518	518
ORDR	0	0	0	608	0	0	0	0	0
AXLE			50001	214	37	1			
50001	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	214	0	0	0	0
RECT	37	0	0	0	0	0	0	0	0
ONHD	37	37	37	37	.177	.177	.177	.177	.177
ORDR	0	0	0	117	0	0	0	0	0
WHEEL			60000	428	0	1			
60000	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	0	428	0	0	0	0

Contd...

RECT	0	0	0	0	0	0	0	0	0
ONHD	0	0	0	0	.428	.428	.428	.428	.428
ORDR	0	0	0	428	0	0	0	0	0
BLACK DYE			60001	428	0	2			
60001	1	2	3	4	5	6	7	8	9
RQMT	0	0	0	428	0	0	0	0	0
RECT	0	0	0	0	0	0	0	0	0
ONHD	0	0	0	.428	.428	.428	.428	.428	.428
ORDR	0	428	0	0	0	0	0	0	0

Fig. 10. Lead Time Outsetting and Net Requirements

Manufacturing Resource Planning

The manufacturing resources planning is integrative type of planning for production of a manufacturing system and is referred to as MRP-II . It is developed after MRP-I.

MRP-II System

Planning the complete production system and all the resources required in manufacturing a product in the industry, manufacturing resources planning (MRP-II) system is used. It is discussed below.

Manufacturing resource planning consists of the following:

Business planning

Marketing planning

Production planning

Resources planning

Rough-cut capacity planning (RCCP)

Capacity requirements planning (CRP)

Top management planning

Operations management planning

Materials requirements planning (MRP-I)

Business Planning

Selection of product and the customers who will buy that product is related to the business of a company. All the activities necessary for sale of the product is planned in business planning. It includes product development, design and requirement as per customers need through market survey, research and sales promotion.

Marketing Planning

Conducting market survey, sales records and the share of the sales using the forecasting techniques to find production quantity. It is necessary to know demand fluctuations of market and competition for sale of the product.

Resources Planning

The various manufacturing resources are (1) Money (2) Materials (3) Manpower (4) Machines (5) Methods (6) Various facilities, plant and buildings (7) Management.

All these resources are planned using the different techniques of production planning and operations management planning. Operations research techniques help in optimization of various resources. The different production machines will be selected as per capacity of production of the organization.

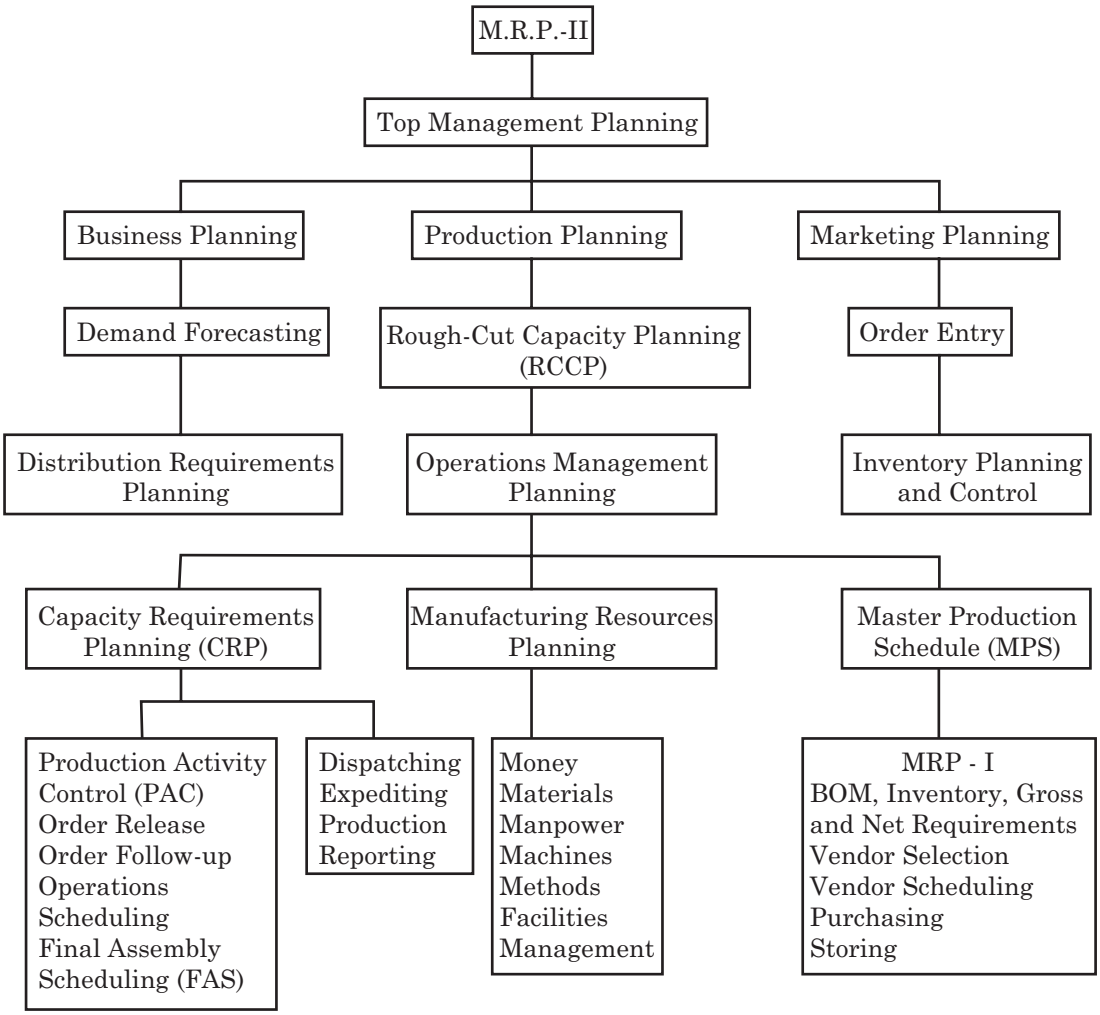


Fig. 11. MRP-II System

Production Planning

It is done through MRP-II. Rough-cut capacity planning, capacity requirements planning and then master production schedule is found out, which is used in materials requirements planning (MRP-I).

Rough-Cut Capacity Planning (RCCP)

After receiving orders and forecasting, the demand for sale of product by the company, the rough cut planning is done to plan tentative production capacity of the plant.

Capacity Requirements Planning (CRP)

The exact capacity of the plant is decided after finding the demand of the product, the organization can fulfill with the available resources particularly the money which will be invested in the plant. Materials required for manufacturing plays important part in deciding capacity of the plant.

Top Management Planning

The objectives and business policies are decided in top management planning. The final manufacturing systems, types of machines and technology needed for production is decided after capacity requirements planning and Master Production Schedule (MPS). Master production programs, plant location, types of building and manufacturing systems are decided by the top management. These things are the decision making in top management planning.

Operations Management Planning

The various facilities are planned and developed as per production systems, methods of manufacturing technology and types of machines used. Operations sequences are decided and plant layouts are prepared. Flow chart, routing and scheduling process is finalized. Man power selection and placement is made by various selection methods. Finally dispatch of orders for production is done. The follow-up action expedites the production activities. The control of all the production activities is done by using modern methods of Manufacturing Information System (MIS).

Materials Requirements Planning (MRP-I)

As per Master Production Schedule (MPS) materials are planned, purchased and inventory is controlled using Materials Requirements Planning (MRP-I) system, which is discussed earlier. Materials requirements planning requires bill of materials explosion (BOM) and it needs

- Demand management
- Forecasting
- Distribution requirements planning (DPR)
- Order input
- Inventory planning and control
- Final assembly scheduling (FAS)

MRP-I is supported by

- Purchasing

Vendor selection

Order placement

Vendor scheduling

Order follow-up

Operation management execution

These activities are directly related to production activities in the manufacturing system and helps in production planning and control, which is further needed for Manufacturing Resources Planning (MRP-II) for

Production activity control

Order release

Operations scheduling

Dispatching

Expediting

Production reporting

When MRP-I leads to performance measurement thereby MRP-II supported by it has high performance. MRP-II system is also computer-based method. The overview of this system is given below:

System Overview of MRP-II

It consists of

Production planning

Planning inventories

Capacity planning

Authorization of procurement and production

Control over materials, capacities and production

Storage and movement of materials, parts and finished stock

The complete MRP-II supported by MRP-I, sales forecasting, inventory planning, capacity planning , production planning and control will develop and run the organization most efficiently and effectively. This type of MRP-II system is given in 11.

CHAPTER VIII

Break Even Analysis

Introduction

Every organization aims at earning the profit and maximizing it. The planning is necessary for this. Break Even Analysis (BEA) is one of the method used to determine how much production can be done by the manufacturing organization and sell in the market so that it will give the earning more than all the expenses required to manufacture the products and give the profits. By doing the analysis of the sales, the cost of product and quantity sold the amount of profit obtained can be found out.

Break Even Chart and Break Even Point

The cost of product is of two types. *Fixed cost* and *variable cost*. Assuming that the sales price of the product remaining same throughout the year or for a particular period of analysis, the cost, sales revenue and profits are plotted against the quantity or volume of the product sold in that particular time or a year on a chart. This graph or chart of cost versus quantity sold is called Break Even Chart. The break even analysis is used to find out the point in this graph at which the revenues obtained by sale of the product or service and the cost of the product becomes equal. This point is called Break Even Point (BEP). The quantity or volume of sales at this point neither earns a profit nor incurs a loss. It is the quantity beyond which if the sales are there, the profit will be earned by the organization Therefore, the aim of every firm is to know the break even point so that it will sell more than this amount of products to get more and more profits.

The production and sales should never fall below the Break Even Point; otherwise there will be a loss to the company. To plan the profit the effects of various factors must be analyzed. The various alternatives, which increase the sales, should be evaluated. Today the profit is multi-dimensional phenomenon and this concept should be followed. The profit depends on selling prices, manufacturing cost, quantity and volume of sales and product mix.

The break even analysis reveals the profit structure of the company. It decides about fixing the prices of the product, how to reduce the cost of manufacturing. Sales promotion policies make and buy decisions and various profitability decisions to make so that return on capital invested should be more. Planned decisions on prices, costs, quantity volume, expenditure and profit can be made by doing proper Break Even Analysis by the management

and experts of the company for present and future developments and expansions. It must be flexible and easily adapted to changing situations.

Break even analysis will study the economical position of the organization. The following methods are used for that. The sales data and costs for one year can be taken for this analysis.

Finding Break Even Point and Margin of Safety

The break even point can be determined in two ways:

1. In terms of physical units i.e., quantity or volume of sales of products
2. In terms of sales value in rupees

1. *In Terms of Physical Units*

The quantity of product sold in a particular period which is just sufficient so that cost of its production and sales in rupees is same. It earns the money just sufficient to equal the expenses. The break even point is given as

$$\text{B.E.P.} = \frac{\text{Fixed cost}}{\text{Selling price} - \text{Variable cost per unit}}$$

2. *In Terms of Sales Value in Rupees*

The companies selling multiproducts may not be able to decide the quantity or volume of units sold and the prices of products will also vary. These companies or firms can determine the BEP in terms of money earned as total sales in rupees. In this case, the BEP will be the point where the contribution margin which is equal to sales value – variable cost = fixed cost. Contribution margin is expressed as a ratio to sales.

$$\text{The BEP is given as BEP} = \frac{\text{Fixed cost}}{\text{Contribution ratio}}$$

$$\text{Contribution ratio} = \frac{\text{Sales value} - \text{Variable costs}}{\text{Sales value}}$$

Margin of Safety

The actual sales must be more than BEP to have the sufficient profit. The margin of safety is the difference between the actual production or sale and BEP. If margin of safety is small, the little decrease in sales will reduce the profit greatly and if margin of safety is large, the small reduction in production will not affect the profit.

Angle of Incidence

The angle between the sales line and total cost line at the point of intersection i.e., BEP, is known as Angle of Incidence. If this angle is large, it indicates large profit and if it is small, the profit is less and not favorable.

Graphical Presentation of BEP

The graph is plotted between the cost and sales income in rupees on vertical axis and quantity or output as sales unit on horizontal axis. See Fig. 1.

Tc = Total cost

F = Fixed cost

Vc = Variable cost

a = Variable cost per unit

Q = Quantity sold

I = Sales income

b = Price per unit quantity sold

Vc = a .Q

I = b . Q

Tc = F + Vc = F + a.Q

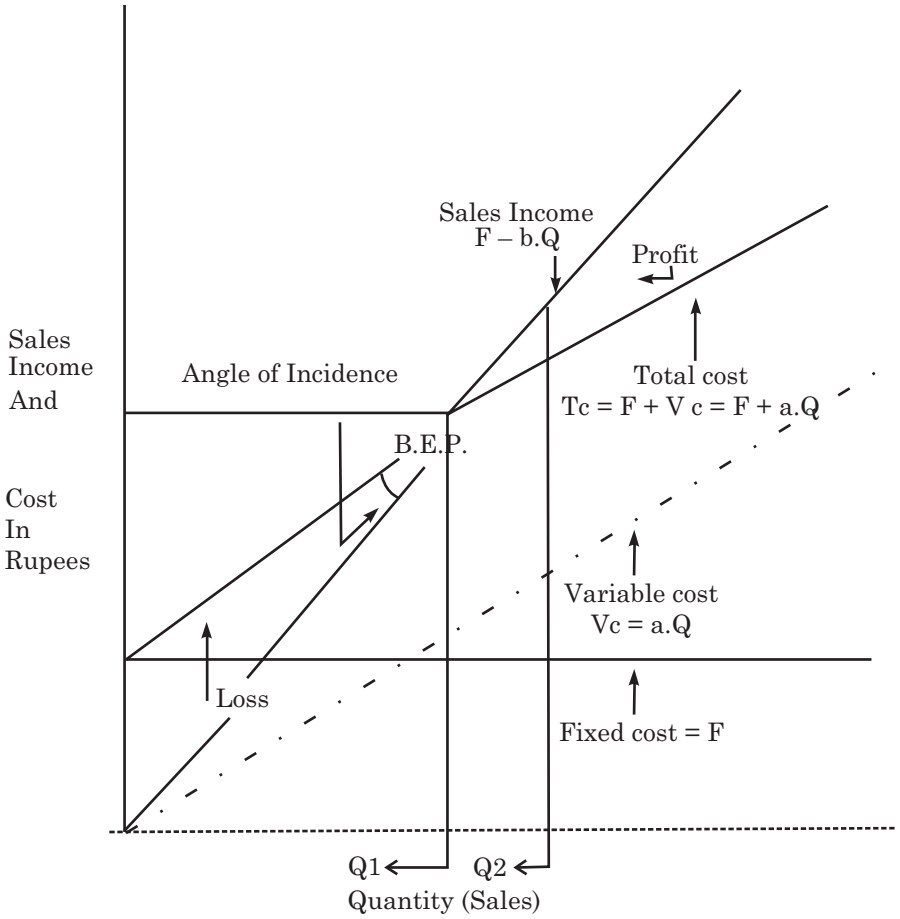


Fig. 1. Break-even chart

The fixed cost line is shown as horizontal line. Variable cost, total cost and sales income lines are inclined. The sales income line intersects the total cost line at a point which is called Break Even Point as shown on the Break Even Chart in Fig. 1. The quantity Q1 at this BEP is the minimum quantity where the total cost and sales income are same. Activity below BEP is loss and above BEP is profit.

Equating both $I = Tc = F + Vc$ ...(*i*)

$$b.Q1 = F + a.Q1 \quad \text{...(}ii\text{)}$$

$$Q1.(b - a) = F$$

$$Q1 = \frac{F}{b-a} \quad \text{...(}iii\text{)}$$

If the plant is operating at a point Q2, it is working with margin of safety dQ which can be defined as

$$dQ = \frac{Q2-Q1}{Q1} = \frac{Q2}{Q1} - 1$$

$$Z = \text{Profit} = \text{Sales income} - \text{Total cost} = I - Tc$$

$$= b.Q2 - (F + a.Q2) = (b - a)\,Q2 - F$$

$$Z = (b - a)\,Q2 - F \quad \text{...(}iv\text{)}$$

$F = Q1\,(b - a)\,b - a = F/Q1$ ... substituting in (*iv*)

$$Z = F\left(\frac{Q2}{Q1} - 1\right) \text{ but } dQ = Q2 - Q1$$

$$Z = dQ \,.\, F$$

$$\text{Margin of safety } dQ = \frac{Z}{F} = \frac{\text{Profit}}{\text{Fixed cost}} \quad \text{...(}v\text{)}$$

$$dQ = \frac{Q2 - Q1}{Q1} \qquad dQ \,.\, Q1 = Q2 - Q1$$

$$Q2 = Q1\,(1 + dQ) = Q1\left(1 + \frac{Z}{F}\right)$$

Desirable level of plant activity $Q2 = Q1\,(1 + Z/F)$ ...(*vi*)

$$\text{Desirable level} = BEP\left(1 + \frac{\text{Profit}}{\text{Fixed cost}}\right)$$

This indicates that if margin of safety is too small (operating near BEP), the plant will be prone to market fluctuations. See Fig. 2.

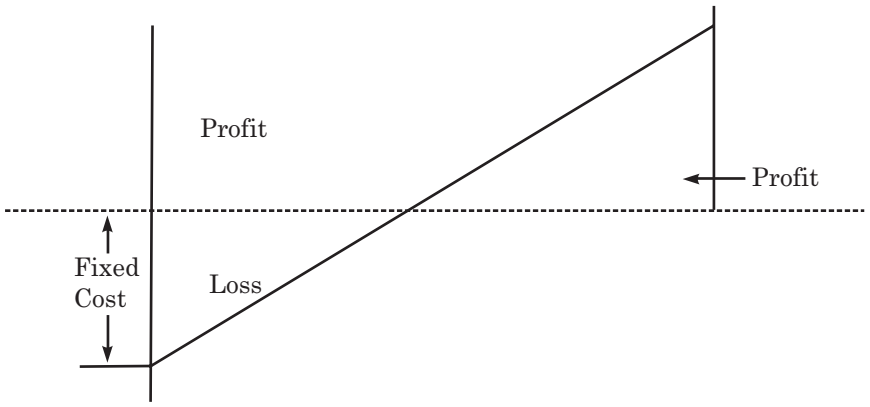


Fig. 2. An annual profit volume chart

The economics of new design If Z1 = Profit of old design

Z2 = Profit of new design

q1 = Sales price – Cost price = b – a

Z1 = (b – a) Q1 – F

Z1 = q1Q1 – F

q2 = b – a and Fixed cost = F – S

Z2 = q2Q2 – (F –S)

Z2 - Z1 = q2Q2 – q1Q1 – F + S + F = q2Q2 – q1Q1 + S

To have more profit in new design Z2 - Z1 > 0 or q2Q2 – q1Q1 + S > 0

This concludes that to have more profit in new design, q2Q2 – q1Q1 should be more i.e.

(i) Difference of price and variable cost multiplied by BEP should be increased, and

(ii) Fixed cost should be reduced by S.

Example 1. An Electric goods shop selling the tube lights has the following data of its monthly sales. How will it improve the profit on selling the tube lights? How many tube lights must be sold so that it will earn profit? Calculate Break Even Point, Quantity and Sales Cost.

Month	*Sales*	*Price (Rs.)*	*Unit cost (Rs.)*
January	425	100	90
February	510	110	90
March	620	105	90
April	780	120	90
May	850	100	100
June	710	90	100

Contd...

Month	*Sales*	*Price (Rs.)*	*Unit Cost (Rs.)*
July	940	120	100
August	650	110	100
September	585	108	110
October	980	95	110
November	460	130	110
December	770	125	110

Solution:

The sales income = Price × Sales; Total cost = Unit cost × Sales

Multiplying 2nd and 3rd column and 2nd and 4th column, the sales income and total cost are calculated. The profit is calculated as sales income – total cost. These values are tabulated as given below.

Month	*Sales*	*Income (Rs.)*	*Total Cost (Rs.)*	*Profit (Rs.)*
January	425	42500	38250	4250
February	510	56100	45900	10200
March	620	65100	55800	9300
April	780	93600	70200	23400
May	850	85000	85000	00
June	710	63900	71000	–7100
July	940	112800	94000	18800
August	650	71500	65000	6500
September	585	63180	64350	–1170
October	980	93100	107800	–14700
November	460	59800	50600	9200
December	770	96250	84700	11550
Total	8280	902830	832600	70230

The average values per month are found out as follows:

Sales average quantity = 8280/12 = 690

Average sales income = 902830/12 = Rs. 75235

Average total cost = 832600/12 = Rs. 69383

Average profit = 70230/12 = Rs. 5852

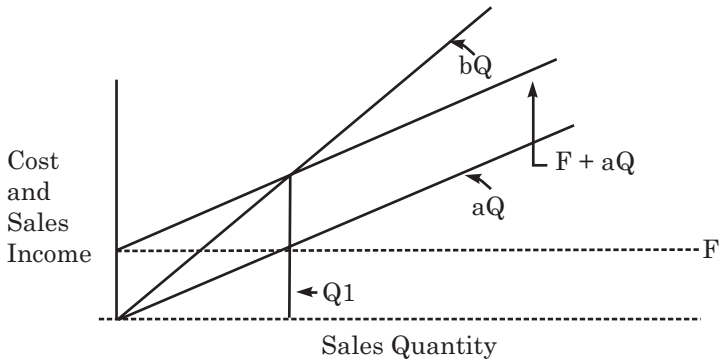


Fig. 3.

The values of Sales Income and Total Cost are plotted on the graph given in Fig. 3. The fixed cost is obtained from the graph as

F = Fixed cost = Rs. 9860 Q1= BEP = 450

$$a = \frac{\text{Average total cost} - \text{Fixed cost}}{\text{Average quantity}}$$

$$a = \frac{69383 - 9860}{690} = \frac{59528}{690} = \text{Rs. } 86.24$$

$$b = \frac{75235}{690} = \text{Rs. } 109$$

$$\text{Margin of safety} = dQ = \frac{Q2 - Q1}{Q1} \times 100 = \frac{690 - 450}{450} \times 100 = 53.3\ \%$$

To increase the margin of safety BEP (Q1) is to be lowered by three methods.

(*i*) Reducing the fixed cost F to F′, see Fig. 4.

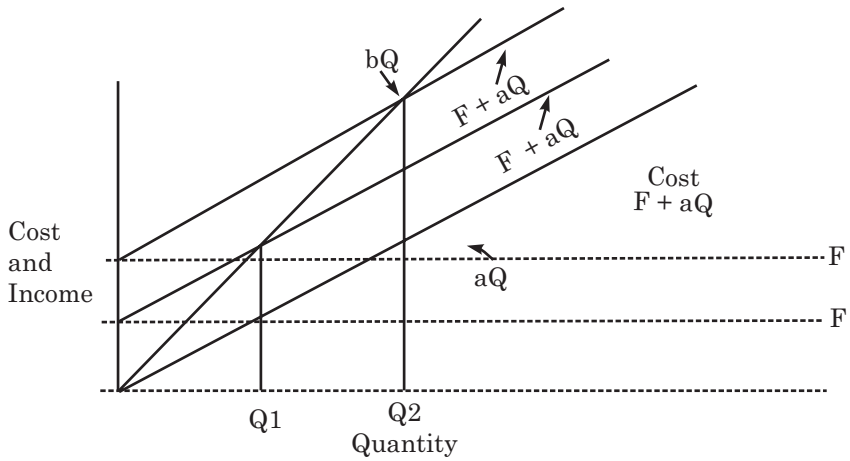


Fig. 4.

By reducing F to F′ $Q1' = Q1\frac{F'}{F}$

(*ii*) Reducing the variable coefficient a to a', see Fig. 5.

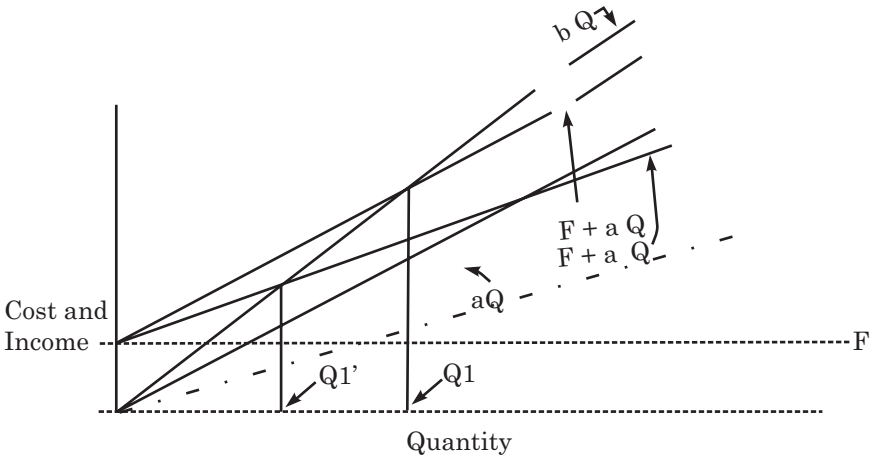


Fig. 5.

By reducing slope a to a′ $Q1' = Q1\frac{b - a}{b - a'}$

(*iii*) Increase the slope of the line b to b′, see Fig. 6.

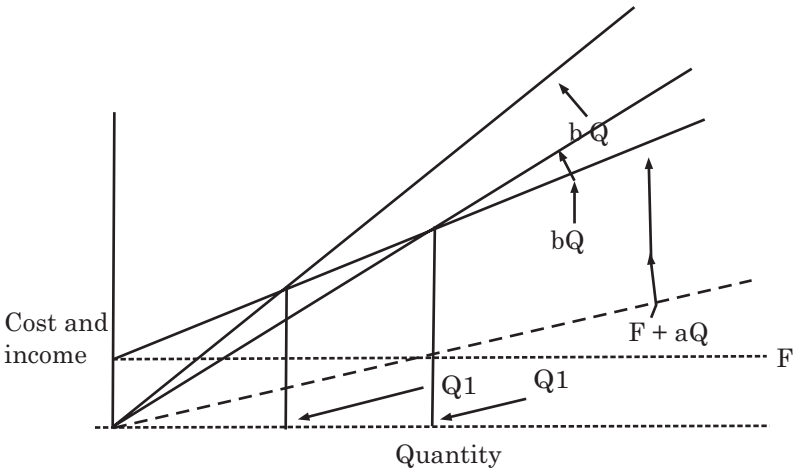


Fig. 6.

By increasing sales income b to b′ $Q1' = Q1\frac{b - a}{b' - a}$

To reduce BEP which increases profit, the three methods as described above by the graphs may be used. The new BEP in each of them will be as follows:

By decreasing the fixed cost F to F' new BEP is

$$Q1' = Q1\frac{F'}{F}$$

By reducing slope of unit cost of the product from a to a', new BEP is

$$Q1' = Q1\frac{b - a}{b - a'}$$

By increasing slope of price or income per unit sale b to b', new BEP is

$$Q1' = Q1\frac{b - a}{b' - a}$$

The reduction of variable cost aQ or fixed cost F will always be beneficial to reduce BEP and increase the profit of the organization as compared to increasing the price of the product bQ.

Example 2. Fixed cost of manufacturing soaps in a factory is Rs. 50,000 per year. The variable cost of its manufacturing is Rs. 2.50 per piece. If the selling price of soap is Rs. 6.00 per piece. Find out BEP.

Solution

$$\text{Break Even Point=BEP} = \frac{\text{Fixed cost}}{\text{Selling price} - \text{Cost per unit}} = \frac{F}{b - a} = \frac{50000}{6 - 2{\cdot}5} = \frac{50000}{3{\cdot}50} = 14286$$

BEP = 14286

Example 3. In the problem given above if the sales are 50,000 soaps per year. What is the profit per year. Calculate margin of safety. If the profit required is Rs. 2, 00,000 per year, calculate sales of soaps

Solution

Profit = 50000 × 6 – 50000 × 2.5 – 50000 – = 50000 (6 – 2.5 – 1) = 50000 × 2.5 = Rs. 125000

If the profit = 2, 00,000 = Q2 (6 – 2.5) – 50000

Q2 × 3.5 = 250000 Q2 = 250000/3.5 = 71428 soaps Q1 = BEP = 14286

Margin of safety = dQ = (Q2 – Q1)/Q1 = (71428 – 14286)/14286 = 57142/14286 = 4 d Q = 4

Profit = Rs. 1, 25,000

Sales of soaps = 71428

Margin of safety = 4

Cost, Volume and Profit Analysis

For planning the profit by the management, the technique used is called cost, volume and profit analysis. This technique uses Break Even Analysis. For determining the profit, the sales volume and price level must be known. The profit is the difference between total sales income and total cost. The total cost consists of fixed cost and variable cost.

Fixed cost: This cost is incurred for a period of time in fixed amount. It is also called *period cost, time cost, contact cost or standby cost*. The fixed salaries, rent, electricity etc. are fixed costs.

Variable cost: Variable cost is direct cost. It increases with volume or quantity of production. Direct labor, material and other expenses are considered as variable cost.

Volume of production: All the costs changes with change in production quantity. The production quantity changes with sales and its price. To optimize the profit the costs should be minimized. The profit optimization must be done using operations research techniques for different models of variable costs of production and materials used. Increasing the selling price.

Profits: The difference between revenues or income and cost is called *profit*. Its analysis is necessary for managing business of any company. The profit increases by the following methods.

(*i*) Increasing the selling price

(*ii*) Reducing the fixed cost

(*iii*) Reducing the variable cost

(*iv*) Increasing the sales volume

The Break Even Analysis is therefore an essential activity of the management to analyze profit from cost, sales price, and volume of sales. For this, the yearly data of cost, volume and profit (C-V-P) monthly-recorded column-wise are used. The following methods can be used to know the BEP and profits.

1 Using mathematical formulae

2 Using graphical charts.

Make or Buy Decisions of Products

The make and buy decisions are based on several important factors. These factors are labor, materials, production facilities, machines and capital etc. The Break Even Analysis is one of the method which is used to make this decision. The decision can be to produce part more economically in the organization or to purchase it from outside supplier at a cheaper price than production cost. By finding BEP and profits as explained in BEA the Board of Directors can take these types of decisions. This will be clear from the following example.

Example 4. A Television company wants to decide whether to manufacture color picture tubes or purchase them from suppliers. The price of picture tube is Rs. 2000 to purchase from supplier. The company will manufacture it then following costs will be required.

Fixed cost will be Rs. 12 lakhs and variable cost will be Rs. 1000 per picture tube.

Give the make or buy decision to Board of Directors of the company for the following cases.

1. The average sales of TV sets in a year is around 1000.
2. The sales are likely to be increased to 2000 by reducing the price of TV sets by 10%.

Solution

(*i*) $$\text{BEP} = \frac{\text{Fixed cost}}{\text{Purchase cost} - \text{Variable cost}} = \frac{1200000}{2000 - 1000} = 1200$$

If sales are 1000 TV sets, better to purchase color picture tube from supplier as BEP is 1200.

(*ii*) By reducing price 10%, cost of picture tube will be 1000 × 0.9 = 900.

$$\text{BEP} = \frac{1200000}{2000 - 900} = \frac{1200000}{1100} = 1099$$

If sales will increase to 2000 TV sets, color picture tubes can be profitably manufactured by the company.

Music-3D

Music-3D stands for Multi-Unit Selective Inventory Control – Three Dimensional Approach. The dimensions being considered are finance, operations and materials. It is based on 20/80 rule. The 20/80 rule is explained below:

20/80 Rule: It can be explained by the example as in sports or in marks obtained by the students it is observed that only about 20 % of the sportsman get 80 % of medals or 20 % of students score about 80 % of marks and remaining 80 % get only 20 % 0f medals and rest of 80 % students score less marks. In the same way in Industries only 20% of materials required for production requires about 80 % of total cost of materials used in producing the final product and only 20 % of the cost is spent for bulk of 80 % materials. It is Just like 20 % people are big industrialist having 80 % of wealth and only 20 % of wealth is distributed to 80 % of people who really work for the society and the industries as employee.

This is the 20/80 rule. This 20/80 rule is also known as Pareto's Law. According to it only about 20 % people account for about 80 % activities and 80 % of the people are engaged in about 29 % activities. The Pareto's law is based on the principle that 'few are vital and many are trivial'.

The Selective Inventory Control identifies the materials which are 20 % in quantity and having about 80 % cost classified as A items and 30 to 35% are having 15 % cost classifies as B items and remaining 50 to 55 % are having only 5% of total cost are called C items. This is a very important ABC classification used in storing the materials and inventory control.

The classification of materials further can also be considered on the basis of performance, warrantee, guarantee, reliability safety, functionality, utility, maintainability, criticality and availability etc. Based on ABC, FSN and HML analysis we have high consumption value or low consumption value annually. Critical and non-critical classification is based on VED and VEIN analysis. Long lead time and short lead time is based on GOLF, SED and SOS analysis. These 8 categories are given in the table below:

MUSIC-3 D

	HCV		LCV	
	LLT	**SLT**	**LLT**	**SLT**
Critical	1	2	5	6
Non critical	3	4	7	8

Cost reduction by Music 3D

(*i*) Items in cell 1, 2, 3 and 4 has annual consumption around 20 % are 80 % of sales value. Rest of the items in cell 5,6,7 and 8 numbering 80 % has 20 % of sales value.

(*ii*) Items in cell 5,6,7 and 8 has no application of cost reduction as their cost is already less.

(*iii*) The items falling in cell 1 and 2 are highly critical therefore it is dangerous to apply any cost reduction techniques to them. Cost reduction can be applied to items in the cell 3 and 4.

The make and buy decisions are based on several important factors. These factors are labor, materials, production facilities, machines and capital etc. The Break Even Analysis is one of the method which is used to make this decision. The decision can be to produce part more economically in the organization or to purchase it from outside supplier at a cheaper price than production cost. By finding BEP and profits as explained in Break Even Analysis the Board of Directors can take these types of decisions. This will be clear from the following example.

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$$\text{BEP} = \frac{1200000}{2000 - 900} = \frac{1200000}{1100} = 1099$$

If sales will increase to 2000 TV sets color picture tubes can be profitably manufactured by the company.

QUESTIONS

1. What is Break Even Analysis?
2. What is Beak Even Point?
3. What is Margin of safety?
4. What is Angle of incidence?
5. What is cost, volume and profit analysis? Explain.
6. How will you take, make or buy decisions in production of an item?

CHAPTER IX

Inventory Control

Introduction

The stock of goods which must be carried out in order to meet the demand of materials in production and to ensure smooth and efficient running of affairs of a business. The smooth and efficient production is possible by keeping sufficient materials in store called *inventory* and controlling the amount of this in order to economise the cost of ordering, storing and issuing these inventories at appropriate time is called Inventory Control.

The recent concept of Just in Time manufacturing is not to store any material as inventory by ordering the exact materials required for production, delivered and received at the production facility just at the start of production operation without any delay. To achieve this type of Inventory Control, availability of all the type of materials and perfect delivery schedules must be followed. This technique is successful in countries like Japan. It is difficult to adopt in Indian industries because of several factors which may not be controllable. The various uncertainties exists in demand and supply of materials therefore the efficient inventory control methods will only be used to overcome the various inventory problems and uncertainties.

The proper quantity of materials required for production must be available as inventory of items. Which materials should be available and how much at what time is the main criterion of selecting the proper inventory control system by the materials management of any organisation. These systems of inventory control are discussed below.

Types of Inventers Control systems

The various types of inventory control systems used to order and replenish the inventories are

(1) Two-bin system
(2) Maximum-minimum system
(3) Economic order quantity (EOQ) system
(4) Fixed order quantity and variable cycle or Q system
(5) Fixed cycle and variable quantity or P system
(6) Replenishment system or S,s policy
(7) Ordering with quantity discounts

All these systems are discussed below.

(1) *Two-bin System*

This is a simple system in which two bins are used to store and issue the materials. Initially both the bins are filled with the material is issued from the second bin. The order is placed when first bin is empty. The order will arrive at the time just before the second bin is empty. This process will be repeated. It is a deterministic system where rate of consumption is known and the time of ordering is also known.

(2) *Maximum-Minimum System*

In this system-maximum and minimum level of inventory stored are fixed. The order is placed when the inventory level touches a particular quantity. Re-ordering is done after a period of review. If maximum amount in the store is 500 units and 50 units is safety stock. The order is placed when inventory level reaches 50 units. The disadvantages of the system are

(*i*) If the stock consumption fluctuates rapidly, the change in the maximum and minimum level is difficult.

(*ii*) If periodic review can not be done, the shortages or overstock may be there.

(*iii*) The control is necessary to keep records of inventories and maximum and minimum levels which can be altered based on demand changes and rate of consumption.

(3) *Economic Order Quantity (EOQ) System*

The economic order quantity is the amount of materials which is ordered or produced so that the cost of ordering and carrying in inventory should be minimum. This system is used to economise the cost of inventory control. The minimum cost is obtained when ordering and carrying cost are equal. In this system, inventory is zero when order is received. Order is placed such that all the materials ordered as EOQ is consumed. This method of inventory control is normally used to store valuable and essential items in the store.

(4) *Fixed Order Quantity and Variable Cycle System (Q System)*

When this system is used the quantity ordered every time is fixed and the number of cycle for which orders are placed and cycle time may vary. It is also called *reorder point* or *Q system*. The fixed order quantity (Q) depends on, price, usage rate and maximum and minimum quantity kept in inventory. The advantages of this system are

(*i*) Every item can be purchased at most economic price and necessary amount.

(*ii*) The items are purchased as per need and consumption rate.

(*iii*) When the demand changes, rapidly the reorder point reduces or cycle time is reduced and number of orders placed are increased as the order quantity Q is fixed.

What amount of order and when to order are two main problems in this system of inventory control to solve. Order quantity Q is decided in such a way so as to minimise the total cost of procurement (production), storage, handling, distribution and other changes of inventory. The safety stock is always present in this system.

(5) *Fixed Cycle and Variable Quantity (P) System*

This is also called Periodic Review System. In this time bound system, period of review is fixed as three, six or twelve months. In this system, period of review is fixed and quantity ordered change as per demand or rate of consumption. The period of review P is decided such that the order quantity is economical to purchase the items.

(6) *Replenishment System or S,s policy*

This is a major system of inventory control, which is called optional replenishment system of S,s policy. When the supplier puts the restriction on minimum order quantity, the variable order quantity is decided based on S,s policy i.e., maximum level of inventory is S and minimum safety stock is s. The replenishment level is in between S and s values. Order quantity is decided as.

Order quantity = Qr = Q1 – I, where Q1 is replenishment level and I is inventory on hand.

This system has advantage of combined fixed order or reorder point systems. To decide the amount of order, Qr to be placed the accurate information of inventory levels and rate of consumption must be available before the orders are placed.

(7) *Ordering when Quantity are Available*

When the materials are purchased in bulk, the supplier offer purchase discount in price of the materials purchased, if the quantity purchased is more than a particular value. Different discounts are offered on different purchase quantities and frequency of purchase. This is called *quantity discount*. For this type of ordering, the inventory control model which is used is further discussed in various types of inventory models.

Safety Stock

In every inventory control situations whatever system is followed to replenish the quantity in the store the consumption of materials or demand always fluctuates. In the economic order quantity system, the demand for a particular period say one year is assumed to remain constant and the value of EOQ which has minimum cost is obtained. This quantity is ordered and will be received when inventory level or stock is zero. This is the ideal situation. Practically in order to avoid shortages because of uncertainties in supply uncertain situations. This amount of stock which always remains in the store as inventory is called Safety Stock or Buffer Stock. To place the replenishment order, the quantity and time to receive it will be decided before the inventory reaches this safety stock. In deciding the type of inventory control system which is to be used in the organisation by materials management, there are several parameters which are to be considered. The safety stock, uncertainly in demand and lead time variations are some of the very important parameters of inventory control system.

Influence of Uncertainty on Inventory Control

There is always variations in sales of product and demand for materials. These variations may be of following three types:

(1) Demand fluctuations will be deterministic or probabilistic, the lead time may be constant.

(2) Lead time varies and demand remains constant.

(3) Both demand and lead time fluctuates.

The fluctuations may be certain or uncertain. In case of certainty the planning of inventory and production becomes easy but if uncertainty exists in these variations there is always risk exists in inventory control about ordering quantity. There are several probabilistic

models used with both descrete and continuous demand variations to predict them using the following probability distributions.

(*i*) Binomial distribution for discrete changes

(*ii*) Poission distribution for discrete changes

(*iii*) Normal distribution for continuous changes

(*iv*) Exponential distribution for continuous changes

The materials management has to take decisions under risk when the uncertainty exists and lot of fluctuations are there. For example, the stock of Umbrellas and Raincoats are to be kept by the seller of the seasonal products in his store in the months of July to October even though the rains may not be there in the month of July and August.

The purpose of safety stock is to keep reserve stock to meet the risk under uncertainty. The past records and forecasting may help in determining the safety stock with certain probabilities. But the unnecessary stock of the costly items with the anticipated sales may lead to loss. The various methods discussed above for inventory control can be used to decide the proper order quantity and safety stock. Max - Min system of inventory control can be used under uncertainty with variation in maximum and minimum quantity in store. If margin of profit is more, more safety stock under uncertainty can be stored. The probability of selling will be increased with reduction of margin of profit.

The buffer stock or safety stock is kept for the following reasons

(*i*) To avoid stockouts when demand or consumption is suddenly increased.

(*ii*) The lead time or procurement time is unexpectedly increased and lot of delay may be there in receiving the order quantity.

Determination of Safety Stock, Buffer Stock or Reserve Stock

In order to find out the safety stock, buffer stock or reserve stock the following things must be known

(1) *Lead time:* is the time required to receive the materials from the date of purchase requisition or placing the purchase order.

(2) Consumption of materials during lead time.

(3) Factor of safety depending upon (i) risk of service failure and (ii) cost of it.

Apart from the above things, the safety stock will depend on

(*i*) Variation in demand, lead time assumed to be constant.

(*ii*) Variation in lead time, demand may be constant.

(*iii*) Both may be varying.

More the safety stock more capital will be invested but less chances of stockouts are there, therefore the safety stock should be carefully determined. In order to find it out, the following relation can be used.

Safety stock = A$\sqrt{}$Average consumption during lead time

Qs = A$\sqrt{}$D where Qs = Safety stock or buffer stock

A = Constant varies from 1 to 4 is a factor of safety desired.

D = Average demand or consumption during lead time.

Variables in Inventory Problems

There are two types of variables in inventory problems.

(1) Controllable variables (2) Uncontrollable variables.

(1) *Controllable variables*

(1) Controllable variable is quantity or volume of materials. It depends on:-

(*i*) Quantity of materials required: It will be either purchased or produced. It is the demand of items.

(*ii*) Quantity ordered, Q: how much quantity is to be purchased in a particular time, it will be in units or volumes of materials ordered per day, per week, per month or per year.

(*iii*) Raising the stock level, s, quantity in units or volumes of materials.

(*iv*) Raising the stock level on hand or on order z, quantities or volume of materials.

2) The other controllable variable is frequency or time of acquisition to find out how often or when the materiels should be ordered so that shortage will not be there.

The order must be placed when

(*i*) Amount in stock is equal to or below s quantity or units.

(*ii*) Amount in stock and amount of order is equal to or below z.

(*iii*) At every t time units.

(2) *Uncontrollable variables:*

They are

(1) Ordering or setup cost (Co)

(2) Holding or inventory carrying cost (Ci)

(3) Shortage or stockout cost (Cs)

(4) Demand D or number of items required per period i.e., per year

Demand Pattern of Items Required

The demand of items can be

(1) Deterministic

(2) Stochastic or probabilistic

(1) Deterministic demand: In this case, the quantity of materials needed over subsequent periods of time are known exactly.

(2) Probabilistic or Stochastic Demand: In this case, the demand over a certain period of time is not known with certainty but it can be described by a known probability distribution.

Lend time: It is the time required before placing an order and its arrival in the stock. The lead time is also known and *deterministic* or *unknown* and *probabilistic.*

Before discussing the techniques to solve all these inventory control problems with different types of variabilities, let us see the essential requirements of them.

Essentials of Inventory Control

The inventory control problems are:

(1) How much quantity of a particular materials ordered, purchased or stored.

(2) How many types of items are stored as inventory.

(3) At what time they are required.

(4) Where they are supplied.

(5) How to economise the ordering and inventory carrying cost.

In order to overcome these problems of inventory control and to supply materials as per demand the various inventory control models are used. In order to formulate these inventory models and solve them the informations are required for:

(*i*) Demands of materials over a period of time say, one year.

(*ii*) Number of times the order is to be placed.

(*iii*) The order is to be placed when stock reaches the reorder point or reorder level (ROP and ROL).

(*iv*) Lead time required before the materials is received.

(*v*) The various costs associated with inventory control.

The elementory inventory control models are given below to solve the various inventory problems.

Elementory Inventory Control Models

Stock of goods which must be carried out in order to ensure smooth and efficient running of production and other activities of business with raw materials, semifinished and finished products. The decision is to determine the following things.

(1) The time at which orders for goods are to be placed is fixed and what quantity is to be ordered.

(2) Both order quantity and order time for which inventory is ordered should minimise all the costs associated with stock of goods.

Costs Involved in Inventory Control Problems

There are three types of costs involved in inventory control apart from price of materials. They are

(1) Ordering cost or setup cost.

(2) Holding or inventory carrying cost.

(3) Shortage or stockout cost.

(1) Ordering or setup cost: Ordering cost involves office work expenses as calling and processing quotations, placing purchase orders, follow up costs, cost of transporting materials, purchasing, receiving, inspection and procuring costs, verification and payment of bills and incidental charges, they may also be called *purchasing* and *procurement cost*. When goods are produced in the plant then in the set up of machines and preparation for production involves the cost per production run which is called *setup cost*.

(2) Holding or inventory carrying cost: This cost arises due to

(*i*) blocking of capital in inventory and interest on this investment.

(*ii*) rent of storage space.

(*iii*) prices of materials may suddenly go down.

(*iv*) damages, spoilage, obsolescence, theft, leakage, deterioration and depreciation of materials during storage.

(*v*) salaries of employees of stores.

(*vi*) insurances and taxes.

(*vii*) the cost which may be required for lighting, electricity and maintaining materials in the stores.

(*viii*) any other expenses required in stores for storage and handling of materials.

(3) Shortage or stockout cost: This cost involves because of loss of sales, goodwill and delay in supply.

Classification and Characteristics of Inventory Problems

The following costs are constant variables:

(1) Ordering cost per order or set up cost per cycle given by Co.

(2) Holding cost or inventory carrying cost per unit item per unit time given by Ci.

(3) Shortage cost per unit item short per unit time given by Cs.

It is assumed that these variables normally remain constant during the time of inventory analysis.

(4) *Demand*: The demand of materials may be known or estimated. The known demand can be constant or variable with time. It is denoted by D.

(5) Quantity of materials required may be in discrete units of continuous quantities.

(6) Distribution of withdrawal of materials over time may be continuous or discontinuous. It may vary at constant or variable rate.

(7) *Reorder lead time*: It will be either virtually zero or positive.

(8) *Reorder cycle time*: It may be known or estimated. The known or estimated reorder cycle time can be constant or variable.

(9) *Input quantities of materials*: They may be discrete or continuous. Both of them can be constant or variable.

(10) Distribution of input quantities of materials over time may be continuous or discontinuous and both may vary at constant or variable rate.

With all these characteristics of inventory problems, various inventory models can be classified as follows:

Classification of Inventory Models

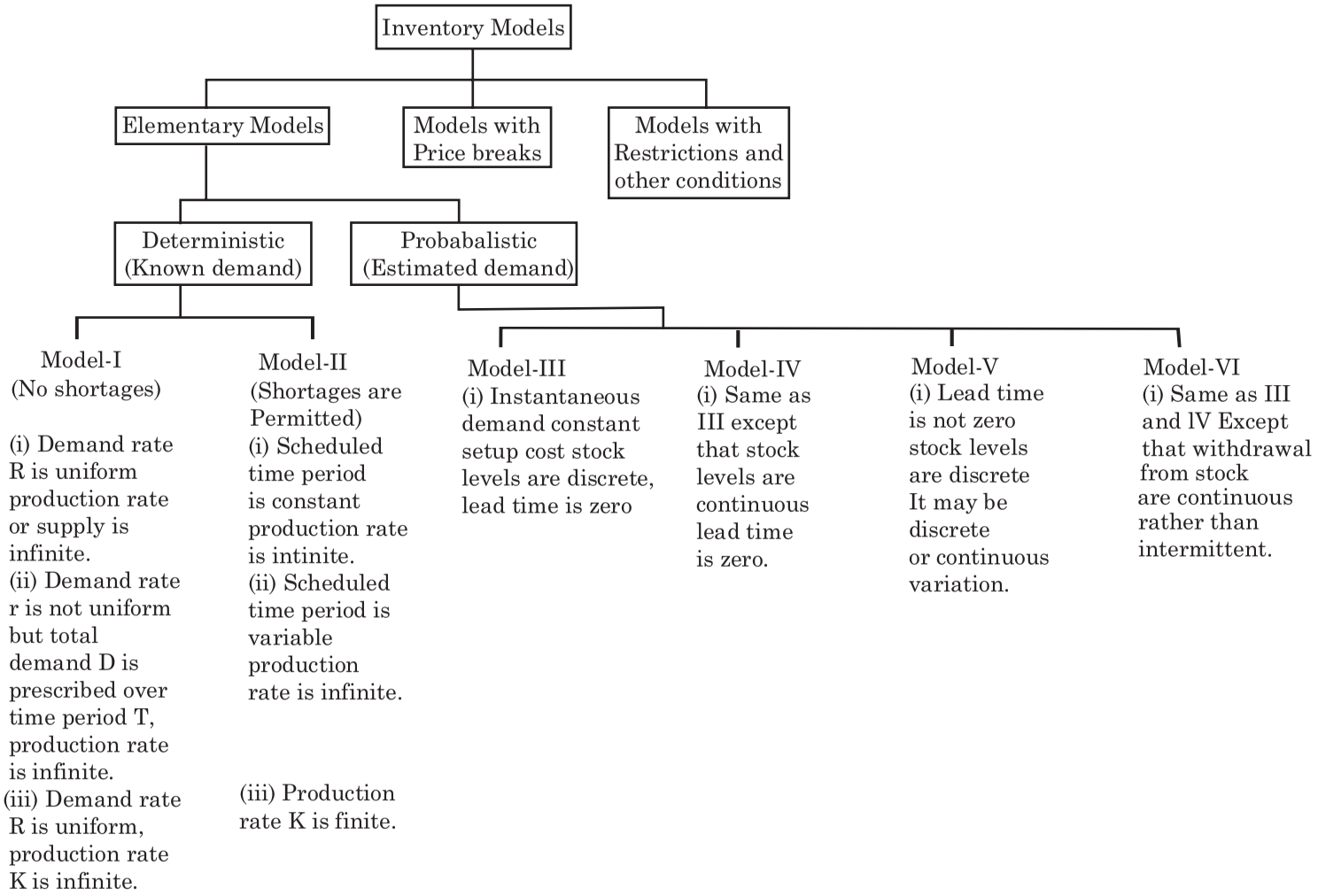


Fig. 1.

The inventory models can also be classified as follows:

(1) Elementary models: They are

(*i*) Deterministic having known demand of materials with

(*a*) no shortages.

(*b*) shortages are permitted.

(*c*) multi-item demands.

(*ii*) Probabilistic (estimated demand) such that

(*a*) instantaneous demand and discrete withdrawal of materials.

(*b*) instantaneous demand and continuous withdrawal of materials.

(2) Models with price breaks.

(3) Models with restrictions and others.

All these models are given in the Figure 1 above describing their further variations as Elementary Deterministic Model-I and II and Elementory Probabilistic Model-III, IV, V and VI.

Deterministic Models of Inventory Control

Only the deterministic models will be considered to solve inventory problems here because the probabilistic models have more variability factors and too complex to solve.

The following assumptions are made to solve the deterministic models of inventory control.

(1) Demand of materials is assumed to be fixed and completely predetermined.

(2) Demand remains constant over a period of inventory analysis.

(3) Production is followed by the economic lot size system and constant production quantity per cycle. The order is placed as per economic order quantity.

(4) The ordered materials arrive instantly at infinite rate when inventory level reaches zero.

(5) The cycle time and orders of materials are same over a period of time say one year.

(6) All the costs associated with ordering the materials and inventory carrying remains constant during this period of one year.

The various notations used in these models are given below

D = Total demand

R = Rate of demand

K = Rate of production

Ci = Holding or inventory carrying cost per unit quantity per unit time.

Co = Ordering cost per order or set-up cost per set-up

Cs = Shortage or stockout cost unit quantity short per unit time

t = Ordering or scheduling time period (cycle time) which is not prescribed

tp = Prescribed scheduling time period

N = Number of orders placed
x = Demand during prescribed period tp with probability F (x)
y = Demand during lead time L with probability G (x)
z = Order level or stock level
q = Quantity already present in the beginning
L = Lead time
f(x) = Probability density function for demand x.
EOQ = Economic order quantity
EBQ = Economic batch quantity
ELS = Economic lot size
ETC = Economic total cost

Inventory Control Model-I

Economic Order Quantity (EOQ)

This EOQ model is used to find out the order quantity or lot size which economises the total cost of ordering and carrying the materials in the store. It is also called the **Wilson Rule**. In order to find out EOQ, the assumptions of deterministic elementary inventory model which are given above are considered to derive the values of EOQ and Economises Total Cost (ETC). The variations of stock in inventory is shown in the Figure 2 given below. The values of quantity of materiels in the store made them the vertical Y axis and the time of storing is shown on the horizontal Z axis for a unit period say, one year.

In the first period of time, the quantity supplied is Q. Quantity in inventory is zero and over this period it is consumed when inventory is consumed quantity Q. Thus, this cycle repeats. This pattern of inventory variation resembles a saw tooth hence it is called as saw tooth pattern of the inventors control.

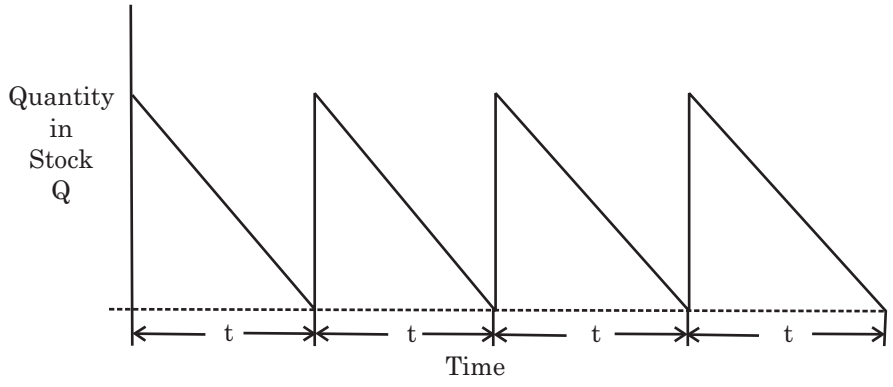


Fig. 2.

In order to find out the quantity Q ordered economically in a cycle time, the following things are assumed.

Assumptions

(1) The total demand D is known in a period inventory planning (one year).

(2) The cost of ordering Co and carrying inventors Ci are constant during this period.

(3) The ordering period or cycle time, t remains the same.

(4) All the quantity ordered Q is consumed during period and inventors is zero when order is received.

(5) Quantity Q is received instantaneously.

(6) The lead time is zero and hence safety stock is also zero.

(7) Order quantity Q is same in every cycle time, t.

(8) Rate of consumption or demand R is constant.

Derivation of EOQ, EBQ or ELS and ETC

Using the notations given above N = No of orders = D/Q *and* t = Cycle time = 1/N Ordering cost Ci = Co × N = Co × D/Q

Inventory carrying cost C2 = Ci × Q/2 as Average inventory carried in total period = Q/2

Tc = Total inventory cost = Ordering cost + Inventory carrying cost = Ci + C2

$$Tc = Co\ \frac{D}{Q} + Ci\ \frac{Q}{2} \qquad ...(1)$$

For the total cost Tc to be minimum $\frac{dTc}{dQ} = 0$ differentiating equation (1) with respect to Q and equating it to zero

$$\frac{dTc}{dQ} = -\ Co\ \frac{D}{Q*2} + Ci\frac{1}{2} = 0 \quad Co\frac{D}{Q*2} = Ci\frac{1}{2} \quad Q*2 = \frac{2\ CoD}{Ci} \text{ the } Q = Qe$$

Economic Order Quantity (Economic Batch Quantity) = Qe also called as *economic lot size (ELS)* is

$$EOQ = Qe = \sqrt{\frac{2\ CoD}{Ci}} \qquad ...(2)$$

Substituting the value of Qe in (1)

$$\text{Economical total cost, } ETC = CoD\sqrt{\frac{Ci}{2CoD} + \frac{Ci}{2}} = \sqrt{\frac{2CoD}{Ci}} = \sqrt{\frac{CoCiD}{2}}\ \sqrt{\frac{CoCiD}{2}}$$

$$ETC = 2\ \sqrt{\frac{CoCiD}{2}} = \sqrt{2CoCiD}, \quad ETC = \sqrt{2CoCiD} \qquad ...(3)$$

Graphical Representation of Inventory Cost and Quantity

The graph is plotted between the inventory cost on Y axis and quantity ordered on X axis as shown in Fig. 3 below. From the graph it is observed that where the curve of ordering cost Co D/Q and straight line of inventory carrying cost CiQ/2 meet the total cost Tc is minimum. Equating them at this point Qe where they are same.

$\frac{Ci\ Qe}{2} = Co\frac{D}{Qe}$ $Qe*2 = \frac{2CoD}{Ci}$ $Qe = \sqrt{\frac{2CoD}{Ci}}$ same as derived above which is called EOQ = $\sqrt{2CoD/Ci}$ and the total cost at this point ETC = $\sqrt{2CoCiD}$ which is the minimum cost at this point and both ordering and carrying cost at this point are equal = $\sqrt{CoCiD/2}$.

In this Model-I of economic order quantity, the following relations are obtained.

EOQ or EBQ or ELS = $\sqrt{2CoD/Ci}$ and ETC = $\sqrt{2CoCiD}$ ...(4)

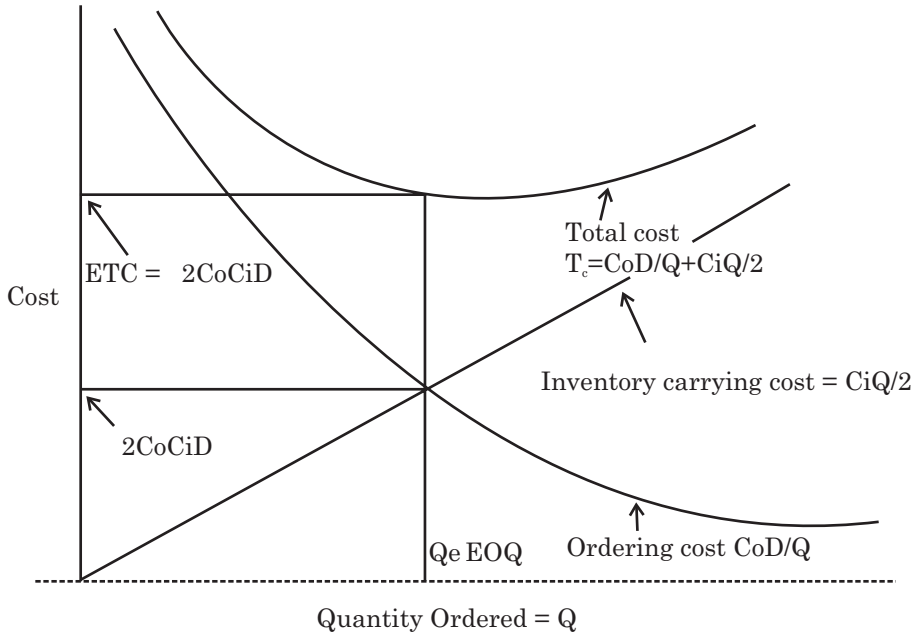


Fig. 3.

Inventory Control Model-II

In Model-I, it is assumed that the order is received instantaneously and rate of consumption is constant. In this Model-II, the following things are assumed:

(1) The ordered quantity is supplied gradually. The rate of production or supply of materials is finite and gradual for a length of time.

(2) The consumption of materials is already there for the entire period of inventory analysis.

(3) The rate of supply or production is more than rate of consumption.

Graphical Representation of Model-II

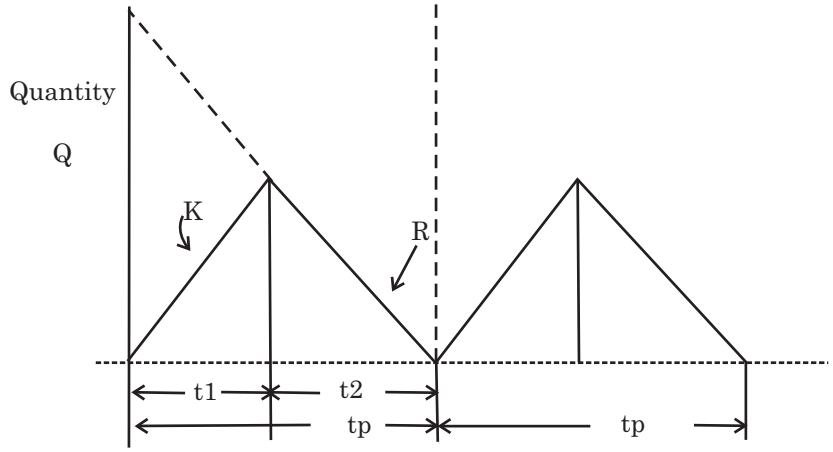


Fig. 4.

The same notations are used as given in Model - I. Some more values are denoted as follows:

D = Total demand

R = Rate of consumption or demand

K = Rate of supply or production

tp = Time for which the quantity q is supplied or produced

q = Quantity ordered or produced

Q = Quantity in inventory after a period t_1 for which the gradual supply of q quantity is done

t1 = Time of supply of production of materials

t2 = Time for which only consumption is there

tp = t1 + t2

Derivation of EOQ, EBQ or ELS and ETC

From the graph, it is clear that Kt1 = Rt2

The cost of inventory control for this model is given as

Total cost = Tc = Ordering cost + Inventory carrying cost

Ordering cost C1 = N Co N = No. of orders = D/q N = 1/tp

C1 = CoD/q

Inventory carrying cost C2 = CiQ/2 Q/2 = Average inventory in the store

The relation between Q and q is found as follows:

Q/t2 = R and Q/t1 = K – R ...(1)

Q = q – R t1 t1 = Q/(K – R) ...(2)

Q = q – RQ(K – R) Q + RQ/(K – R) = q Q(K – R) + RQ = q(K – R) QK = q(K – R)

Q = q (K – R) / K C2 = Ci Q/2 = Ciq (K – R)/2K

For minimum total cost C1 = C2 or dTc/dq = 0. Using these conditions

First equating ordering cost = Inventory carrying cost

CoD/q*2 = Cio(K – R)/2K q*2 = 2CoD/Ci{K/(K – R)} ...(3)

EOQ = Qe = q = $\sqrt{\frac{2CoD}{Ci}}\left(\frac{K}{K-R}\right)$. This can also be derived by differentiating Tc with respect to q

Tc = C1 + C2 = Co D/q + Ciq (K – R)/2K ...(4)

dTc/dq = - CoD/q*2 + Ci(K-R)/2K = 0CoD/q*2 = Ci(K – R)/2K which gives

q*2 = 2CoD/Ci{K/(K – R)} ...(5)

EOQ = Qe = q = $\sqrt{\frac{2CoD}{Ci}}\left(\frac{K}{K-R}\right)$...(6) substituting this value of q in (4)

Tc = $\sqrt{1/2q(K-R)/RCi} = \sqrt{2CoD/CiK/(K-R)}$ × (K – R)*2/K*2Ci*2

ETC = Tc = $\sqrt{2CoCD(K-R)/K}$ ...(7)

If K is infinite i.e., supply is instantaneous then R/K = 0 it becomes Model-I. For

Model-II, the values are derived as EOQ = $\sqrt{\frac{2CoD}{Ci}\left(\frac{K}{K-R}\right)}$ and ETC = $\sqrt{\frac{2CoCiD(K-R)}{K}}$

Inventory Control Model-III

If the shortages or stockouts are allowed in the inventory control, the cost of shortages will also be there. If orders are received when inventory level falls to zero and demand or requirement continues the situation arises where -ve inventory or stock out will be there. This is shown in the Fig. 5 below.

The order quantity Q is received after time t, but the inventory becomes zero at time tp earlier to t, t is greater than tp. The shortages are there for the period t – tp.

In this Model-III, Economic Order Quantity = Qe is given as Cs-Shortage cost and other values are same as given above in Model-I.

EOQ = Qe = $\sqrt{\frac{2CoD\,(Ci+Cs)}{Ci\cdot Cs}}$ and economical total cost ETC = $\sqrt{\frac{2CoCiCsD}{Cs\cdot Ci}}$

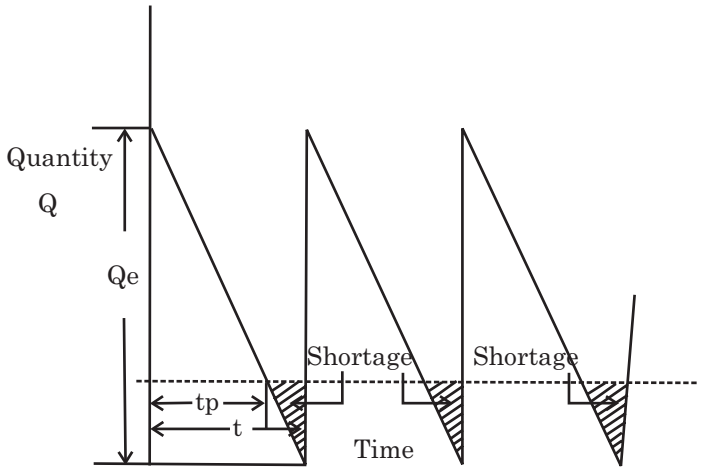


Fig. 5.

Price Discount in Inventory Control

When large quantity of materials are purchased from the supplier they offer discounts on a purchase lots. But since the inventory carrying cost is also high for costly materials therefore purchase of large or bulk materials with price discounts may not be economical. This type of inventory control problems of order quantities with price discounts is discussed below.

Economic Order Quantities with Price Discounts

When bulk of materials are to be purchased with price discounts from the supplier, the EOQ model should be used with price-discount so that economic purchase will be done. When a large order size is offered, the discounts per unit price, the *Heuristic method* will be used to accomodate quantity discounts.

Suppose that all the assumptions of simple EOQ model are satisfied, but that the per unit cost of the goods stocked as inventory depends on order quantity as follows.

If $0 \leq Q < K1$ then goods cost @ Rs. a0 per unit

$K1 \leq Q < K2$ then goods cost @ Rs a1 per unit

$K2 \leq Q < K3$ then goods cost @ Rs a2 per unit

... ...

... ...

$Ki \leq Q < Ki+1$ then goods cost @ Rs ai per unit

... ...

... ...

$Kn \leq Q < Kn+1$ then goods cost @ Rs an per unit

Here Ki represents price break points and ordinarily a0 > a1 > a2. If the quantity discount factor is ignored then

$$Qe = \sqrt{\frac{2CoD}{Ci}}$$

If this quantity Q falls within the range (Ki, Ki+1) then the total cost per unit time of the inventory system plus the cost of materials will be Tcm = √2CoCiD + aiD.

It is clear that if the order is less than Q both the cost of inventory system and cost of materials would be higher. If we were to order more than Q it is possible that increase in inventory system cost would be higher. If we were to order more than Q it is possible that increase in inventory system cost would be compensated by the saving in the cost of materials. Hence the order size which gives lowest total cost of materials is selected. This will be more clear from the example given below. Ki + 1 is a candidate for the optimal order quantity, as are Ki + 2, Ki + 3..... and so on. The procedure involves comparing the total cost per unit time if Q is ordered to the total cost per unit time Ki + 1, Ki + 2, ... or Kn in order.

The order size which gives lowest total cost of material is selected. This will be more clear from the examples given below:

Example 1. A paper seller who wants to purchase paper rolls to stock and sell, from manufacturer offering discounts to him as follows.

Rs. 1200 per roll for 1 - 99 rolls

Rs. 1000 per roll for 100 - 149 rolls

Rs. 950 per roll for 150 - 199 rolls

Rs. 900 per roll for 200 or more.

Cost of ordering is Rs. 250 per order. Cost of carrying inventory is Rs. 10 per roll in the stock. The demand is 320 rolls per week. Find the order quantity which gives minimum cost of purchase and inventory control with price discounts.

Solution: Qe = EOQ in √2CoD/Ci = √2 × 250 × 320/10 = 40√10 = 40 × 3. 16 = 126.4. If this quantity is ordered, the price of the roll will be Rs. 1000.

Total cost = $\sqrt{2CoCiD}$ + 1000 × 320 = √2 × 250 × 10 × 320 + 320000 = 400√10 + 320000 = 1264.91 + 320000 = 321265 Rs.

No incentive to order less then 99 rolls.

If 150 rolls are ordered of price break of Rs. 950 per roll. The total cost will be = 150 × 10/2 + 250 × 320 / 150 + 950 × 320 = 750 + 533.33 + 304000 = – 305283.33 Rs.

Though inventory system cost is more (1283 – 1265) = Rs. 18 in ordering 150 rolls instead of 126 rolls but total cost is less. Let us calculate the total cost for price break of 200 rolls.

It is = 200 × 10/2 + 250 × 320/200 + 900 × 320 = 1000 + 400 + 288000 = 289400.

Therefore it is advantageous to order 200 rolls to get maximum benefit of price break. Ordering more than 200 rolls will not give any more benefit.

Optimal ordering quantity = 200 rolls with total cost = Rs. 289400.

Example 2. (Management Science Summer 1987).

A chemical company regularly uses a certain chemical in several end products. The chemical is used at an average rate of 500 Kg per month. The price of chemical is Rs. 500 per Kg. However, each time an order is required to be placed a cost of Rs. 1000 is incurred in the process. The estimated inventory holding charge is 2% per rupee per month. Find the EOQ and total economic cost.

Solution: Demand, D = 500 Kg, Ordering cost, Co = Rs. 1000, Holding cost Ci = 2 × 500/100 = 10 Rs.

EOQ = $\sqrt{2CoD/Ci} = \sqrt{2}$ × 1000 × 500/10 = $100\sqrt{10}$ = 100 × 3.16 = 316 Kg.

ETC = $\sqrt{2CoCiD} = \sqrt{2}$ × 1000 × 10 × 500 = $1000\sqrt{10}$ = 1000 × 3.162 = 3162 Rs. per month.

Example 3. A company has a demand of its product of 12000 units per year. Its production capacity is 2000 items per month. The cost of one setup is Rs. 4000. Holding cost of product per month is 15% of its price. Find the following things.

(1) Optimum lot size of production if the price of the product is Rs. 400.

(2) Maximum inventory and member of setups.

(3) Manufacturing and total time of production.

(4) Cost of production setup and holding inventory.

Solution: Economic lot size qe = $\sqrt{2CoD/Ci}$ × K/(K – R) Demand rate(D) R = 12000 per year.

Production rate = 12 × 2000 = 24000 per year, Co = Set-up cost = Rs. 4000, Ci = holding cost = 15 × 400/100

Ci = 60 qe = $\sqrt{2}$ × 4000 × 12000/60 × 24000/(24000 – 120000). = $\sqrt{2}$ × 4000 × 200 × 2 = 400 × 4.44 = 1788.85 Economic lot size qe = 1789.

Maximum Inventory = Q_{max} = K – R/Kqe = (24000 – 12000)/24000 × 1789 = 1789/2 = 895

No. of setups N = D/qe = 12000/1789 = 6.708

Manufacturing time t1 = Q_{max}/(K – R) = 895 / (24000 – 12000) = 895/12000 = 0.0745 year

0.745 × 12 = 0.894 month = .894 × 30 = 26.83 = 27 days

Total time = tp = qe/R = 1789/12000 = 0.149 year = 1.789 months = 1.789 × 30 = 53.66 = 54 days.

(4) Total cost = Cost of product + Inventory cost = 400 × 12000 + $\sqrt{2CoCiD}$ (K – R)/K = 4800000 + $\sqrt{2}$ × 4000 × 60 × 12000(24000 – 12000)/24000 = $\sqrt{480000}$ × 12000/2 = $12000\sqrt{20}$ = 12000 × 4.472 = 53665 K = 4800000 + 53665 = 4853665 Rs.

Example 4. The demand of stocks in a Hosiery shop is 9000 per year. Its cost of procurement is Rs. 100 and holding cost is Rs. 2.40 per year. Cost of shortage is Rs. 5.00 per year, if socks are not received from supplier in time. Its price is Rs. 10. Find (1) EOQ, (2) Number of orders per year, (3) time between orders (4) total cost of inventory carrying.

Solution: (1) Economic order quantity = Qe = $\sqrt{Ci+Cs)/Cs}$ 2Co D/Ci = √(2.40 = 5.0)

√5.0 × 2 × 100 × 9000/2.40 = $\sqrt{7.4/5}$ × 1800000/2.4 = 1053 socks

(2) Number of order per year = 9000/1053 = 8.549

(3) Time = 12/8.549 = 1.40 months = 1.40 × 30 = 42 days

(4) Total cost of inventory carrying (ETC) = Te = $\sqrt{Cs/(Cs+Ci)}$ 2CoCiD = $\sqrt{5}$ /(2.4+5) × 2 × 2.4 × 100 × 9000 = $\sqrt{5}$ /7.4 × 4. 8x900000 = 300√32.43 = 300 × 5.694 = Rs. 1708

Total cost = cost of purchasing + cost of inventory = 10 × 9000 + 1708 = Rs. 91708

Example 5. An item is produced at the rate of 50 per day by an Industry. The expected rate of demand is 25 items per day. The set up cost for the item is Rs. 100 per run, while the holding cost is Rs. 0.01 per item per day. Determine the economic lot size.

Solution: Economic lot size = Qe = $\sqrt{2CoD/Ci(1-R/K)} = \sqrt{2}$ × 100/0.01 × (1 – 25/50) = 2 × 100 × 100/(1 – 0.5) = 200 items per day

Example 6. The monthly demand of bicycles in a shop is as follows for 6 months.

Month	*Demand*
1	120
2	80
3	340
4	25
5	230
6	175

The shopkeeper wants to order the bicycles from dealer regularly. The ordering cost is Rs. 800 per order and carrying cost of bicycle is 10% of its cost which is Rs. 600. The lead time is one month. What is the ordering quantity and reorder level.

Solution: Ordering quantity, Qe = √2CoD/Ci

Mean Demand = (120 + 80 + 340 + 25 + 230 + 175)/6 = 970/6 = 161.6 = 162 bicycles

Qe = $\sqrt{2}$ × 162 × 800/(10 × 600/100) = $\sqrt{108}$ × 40 = √43220 = 66

Standard deviation, s.d. = $\sqrt{(Dm-D)*2/}$ n – 1 = $\sqrt{\{(162}$ – 120)*2 + (162 – 80)*2 + (162 – 340)*2 + (162 – 25)*2 + (162 – 230)* 2 + (162 – 175)*2} / (6 – 1) = $\sqrt{42*2+82*2+178*2}$ +137*2 + 68*2 + 13*2)/5 = $\sqrt{(1764}$ + 6724 + 31684 + 18769 + 4624 + 169)/5 = $\sqrt{63734/5}$ = $\sqrt{12746.8}$ = 112.90 = 113 sd = 113. Buffer stock = sdx safety factor = 113 × 3 = 339 Average lead time consumption = Mean monthly demand × lead time 162 × 1 month = 162

Reorder level = Average lead time consumption + Buffer stock = 162 + 339 = 501

The reorder quantity = 66 bicycles. The order level = 501 bicycles.

Example 7. A manufacturer wants to produce piston of an engine. The cost of setup for production is Rs. 25000 and carrying cost of pistons is 15% of its cost. The piston will be sold for Rs. 200 each. The demand for piston is probabilistic with the following distribution.

Demand	*Probability distribution*
2000	0.2
3000	0.3
4000	0.2
5000	0.2
6000	0.1

Calculate the economic lot size of producing the pistons.

Solution: The mean demand is = 2000 × 0.2 + 3000 × 0.3 + 4000 × 0.2 + 5000 × 0.2 + 6000 × 0.1 = 400 + 900 + 800 + 1000 + 600 = 3700

Economic lot size = $\sqrt{CoD/Ci} = \sqrt{2}$ × 25000 × 3700/(15 × 200/100) = $\sqrt{25000}$ × 74/3 =

= 500 $\sqrt{22.66}$ = 2483.28 = 2484.

Example 8. A fan manufacturer wants to manufacturer 1500 rotors of fan per year in his industry. The various costs involved to manufacture it are as follows:

Set-up cost of machine = Rs. 1200 per setup

The cost of casting = Rs. 80 per piece

Time required to machine and finish it = 10 hour

Labour charges = Rs. 10 per hour

Overhead expenses are 60% of direct cost

Cost of carrying the finished rotor in inventory = 20% of its cost.

Find out the following things:-

(1) The economic batch size to manufacture it

(2) The total cost of manufacturing the finished rotor

(3) If the machine runs for 60% time and its running cost is Rs. 5 per hour, calculate the running time for the machine and its cost

Solution: The production cost = material cost of casting + machining charges + labour charges + overhead expenses

Machine charges = 10 × 5/0.6 = 83.3 = 84

Labour charges = 10 × 10 = 100 direct cost = machining charges + labour charges = 100 + 84 = 184.

Overhead charges = 184 × 0.60 = 110.4 production cost = machining charges + labour charges + overheads = 110 + 184 = 294

Total cost, Cm = Cost of casting + production cost = 80 + 294 = 374.

(1) The economic batch size (EBS) = Qe = $\sqrt{2CoD/Ci} = \sqrt{2}$ × 1200 × 500/(20 × 374/100) = 100 $\sqrt{12}$ × 15/37.4 = 219.38 = 220

Economic batch size = 220

(2) Total cost = √2CoCiD + D × Cm = $\sqrt{2}$ × 1200 × 1500 × 20 × 374/100 + 1500 × 374 = 100√269.28 + 561000 = 100 × 16.409 = 561000 = 1641 + 561000 = Rs. 562641

(3) Running time = 10/0.6 × 1500 = 16.66 × 1500 = 2790 hours = 2790/24 × 30 = 34.6 = 34.6 months

Example 9. An utensil selling business company wants to order utensils from the manufacturer having the following requirements:

Demand of utensils = Rs. 4.00,000 per year

Ordering cost per order = Rs. 5000

Average price of the utensil = Rs. 200 each

Inventory carrying cost = 15% cost of utensils per year

Lead time = 1.5 months for receiving the materials.

Calculate (1) Economic order quantity

(2) Total cost of ordering and carrying the inventory of utensils.

(3) Safety stock with 2.5% for which constant A = 2 risk of stockout.

Solution: (1) Economic order quantity EOQ = $\sqrt{2CoD/Ci} = \sqrt{2}$ × 5000 × 400000/200 × 0.15 × 200 = $100\sqrt{400/6}$ = $100\sqrt{66.66}$ = 100 × 8.1649 = 817

(2) ETC = $\sqrt{2CoCiD}$ = √2 × 5000 × .15 × 400000/200 = 10000 √.15 × 40 = 10000 √6 10000 × 2.448 = Rs. 24,480

(3) Demand during lead time D1 = (400000/200) × 12 × 1.5 month = 500 × 1.5/3 = 166.66 × 1.5 = 250

Safety stock = $A\sqrt{\text{demand during lead time}} = A\sqrt{D1} = 2\sqrt{250} = 10\sqrt{10}$

= 10 × 3.162 = 31.62 per month.

Example 10. A firm dealing in general supply of materials wants to plan its inventory of a material for selling the item selected is torch cells whose past selling data are as follows

Demand = 6000 per year

Lead time for purchase = 3 months

Review period = 1.5 months

Service level = 9.5% constant for this service level A = 1.7

Find out the buffer stock, order quantity, replishment level at the time of first review if the stock in hand is 400 torch cells and order placed is 200 units.

Solution: Buffer stock or safety stock Qs = A√D(RP + L)

RP = Review period = 1.5 months

L = Lead time = 3 months

D = demand per month = 6000/12 = 500

A = constant = 1.7

Qs = $1.7\sqrt{500(1.5 + 3)} = 1.7\sqrt{500}$ × 4.5 = 1.7√2250 = 1.7 × 47.43 = 80.63

Replenishment level – Average consumption during lead time

DxII. safety stock where 1L = (RP + 1)

– 500 (3 + 1.5) + 81 = 2250 + 81 = 2331

Ordering quantity DIL – (stock in hand – stock in order)

= 2331 – (400 + 200) = 2331 – 600 = 1731

Example 11. The lead time for procuring the washing soaps to sell by a general store is 3 weeks. The weekly sales are normally distributed and it is 80 units and weekly standard deviation of sales is 10 units. Assuming 5% risk (constant A) is (95). Find the reorder point and safety stock of the washing soap in the general store to be kept by the owner.

Solution: The ordering system followed by the store is Q system

Mean demand Dm = 30 units standard deviation of sales is 10 units lead time L = 3 weeks

D1-mean demand during lead time Dm - 1

The weekly demand is normally distributed variance Va = $(Sdt)^2$ where Sd1 = standard deviation during lead time Va. = $(10)^2$ = 100

The risk level is 5%, Service level is 1-risk level 1-0.05 0.95 = 95%

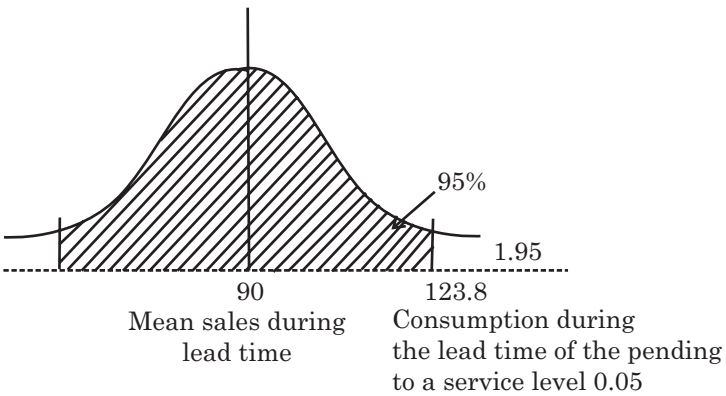


Fig. 6.

Z = (X-DI)/Sd1 corresponding to 05% service level from normal distribution given that

Z = 1.95 1.95 = (X – 90) / $10\sqrt{3}$ where X Reorder point

X – 90 = 1.95 × 10 $\sqrt{3}$ = 19.5 × 1.73 = 33.8 × 90 + 33.8 = 123.8

Safety Stock = X – D1 = 1238-90 = 33.8

Reorder Point = 124 and Safety Stock = 34 units

Verification of Stock

In order to properly control the inventories in the store the verification of stock, quantity of materials and their volume are physically verified time to time. The inventory control is done through a series of reports and records that provide information on receipts, usage and

balances. This is necessary to prevent theft, spoilage, damages, obsolescence and errors in stores materials. The inventories are verified with the records and the term is fixed which verifies the stock of material and gives the report to management for the various types of discrepancies, shortages and errors. The records of inventory and stores are kept by stores registers, ledger, receipt and issue books, bin cards, indents, requisition slips, purchase orders, and other stock books and store informations.

The following types of discrepancies and errors are generally found during the stock verification or stock taking of actual materials in inventory and entries in stock books.

(1) Wrong entries and clerical mistakes in entering and issue of materials.

(2) Thefts and pilferages.

(3) Careless material handling and bad housekeeping

(4) Improper preservation of stock and leakages etc.

(5) Deterioration, obsolescence.

(6) Loss due to natural causes, rusting, chemical action, dust and changes in atmospheric conditions.

(7) Wastage due to materials remain as last pieces, cuttings, damaged portions etc.

(8) Purchase of out dated items, excess materials and materials of improper quantity and specification.

Methods of Physical Verification of Stock Taking

For detecting and removing the errors, controlling the purchase and issue and maintaining the proper records of all the inventories in the store there are two methods used for physical verification or stock taking. They are also used to check the inventory control system adopted in the organisation.

(1) Annual physical verification.

(2) Perpetual inventory control

(1) *Annual Physical Verification*

In this method once in a year the verification of materials from the stores is done by a team of responsible persons. Each individual of verification team verifies the quantity or volume of materials from the bins or store places from the stock books or ledger, records the shortages, excess items, errors and discrepancies and submits this report to the management for further action and rectification so that they may be prevented in future.

During stock taking the purchases, receipts and issue of materials are stopped till the physical checking is complete and verified from stock books. The reports of all the stores after completing the stock taking, consulting with the chief storekeeper or materials manager are submitted to the management by the chief verification officer of the team. This annual stock verification reports are also used for cost accounting purposes.

(2) *Perpectual Inventory Control*

In this system of verification, the inventory is checked perpetually or continuously throughout the year so that details of quantity and value of stock of each item of store is

available at any time. In this method, the storekeeper has to maintain the proper records of physical movement of stock and the balance inventory in the store regularly. The material is checked when it reaches a minimum level. Every material stock is verified at least once in a year and the continuous records of receipt and issue of materials are always available. Thus, this method is more accurate and keeps better inventory control.

Introducing Perpectual Inventory System

This method is mostly used in large manufacturing industries or business companies selling huge quantities of various goods. In order to introduce this system, the following two steps are required to be used to maintain the control over the inventory and stores.

(1) Proper Maintenance of Stores Ledger, Stock books and bin cards

(*i*) Stores ledger and stock books: They keep the record of each material purchased, received and balanced in the store, the value and cost of materials. All the entries in these books are made from purchase vouchers, invoices, material requisition slips and return note and bin cards. The store ledger is maintained by cost department and checked regularly.

(*ii*) Bin cards: The bins are the places where materials are stored. They will be racks, store place or bins showing the particulars of items, name, description, maximum and minimum inventory levels, receipt, issue and balance of materials stocked in bin. The materials present as inventory and balance shown in the bin card always tally.

(2) Perpectual or Continuous Stock Taking

It is a system adopted by internal, independent staff for auditing and checking the entries and physical stock of materials in the store as per bin card, store ledger and stock books regularly. Any error or discrepancies are reported and corrected time to time.

Advantages of Perpectual Inventory Control System

(1) In this system, the stores need not be closed during stock taking and verification. The production continues uninterruptly.

(2) Since minimum quantities are counted less labour and time are required. The work load is distributed on staff and errors are reduced. The system is more accurate.

(3) The quantities weight or volume of materials shown on bin cards and stock books tally with the physical stock. If it is not the discrepancies, which can be checked and rectified and its occurrence in future can be avoided.

(4) The records are easily available and always kept up-to-date for accounting and taking timely decisions. Inventory control for maximum and minimum stock, safety stock and materials planning can be easily done by the store keeper.

(5) It prevents excessive stocking of materials, large investment and capital blockage is avoided. It reduces inventory carrying cost.

(6) It provides moral checks on store staff by keeping the up-to-date records and mistakes are easily located. Dishonesty is avoided. The settlement of claims are easily done for insurance and losses as records are always available and maintained.

QUESTIONS

1. What is inventory control? What are its objectives and functions?
2. What are the various types of inventory control systems used to order and replenish the inventories?
3. Explain the following types of inventory control systems
   (*i*) Two-bin system (*ii*) Max-Min system
4. Describe the Economic Order Quantity (EOQ) and Fixed Order Quantity (Q) system Differentiate between them.
5. Describe the fixed cycle (P) system and replacement system (S,s policy) of inventory control.
6. What is the ordering system with quantity discounts? Explain how EOQ changes with price discounts.
7. What is Safety Stock or Buffer Stock? How will you determine it?
8. What is the influence of uncertainty on inventory control? How does the minimum stock or reserve stock is helpful to meet the uncertainty of demand and requirements in production or sales?
9. What types of inventory control problems are there? Give the controllable and uncontrollable variables in Inventory problems.
10. What types of fluctuations are there in demand?
11. What is lead time? What is its effect on inventory problems?
12. Explain essentials of inventory control.
13. What are the Elementary Inventory Control Models? Give the structure of various inventory models.
14. What are the costs involved in inventory control problems?
15. Give the application of characteristics of inventory problems.
16. What do you understand by the terms EOQ, EBQ, ELS and ETC?
17. Derive EOQ and ETC formulae and give graphical representation of inventory cost and quantity.
18. Derive EOQ with finite rate of demand and production or supply order and economic total cost formulae.
19. Give the formulae of EOQ and ETC when shortage is there.
20. What is Economic Order Quantity with price discounts? Explain how will you decide the order quantity with price breaks.

EXAMPLES

1. A Kirana shop purchases various materials to sell every year for Rs. 2 lacs. Every purchase order costs Rs. 1000 and inventory carrying charges are 20% of cost of materials. Calculate EOQ. How many orders are to be placed every year.

   Answer: EOQ = Rs. 44400, No. of orders placed = 4.5 per year

2. A floor tile is costing at the following price breaks from the manufacturer.

Price per unit (Rs)	*Quantity*
50	1-499
45	500 - 999
40	1000 and above

Number of tiles required by a building contractor are 10,000 per month. Ordering cost is Rs. 200 per order and carrying cost is 10% cost of tile. Find out the ordering quantity and total cost of tiles per order.

Answer: Order = 1000 tiles = 1000 tiles, total cost = Rs. 404000

3. A manufacturer has to supply 15000 units of a product per year to his customer. The demand is fixed and known. The inventory holding cost is Rs. 2 per unit per month and set up cost is Rs. 350

Determine (*i*) Optimum size to supply

(*ii*) Scheduling period

(*iii*) Minimum total expected yearly cost

Answer: (*i*) Optimum size of supply = 2250

(*ii*) Scheduling period = 1.8 months

(*iii*) Yearly cost = Rs. 4500

4. The annual demand of electric bulbs of a shop is 8000. The cost of bulb is Rs. 10. Inventory carrying cost is 20% of its price. Calculate EOQ and total cost of ordering the bulbs if rate of supply is 800 bulbs per month and ordering cost is Rs. 400 per order. How many orders are to be placed in a year?

Answer: EOQ = 7280 N = 1.

5. The peak demand of heater in winter is 2400 per month in a electrical goods selling shop. Cost of ordering is Rs. 50 per order. Cost of heater is Rs. 250. Inventory carrying cost is 15% of its cost. The shortage cost is Rs. 10 per heater per month. Calculate the economic order quantity and total cost. If lead time demand is 200. Calculate safety stock of heaters in the shop. Lead time is one month and constant A = 1.90.

Answer: EOQ = 174 ETC = 2655 and safety stock = 84.

CHAPTER X

Value Engineering

Value Engineering or Value Analysis

The customer value the product and pay its cost if it justifies its use and functionality. The Value Engineering or Value Analysis evaluates this value of the product. The analysis is necessary to find out the value of the product. This analysis which attempts to find out the value of the product and reduces the cost is called Value Engineering or Value Analysis. The desired approach of Value Engineering is better performance and lower cost.

Thus, the Value Engineering is management tool to analyse the value or function of the item or product and its relationship with cost of the product. The value analysis was developed as a technique of cost reduction of a product through change in design, modification in specification, change of material and cost of production. This technique was developed by Lorry D. Miles working at General Electric Company of U.S.A. in 1947. He was the president of Society of American Value Engineers.

Value: In value analysis, it is necessary to understand the meaning of value. The Value is different from Cost. The relationship between value, cost and function are given as follows.

Value = Function/Cost

This shows that value is not the cost or price of the product. It is directly related to function and inversely related to cost of the product. Value increases if cost of the product is reduced. A material or item may be more useful or having better function its value will be more. The value of the item can be determined on the basis of two things.

(*i*) Use value

(*ii*) Esteem value

(*i*) Use value: The use value of an item is the cost which is included to perform its basic function.

(*ii*) Esteem value: It is the total features which attracts the people to buy the product. Esteem value of an item is market oriented and is more than use value. Scarcity of item many a time value more to possess a product and its easy availability reduces its value and sales.

The value of the product is thus increased by its functionality and the use, customer gets by spending the money he pays for it. Customer pays the price for a product for the satisfaction he gets by utilising the product and continues to purchase such items. The value of the

product is decided by its use value, esteem value, cost value and exchange value. Cost value is the cost of producing the item and exchange value is the value of quality of the product due to which it can be exchanged with others.

Function: The function is defined as the need or the purpose of the item for which it will be used. A product can have one or several uses i.e., one or more function to perform and they can be classified as

(*i*) Primary function

(*ii*) Secondary function

(*iii*) Tertiary function

(*i*) **Primary function:** It is the main basic function for which an item is used.

(*ii*) **Secondary function:** It is the function which supports the basic function for which it is meant.

(*iii*) **Tertiary function:** It identifies some more use of the product and added to primary and secondary functions.

The value of a refrigerator is to preserve vegetables and food products. It is the primary function to preserve them and give *ice*. The secondary function is to provide space to keep more and more items or eatables for storage and tertiary function is to save efforts of cooking and attraction to possess multi-utility and attractive coloured refrigerator.

Cost: In making the product, the cost is necessary for materials, labour and production, the value has input and output relationship. The cost at which the product will be sold is the measure of its value. The profit is earned if the price of the product is more the cost involved in producing it. It is the objective of every producer. There are two aspects of cost in value analysis. They are cost control and cost reduction.

Cost control: Adhering to the set standards which are meant to achieve efficiency and lowest cost of the product and system.

Cost reduction: Cost reduction is to save the cost in material, labour, production and overhead charges. This is done by improving the standard and reducing the cost. The advantages of cost reduction are:

(*i*) It increases the profit

(*ii*) Sales are increased

(*iii*) Value of the product will be more

Objective and Purpose of Value Engineering

The objective of Value Engineering is to provide the cost control to the product life cycle by reducing and eliminating the unnecessary cost. Systematic approach is done to maintain required quality and reliability of the product.

Purpose of Value Engineering is to provide skillfully and systematically control over the total cost of product by proper analysis and achieving the desired functions.

Value means many things to many people used in variety of ways. It should not mean the cost and price. There are seven classes of value.

1. Economic
2. Moral
3. Aesthetic
4. Social
5. Political
6. Religious
7. Judicial

The Value Engineering Systematic Approach is for economic value and as stated above the economic value comprises of use value, esteem value, cost value and exchange value. Out of these values, only use value is wholly objective and esteem cost and exchange values are subjective, they are personal value or prestige value. Wearing a gold ring is personal value.

Aims and Philosophy of Value Analysis

Aims: The aims which govern and direct the value analysis systematically are

(1) Equal performance at lower cost

(2) Multiple solutions

(3) Constructive discontent

The performance has some level of achievement and beyond that it can not be improved but cost can be lowered to some extent. The second aim is more feasible to have more than one multiple solution to improvements. The development of number of possible solution can be successfully achieved. Creativity can be explored. The function is that which makes a product work or sell.

Product: Anything produced or obtained as a result of some operation or work as by skill and effort of a labour is called a Product. This product obtained by some systematic way or approach to have the function for which it is produced is the approach of value analysis and aims of value engineering.

Philosophy: The aim by which an individual governs or acts himself is the philosophy of human beings. The philosophy of systematic approach governs the value engineering methods. There are three types of things in this philosophy.

(1) Have a positive approach: A positive approach is the positive motivation each individual must develop within himself as ways of life. The positive approach is that a job can be done how simple or complex it may be.

(2) Team work: Team work just like a team achieving the high level of performance in sports is obtained by joint efforts, collaboration and united work and attitude towards positive approach.

(3) Do a better job: Doing a better job is the main part of systematic approach philosophy and aimed by every individual putting his best and as a team work. These aims and philosophy are necessary for improvement and Value Engineering. The Value Engineering Job Plan was born with this philosophy and it is done in different phases as discussed below.

Value Engineering Job Plan

The value engineering job plan for product development, improvement and cost reduction have seven phases. These seven phases of job plan are discussed below. They are

1. General phase
2. Information phase
3. Function phase
4. Creation phase
5. Evaluation phase
6. Investigation phase
7. Recommendation phase

Each of these phases of job plan are supported by various techniques used for value analysis, they are old and new techniques and these are about 22 individual techniques are employed for value analysis.

1. *General Phase*

For the strong structure of the building strong foundation is necessary. The General Phase provides the strong foundation to the Value Engineering Job Plans. There are five techniques used in the general phase. There are given as follows:

(*i*) Use of good human relations: Everywhere we go and do a thing, we come in contact with people. In society, everyone is dependent on other. We must adjust to others, develop good relations, investigate and master abilities and skill while working with people and utilise them to the best.

(*ii*) Inspire team work : Things are learned by contacts and experience of others. The group that have togetherness works as a team can always achieve the goals as an individual and as a group. When the job is done by a group of people they should have togetherness. The code of ethics is to be developed which will conform all the members of the team to work together in achieving the goals by assisting each other.

When a man is asked to participate with others in achievement of a plan he develops esprit de corps and the feeling of belonging to the plan rather than the feeling of one standing on the outside looking in.

He becomes aware of a mutual dependence.

The mutual sharing of responsibility, flexibility and sacrifice are the significant conditions producing good team work. Without team work, any efforts may not be fruitful. The team work gives solution to each problem.

(*iii*) Work of specifics: The difficult problems are decided in large and smaller parts and then using specific knowledge and technique they will be easily solved.

(*iv*) Overcome road blocks: The resistance is always there for the changes and progress. New ideas and working differently have road blocks risks are involved for its failure. They may be imposed on us or found in ourselves because of circumstances. But if the good ideas and something good is tried it will be overcome by the efforts.

(*v*) Apply good business judgements: Good business judgements, demands, elimination of personal prejudices and strong desire to please by open mind and straight thinking. Decisions must be based on specifics. New knowledge and understanding is must for good business judgement.

In this way the foundation of the Value Engineering Job Plan lies on the above mentioned five general phases.

2. Information Phase

In this job plan phase, the various techniques and tools are used for cost improvements and its control. The various worksheets are used for records and planning. It is a working phase. Three techniques are used in this phase securing the facts, determining the costs and fixing the costs on specifications and requirement. For thorough understanding the informations, facts, figures and data are necessary.

Secure the facts: The facts about the problem are to be found out and then solution is to be obtained. The information are to be obtained from some source. The information can be collected in the information sheet given below in Fig. 1.

Value Engineering

XYZ Company Ref. no.....

Information worksheet

Product .....

Project ..... Drawing no. .....

Quantity required .....

Application and marketing background

Engineering background

Manufacturing and procurement background

Team members ..... Date.....

Fig. 1

The worksheet shown above in Figure 1 has the information about project member using sequential or group numbering system, for example 8 - 4 - 03 gives 8 as August month 4 as fourth project started in 2003. The other informations are about product, drawing number and quantity required for manufacture. The information is required about entire project in following areas:

(1) Application and Marketing Background

Detailed specifications, requirements, environmental, conditions, space, reliability, serviceability, maintainability and operability for required life anticipated market requirements, competitors, changes and improvements required in the product are the information necessary in the marketing background.

(2) Engineering Background

Information of design original specifications and requirements about material weight life, environment and appearance are required for engineering background. How the cost can be reduced will be the important analysis in this background.

(3) Manufacturing and Procurement

It requires information about process, operation, quantities produced per run, month or year, equipment, method and tools needed for manufacturing. If the part is to be purchased the supplier information and cost are needed.

(4) Consultation Summary

All the informations are summerised in this worksheets which is shown Figure 2.

Value Engineering

XYZ Company Ref. no.....

Consultation Summary

Product .....

Project ..... Drawing no. .....

Quantity required .....

Idea being developed .....

Source of information	*Information received*	*Action taken*

Team member ..... Date

.....

Figure 2

Determination of Cost

The various costs are determined accurately in Value Engineering systematic approach and it is very necessary. The following costs are found out:

(*i*) Prime cost

(*ii*) Overhead cost

Difference between cost and price is to be understood. Cost is expenses incurred to manufacture and money paid for material. Price is money spent for services and transfer of ownership of goods. The following types of cost are determined for value analysis.

Prime cost: It is direct material and labour cost.

Overhead cost: It is indirect cost other than which is involved in making the product.

Convertion cost: This cost is the money spent for efforts and materials indirectly required to produce the product.

Total cost: It includes all the costs mentioned above and maintenance, operating and shipping cost.

Lowering all these costs and controlling them is the main purpose of value analysis. In order to to this all the of costs are correctly and accurately obtained in the information phase for further analysis.

3. Function Phase

The functional approach of Value Engineering uses the following three techniques:

(*i*) Defining the function

(*ii*) Evaluating the functional relationship

(*iii*) Functional alternatives

These techniques are applied to increase business profit.

Definition of the function: Value Engineering defines the function as 'which makes a product work or sell'. There are three rules used for defining the function. They are:

Rule 1 Function must be accomplished in two words a verb and a noun.

Rule 2 Work is action and quantity. Sell is to sell qualitatively.

Rule 3 All the functions are divided in two levels as basic function and secondary function.

These rules are established to simplify, standardize and channel the thinking process for scientific measurements of any function. It establishes the relationship between function and cost. There is only one basic function where as the secondary function involves specific function and dependent function. Input and output are not functions, they are parameters of the project. There can be multiple inputs to and outputs from any project. Anything to have value of any kind, it must have both inputs and outputs. There are always some unnecessary functions associated with the project by eliminating them the costs associated with them can be eliminated. This will be done by evaluating the functions using functional definition worksheet in the functional analysis. It is shown in Fig. 3.

Value Engineering

XYZ Company Ref. no.....

Functional definition

Product .....

Project ..... Drawing no. .....

Input		*Basic function*				*Output*		
Quantity	*Part*	*Function*		*Functional part*		*Level assembly*		*Notes and/or comments*
		Verb	*Noun*	*Basic*	*Sec.*	*Basic*	*Sec.*	

Team member..... Date .....

Fig. 3.

Evaluate Functional Relationships

The functional balance is that which makes the product work and sell most effectively at the lowest total cost. This is possible to do by evaluating the functional relationship. For evaluation of the functions, numerical values are assigned to each function and then they are compared.

Numerical Evaluating of Functional Relationship

When functional definition sheet is complete after numerical assignment of value the functional evaluation is done. The comparison and evaluation of each function requires understanding of facts, data information and their relative importance. Weightages are assigned to more important functions and numerically evaluated. They are then summarised. The basic functions and secondary functions are listed in descending order of these numerical values. This is shown in Figure 4. The Functional Evaluation Sheet is given in Figure 5.

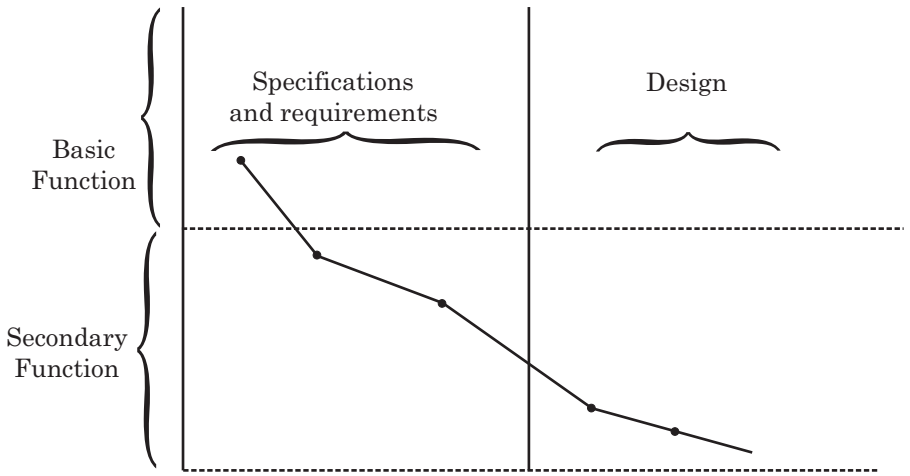


Fig. 4.

Value Engineering
XYZ Company Ref. no. .....
Functional evaluation
Product .....
Project ..... Drawing no. .....

Key letters	*Functions*	*Weight*
A		
B		
C		
D		

Evaluation Summary

Numerical Evaluation

	A	B	C	D
A				
B				
C				
D				

Team members ..... Date .....

Fig. 5.

4. Creation Phase

There are two types of abilities every human being possesses, they are creative and judicial abilities. These are developed as useful abilities of ambition, accomplishment, enthusiasm and devotion towards working willingly for factual evaluation and truth. Creativity is to develop these abilities. These two abilities are possessed by our mind. The creative abilities is developed in childhood at home by education and training environment. The persons with whom we are associated as parents, educators and business associates affect the thinking from pattern that is creative to judicial for varying degree of fear and resistance. The fears and resistances can be separated into three groups as culture, emotional and perceptual. The creative abilities are developed to remove the fear and resistance.

Establish positive thinking.

The fear which is developed by environment will be eliminated by thinking positively.

Develope Creative Ideas

The creativity and ingenuity grow by exercise. There are three mental processes used in creative thinking. They are imagination, inspiration and illumination. The noncreative and creative mental processes are simulated by Idea Activators. Idea Activators takes the form of checklists where direct or indirect questions are asked about problem under study and simulated.

5. Evaluation Phase

In the evaluation phase, the preliminary alternatives which are considered for the function they are developed and evaluated by comparison. Four techniques are used for this.

Refine and combine ideas

Establish cost on all ideas

Develop function alternatives

Evaluate by comparison

Refine and combine ideas: Before combining the ideas further creativity, appraisal, refinement and judgement must be applied. Ideas can be developed into a workable solution. The advantages and disadvantages of ideas are listed and on that basis they are combined having advantages and others are eliminated.

Establish costs on all ideas: In refining process, relative cost on each idea or combination of idea is found out. After establishing cost on all ideas for each function lowest cost is evaluated.

Develop function alternatives: The refined creative ideas and judgement starts the elimination of unnecessary cost and develop value alternative of merit. This is done by functional development sheet filled with required data. It is shown in *Figure* 6. The specification and requirements are reviewed and modified and workable solution is obtained

Value Engineering

XYZ Company Ref. no.....

Functional development

Product .....

Project ..... Drawing no. .....

Basic function .....

Function	*Creative ideas and development*	*Estimated cost (cumulative)*

Total

Present cost summary

Material .....

Direct labour .....

Others .....

Total .....

Team member ..... Date .....

Fig. 6

Evaluate by Comparison

In the process of evaluating functionally developed alternatives, many factors must be compared. This is done by writing in short idea from functional development.

For idea evaluation of all alternatives, the good business judgement is necessary in this evaluation process. In comparison and evaluation, the cost quantity, maintainability and reliability aspects of products are considered.

Value Engineering

XYZ Company Ref. no.....

Idea evaluation

Product .....

Project ..... Drawing no. .....

Function .....

Functional Development	*Advantages*	*Disadvantages*

Plans for action on ideas

Team member ..... Date .....

Fig. 7

6. *Investigation Phase*

The personal demands and requirements are fulfilled in the investigation phase of Value Engineering using company and industrial standards, consulting suppliers and specialists about product, process and materials.

Use Company and Industrial Standards

Standard parts have lot of advantage as they represent good quality and reliability of product. The standard materials and processes are to be used.

Consulting Suppliers or Vendors and Specialists

The vendors and specialists are consulted for proper approach to find lowest cost and marketable quality of the product. These services may cost for consultations but it will save time in the analysis which will be useful in evaluation process. The trade association or research organisations can be consulted for this work.

The speciality products, process and materials cost.

The new improved technology may provide lowest cost and improved product. Development in speciality products, processes, procedures and materials must be known to the management and be aware of all new technologies. The experts in this field can be consulted for analysing existing products and development of new products.

All the roadblocks are to be removed till than the work will be done so as to develop reliable product at lower cost.

Final Functional Development of Alternatives

In the final stage of elimination and minimization of problems done by comparison they are reviewed by company specialists and consulted with them. With their acceptance the consultation summary is prepared which is shown in Fig. 8. The objective is the largest total cost and supplier's quotation summary as given in Fig. 9 evaluates the various quotations received from the vendors. Finally arrived at final solution with relaxed and calm mind.

The final solution developed in this investigation phase will be used in the last phase.

Recommendation phase for its implementation.

Value Engineering

XYZ Company Ref. no.....

Consultation summary

Product .....

Project ..... Drawing no. .....

Quantity required .....

Idea being developed

Source of information	*Information received*	*Action taken*

Team members ..... Date .....

Fig. 8.

Value Engineering

XYZ Company Ref. no.....

Vendor Quotation Summary

Product .....

Project ..... Drawing no. .....

Basic approach .....

Vendor's name and address .....

1. ..... 2. ..... 3. .....

Additional data for vendors

Vendor quotation	*Vendor 1*	*Vendor 2*	*Vendor 3*
Unit price/Quantity			
Tooling/delivery			
Remarks			

Team member ..... Date .....

Fig. 9.

7. Recommendation Phase

In this phase, all the previous work will be finalised. All the duties with detailed plans are presented for final recommendation on worksheets.

Presenting facts: All the informations collected are presented as facts after investigations, objections and road blocks which are faced. The findings and solutions requiring change will be based on these facts evaluated precisely.

Present costs: The costs presented must be realistic. The cost savings are indicated clearly with proper reasoning. The cost which is to be implemented, is finally recommended on cost improvement recommendation priority sheet, which is given in Fig. 10.

Value Engineering

XYZ Company Ref. no.....

Cost improvement recommendations

Priority .....

Date .....

Product ..... Assembly or part .....

Project ..... Drawing no. .....

Part number ..... Quantity product ..... Quantity/year

Recommended

Present

Calculation of saving	*Material*	*Direct Labour*	*Fringe benefit*	*Total*
Present				
Proposed				
Difference per piece/assembly				
Implementation cost				

Manufacturing Engineering

Findings and Recommendation

Approved by ..... Rejected ..... Date .....

Engineering change order number ..... For further information .....

Team Member ..... Date .....

Fig. 10.

Findings and Recommendations

Team recommendation: The team recommendation is one page statement of all the facts about the problem and total job plan where the facts are presented in simple, clear and precise manner for final approval. A simple sketch will also be given for present approach and proposed change. This recommendation is given as team recommendation worksheet shown in Figure 10. All the facts are given in short in this sheet so that they will be finally approved as recommendation of team work.

Project implementation: Well planned and evaluated team recommendation and final decisions will be approved for implementation of the project by the authority as it is the outcome of all the seven phases of Value Engineering Job Plan Systematic Approach.

Application: The systematic approach of functional evaluation of alternatives and changes and reduction of cost using Value Engineering for product development has successful application and scope for individual products, assemblies and parts. Its application are to entire industry and community. Its application can also be used for construction work and service facility improvement.

Advantages

(*i*) It reduces cost, increases profit and improves functions.

(*ii*) The suitable products are produced as per customer requirements and utility.

(*iii*) Simplification, standardisation and quality aspects are considered in product development and manufacture.

(*iv*) Improved methods of production are used with cost control.

(*v*) Use of alternatives, lighter and cheaper materials saves direct material cost.

QUESTIONS

1. What is the Value Engineering or Value Analysis?
2. Define the following terms and give their relation.
   Value, Function and Cost.
3. How does Value Analysis control and reduce the cost?
4. What is the objective and purpose of Value Engineering?
5. What are the aims and philosophy of Value Analysis?
6. What is Value Engineering Job Plan?
7. Discuss the following phases of Job Plans.
   (*i*) General phase
   (*ii*) Information phase
   (*iii*) Functional phase
8. What is Functional Relationship and its numerical evaluation? Explain the functional development.
9. What is done in creation and evaluation phase of Value Engineering?
10. How the Investigation Phase and Recommendation Phase are correlated and how finally the project is implemented?
11. What are the applications of Value Engineering?
12. Give the advantages of Value Engineering or Value Analysis.

CHAPTER XI

Materials Handling

Materials Handling is defined as movement of materials in the plant from receiving center to distribution places and production centers. It is loading and unloading of different types of materials to and from the transporting vehicles or material handling devices. Keeping the materials in different racks, storage places and bins by the material handling equipments helps the material management personnel.

Minimizing Materials Handling

One of the objective of Facility design and Plant Layout is to minimize material handling at the same time using efficient material handling system to facilitate the manufacturing process A layout should be planned in such a way so that the material handling is reduced to a minimum. Material handling does not add any value to the product. Therefore it should be kept to minimum. The poor material handling can add to the cost of the product. Operations in manufacturing should be combined to avoid unnecessary material handling. Processing can be done during moving the materials when using conveyors. These are widely used for processes like painting, heat treatment, curing and chemical treatment. As far as possible the material handling should be mechanical in order to minimize the manpower required. All movement of materials and parts should be planned to move towards shipping area and they should be in process while in transit as in painting, baking, degreasing and finishing. The material handling is considered as an integral part of total manufacturing system.

Relationship of Materials Handling and Facility Planning

Plant layout must be done before installing the materials handling and manufacturing process equipments. The material handling system related to a facility operation has to integrate the following material handling function.

(*i*) Transportation to the manufacturing facility.

(*ii*) Receiving, storage and retrieval.

(*iii*) Transportation to the production centers.

(*iv*) Transportation between operations and staging.

(*v*) Packaging and shipping.

Designing a Material Flow

Designing the material flow through the plant in the efficient way will increase the productivity of an organization. It is possible by designing the movements of materials, parts and workers from beginning the process (receiving) to the end (shipping) in best possible way so that smooth movement of all the elements mentioned above is possible.

The material handling will be helping in designing this type of efficient movement.

Objectives of Materials Handling

The objectives of materials handling are

(1) It increases space utilization by keeping the materials in racks one above the other. The materials handling generally affect space requirements. Storing various types of materials like raw materials, parts, sub assemblies, assemblies and finished parts is facilitated by material handling devices and methods, stored at proper space.

(2) The operating efficiency is improved by reducing material handling. Material handling involves movement of materials mechanically using different equipments or manually. By increasing load per movement using proper material carriages improves productivity and saves cost of materials handling.

(3) The timely delivery of materials to production center or customer is essential criteria in material handling. Materials, parts and finished products must be moved from the place of storage to their destination speedily and efficiently. It improves service level if speed of movement of materials is increased.

(4) Reducing production cost by increased capacity, improving working conditions, improving customer services, increased equipment and space utilization and reducing cost of materials handling.

The material handling problems are what materials are moved, who will move and how it will be moved. They are divided in to the types of materials, how moved and methods of handling them. It enables results of reactions of man, materials and machines.

Functions of Materials Handling

(*i*) Planning the plant layout, building and production center to suit the particular type of materials handling equipments.

(*ii*) To minimize the movement of materials and material transportation.

(*iii*) Increase the speed of material handling equipments and devices.

(*iv*) Eliminating the backtracking or minimizing it. The flow of material should be planned so that distance moved is minimum.

(*v*) Material handling devices should be safe and its movement should be such that accident should not occur.

(*vi*) Wastage of materials should be avoided during materials movement, loading and unloading. The packages should not be damaged.

(*vii*) The cost of materials handling should be minimum.

(*viii*) The persons operating the materials handling equipments should be trained for their efficient handling and safe working.

Advantages of Planned Material Flow

The advantages of planned materials flow are given as follows

(*i*) Increased efficiency of production and better productivity will be obtained.

(*ii*) Better floor space utilization will be done.

(*iii*) Reduced in-process inventory is possible.

(*iv*) Reduced walking distance is there.

(*v*) Reduced traffic congestion will be there.

(*vi*) Smooth production flow is there.

(*vii*) Simplified handling activities will be there.

(*viii*) Better utilization of equipment and workforce is obtained.

(*ix*) Accidents hazards will be minimum.

(*x*) Better production control will be there.

Designing the Material Flow Patterns

The following types of flow pattern can be designed.

1. Straight-line flow pattern: which is used where the production process is short and simple and contains few components and production equipments.

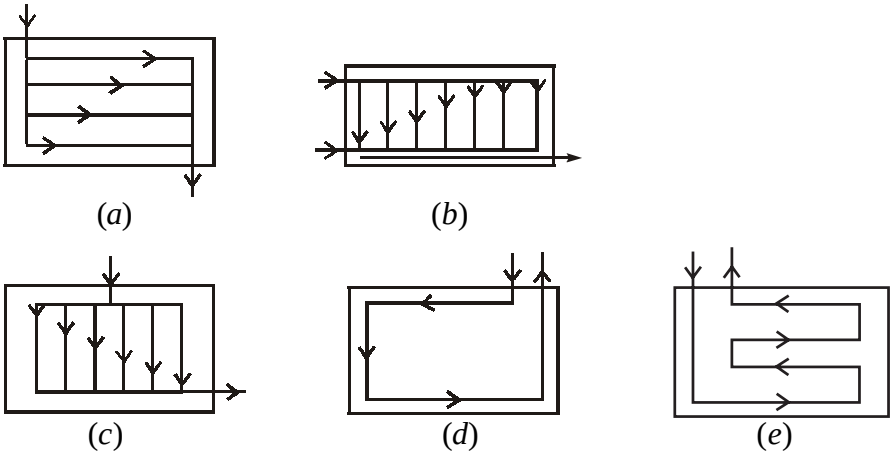
2. Zigzag flow pattern: It provides longer flow line.

3. U shaped flow pattern: It is used where the finished product ends in the process from where it begins in the process.

4. Circular flow pattern: It is used where the material or product returns from where it is started. The shipping and receiving are at the same location.

5. Odd-angle flow pattern: When no particular pattern is used in this flow pattern material handling is mechanized. A typical material flow patterns are shown in Fig. 1.

The (a) type flow pattern is used in long production lines., the (b) type for transportation available at the ends of plant, the (c) type if it is available at one end on one side, the (e) and (f) are useful for long flow line and (g) and (h) are used in subassembly operations.



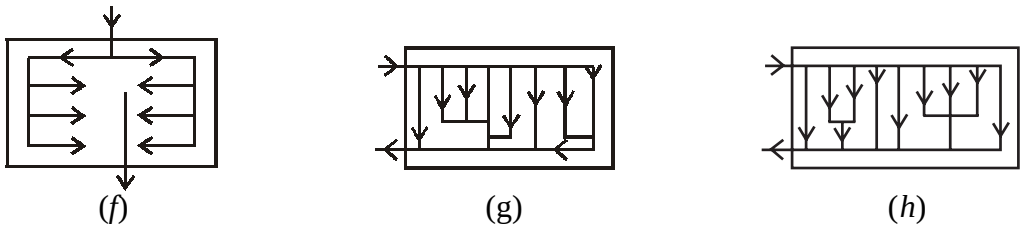


Fig. 1. Flow Patterns

Developing the Material Flow Pattern

For planning and developing the material flow pattern the first objective is to consider flow path the parts, materials and personnel will follow as required by the production operations and processes, and layout of assembly, ware housing and shipping activities. The other things necessary is that the movement should be safe, efficient and economical. The following procedure is adopted to select the material flow pattern.

1. Identify the thing that will blow through the facility such as (*a*) Material (*b*) Scrape and waste (*c*) Man power (*d*) Equipment (*e*) Information (files and office work).

2. Collection of all necessary data and information required to design the flow pattern such as (*a*) Production process for materials and parts (*b*) Types of scrape and wastes, their quantity and volume (*c*) personnel movements (*d*) processing equipments and material handling equipments, engineering data and specifications (*e*) Communication system for information transmission and handling requirements. The use of computers.

Conveyor Analysis

Conveyors are used as material-handling linkages between production centers. They are also used for transportation and in-process storage. They are classified in to four categories as given below:

(1) Constant speed and irreversible belt conveyors which are used to simply transport and store materials.

(2) Conveyors having controlled movements and they are reversible. Operators control them. They can be moved away for storing and carried to work station to receive materials.

(3) The conveyors consisting of parts, which can be connected and disconnected from moving portion of conveyors.

(4) Conveyors having closed loop continuous operating system having pats which can not be removed. See Fig. 2.

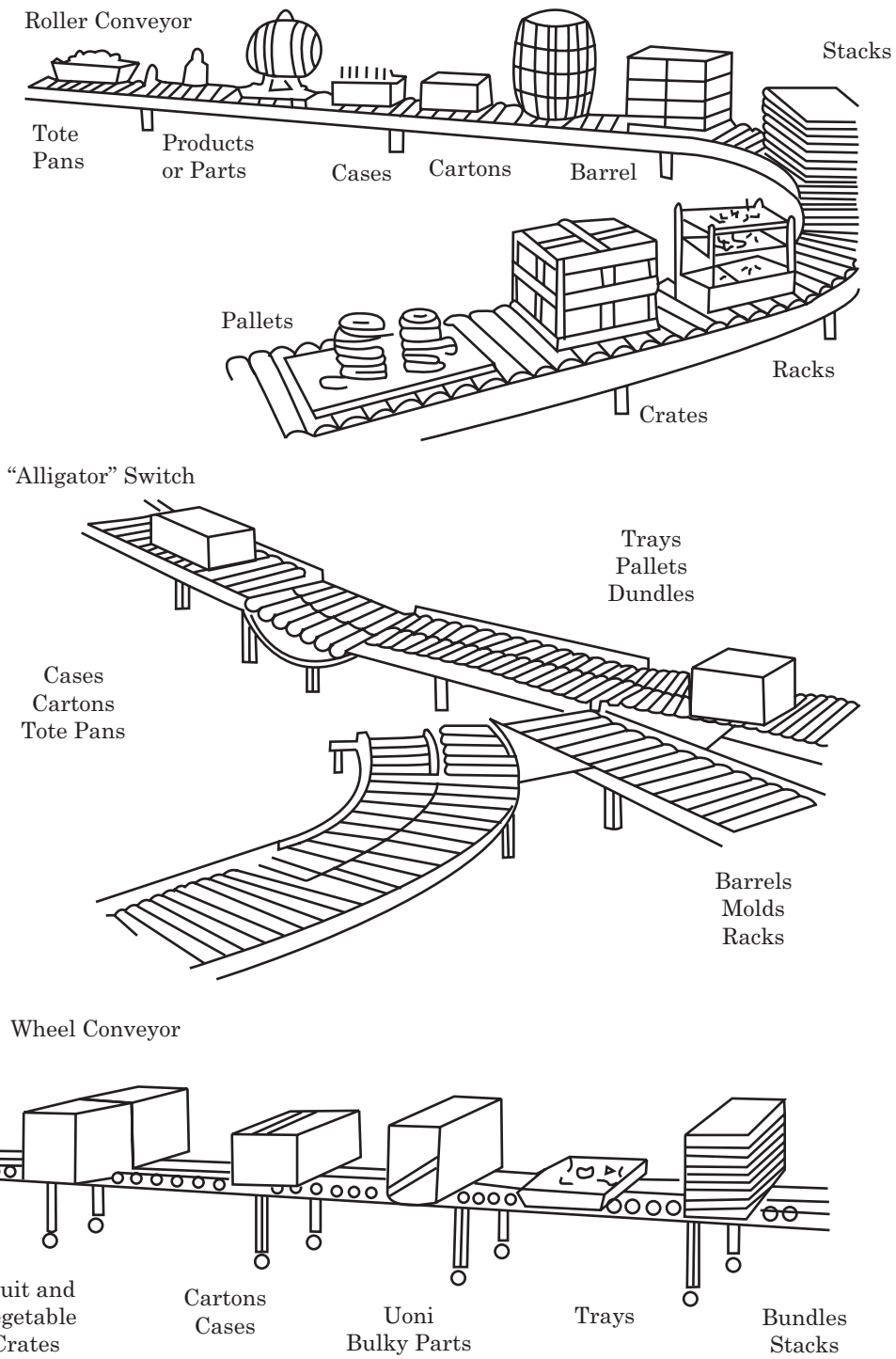


Fig. 2. Types of gravity conveyors. The most commonly used are roller and skate wheel types.

Material Handling at the Work Place

It may be defined as the handling that would normally be done after material has been delivered and kept at the work place for use before it will be picked up for moving to the next operation. The unique aspects of this type of material handling are given as follows which are different from traditional material handling.

(1) The distances involved in this type of material handling are relatively short.

(2) The number of moves in handling is more depending upon number of cycles performed.

(3) The greater portion of cycle time is required in this type of material handling.

(4) The material handling activity at the work place needs improvement using modern handling devices.

Introduction to Material Handling Activities

The primary function of material handling is the movement of materials. It has 50 to 75% of production activity. The material handling activity involves

(1) The movement of all types of materials from all sources of supply.

(2) All intra plant material handling.

(3) Distribution of finished goods to all customers.

Principles of Material Handling

Analyzing and designing the material handing system requires large experience and exposure to the work.

The principle of material handling is given by the unit load concept, which is explained below.

Unit Load Concept

It states that the larger the load handled, lower will be the cost per unit handled. The unit load is defined as a number of items or bulk material so arranged or restrained that the mass can be picked up and moved as a single object, too large for manual handling, and upon being released will retain its initial arrangement for subsequent movement. Single object too large for manual handling is a unit load. Basic ways to move unit loads are how the load will be lifted and carried.

They can be done by:

(1) A lifting device under the mass.

(2) Inserting a lifting element in to the body of the load.

(3) Squeezing the load between two lifting surfaces.

(4) Suspending the load.

These are possible by the related devices as a platform, a sheet, a rack in a container or self contained. The majority of unit loads are probably handled on pallets or skids. They are shown in Fig. 3. They are selected on the basis of following factors:

(1) Purpose for which unit load is intended.

(2) Characteristics of item handled.

(3) Handling system, capabilities and limitations.

(4) Carrier characteristics.

(5) Physical facilities: Vendor, plant and customer.

(6) Disposition of pallet.

In carrying out the design of unit load it should be evaluated against the following criteria:

(1) Low cost.

(2) Minimum tare weight.

(3) Versality and universal.

(4) Mechanical strength.

(5) Disposable.

(6) Optimum size.

(7) Ease of utilization and identification.

(8) Transportable and Interchangeable.

(9) Optimum shape.

(10) Meet customer requirements.

In designing a unit load system the procedure used suggest that:

(*i*) Determine the applicability of the unit load concept.

(*ii*) Select the type unit load. and determine its size.

(*iii*) Identify the most remote source of a potential unit load.

(*iv*) Establish the configuration and determine the method of building the unit load.

Material handling problems occur in different ways, each requiring careful analysis and individual solutions. Hastily derived solutions often result in accidents or costly modifications that may even permanently shut down the operation of the facility. It is necessary when solving materials handling problem to be aware of its effects on downstream operations, costs and safety.

Materials handling education committee consisting of colleges and industries experts have compiled a list of principles based on their experience of many years.

They are given as follows:

1. Planning: Plan all material handling and storage activities for best over all results.

2. Systems: For efficiency and overall cost control, integrate as many individual handling activities as possible in to one coordinated system. The different handling activities may involve receiving, stores, inspection, kitting, distribution process handling, packaging and transportation. This will ensure standardization, optimum space utilization and overall cost control.

3. Material flow: Provide a material flow pattern that is easy to work with and does not create congestion, cross traffic, or an excessive spacious environment.

4. Simplificaion: Simplify a process first by eliminating any non-value-added operation, combining operations or using group technology.

5. Gravity: Design the system to take advantage of gravity wherever possible, thereby eliminating equipment requirements.

6. Space: Utilization: Keep the third dimension, building height in mind when designing system.

7. Unit size: Increase unit size as much as possible to keep the frequency of moves low.

8. Safety: Keep safety as prime concern in handling and storage operations.

9. Mechanisation/automation: Mechanize and automate handling functions when practical.

10. Equipment selection: In selecting equipment give attention to the moves to be made and how it performs for overall cost and flexibility.

11. Standardiszation: For flexibility and cost control standardize methods, equipment and containers.

12. Flexibility: Select methods and equipment that can be applied to a variety of tasks.

13. Dead weight: Keep ratio of the weight of moving equipment to the load it carries to minimum.

14. Motion: for maximum utilization, transport equipment must be kept in motion as long as possible.

15. Idle time: Reduce unproductive time for equipment and personnel.

16. Maintenance: Plan for preventive maintenance and schedule repair during off time.

17. Obselescency: Replace obsolete methods and equipment when newer methods can be justified for implementation.

18. Control: Use material handling equipment to control manual operation time, scheduling, testing and processing.

19. Capacity: Use handling equipment to achieve planned production capacity.

20. Performance efficiency: Determine efficiency of the handling system in cost per unit handled.

These principles serve as a good checklist for a system designed to handle either a small part of or an entire facility complex.

Material Handling Methodology

For planning plant layout it is necessary to know the movements of materials inside the plant during processing. The space between the machines, containers and storage requirements decides the material handling system. The following things are necessary in facility planning for layouts to use materials handling.

(*i*) Avoid unnecessary material transportation and excessive handling.

(*ii*) Avoid the use of specialized handling equipments.

(*iii*) Prepare the detailed specifications of material handling equipments before purchase.

(*iv*) Avoid repacking of materials and immediate storage.

(*v*) Avoid cross traffic and backtracking of materials during process.

(*vi*) Utilize containers.

(*vii*) Move materials only in quantities required for immediate use.

(*viii*) Make use of building height for storage and curing of product.

Material Handling Safety

Safety aspects of material handling cannot be over emphasized. A majority of industrial accidents are related to improper materials handling. Safety should be the prime requirement in a material handling operation such as the lifting of a case of liquid detergent or in moving a pallet load of parts with a forklift truck. Many companies have an internal safety and health department over seeing all of the plant's practices. Their contribution in the area of employee safety has largely reduced workman's compensation claims and injuries resulting in absenteeism and medical cost. Their recommendation for items such as wrist and elbow supports, waist supports, and smaller package sizes have enabled the management to look seriously in to the materials handling operation to enhance employee safety and minimize injuries.

Materials Handling Equipments

The material handling equipments are designed, selected and used by an analysis of the type of materials to be handled, the moves to be made should indicate a method.

The material handling operation is classified as a system requiring many kinds of moves done by a variety of equipments. It depends on

(1) Material characteristics.

(2) Move requirements.

(3) Method (equipment capabilities).

Work simplification approach and the place of equipment in material handling system

The equipments used for it do not always solve the material handling problems.

Sometimes the simplest and most economical method will require no equipment at all.

The work simplification approach suggests the following procedure.

(1) Eliminate the move.

(2) Combine the move, such as processing; inspection and storage function can be combined.

(3) Change the sequence of activities such as shorten, eliminate or alter the move requirements.

(4) Simplify the move such as to reduce the scope of distance; to improve on the method or selection of equipment.

On the basis of the above approach the equipment of the materials handling can be selected. Manual handling may be in fact the easiest, most efficient and least expensive

method of moving the materials. Only after the proper analysis the equipments are selected which may be non powered manually operated, powered or mechanized.

There are various types of materials handling equipments used in industries. They are particularly designed and used to handle in a plant. The following criteria are used for selection of materials handling equipments.

Selection of Materials Handling Equipments

(*i*) It depends on types of materials moved. The size, shape, weight and volume of the materials decide the type of materials handling equipments to be used.

(*ii*) Physical and chemical properties of materials decides the type of containers to be used to carry them. Solid, liquid and gaseous materials are carried in different types of containers.

(*iii*) Layout of the plant, production center and other facilities are designed to suit the materials handling. Types of buildings, width of roads, corridors, pavements, floor levels, doors, height ceiling, size of rooms and storing places, single-storey buildings and multi storey buildings decides the types of transportation system used in materials handling and types of equipments are to be used in handling the materials. Use of conveyors and type of trucks are developed according to design of all the things mentioned above.

(*iv*) Methods, direction and movement of materials also decide the type of materials handling equipments, which are to be used. The liquids and gases will flow through pipes. Small materials like coal, ores and powdered materials flow through various types of conveyors. Trucks, overhead cranes and lifts carry large materials. Movement of these materials can be horizontal or vertical.

(*v*) Types of machines and equipments used for production also decide the type of material handling equipments are to be used. Various types of machines are used to produce different types of parts. The production can be continuous or intermittent. The CNC machines used in Flexible Manufacturing requires different types of material movement with pallet loading and uses robots to carry materials and parts. All the materials handling system is automatically controlled by computers.

(*vi*) Production processes and methods of manufacturing are main things to decide the type of material handling equipments. The different types of production processes and manufacturing methods require different types of material handling devices and equipments.

The various factors, which are considered for selection of equipments for materials handling, are also based on the following things:

(*i*) Material handling cost.

(*ii*) Cost of material handling equipments.

(*iii*) Material handling efficiency and automation needed.

(*iv*) Life of equipment.

(*v*) Safety of equipments.

(*vi*) Maintenance of material handling equipments.

(*vii*) Ease of operation.

Types of Material Handling Equipments

There are several types of material handling equipments used in Industry. They are operated manually. They are also operated mechanically or by using computers and other electrical and electronic devices. For convenience they are divided into four basic types of equipments used in Industries. Given as follows.

(1) Conveyors.

(2) Industrial trucks.

(3) Cranes and Hoists

(4) Auxiliary equipment.

All these materials handling equipments are described below.

1. Conveyors: The conveyors are material handling devices used to move materials horizontally or vertically from one point to other point over fixed path. They are expensive devices and need space and fixed route. They are gravity or powered devices commonly used for moving uniform loads continuously. The primary function of conveyor is conveying the materials. See Fig. 2. The various types of conveyors are used in industries for materials handling are:

(1) Belt Conveyors.

(2) Roller Conveyors.

(3) Trolley conveyors.

(4) Pneumatic Conveyors.

(5) Buckets.

(6) Chutes.

(7) Pipes.

Conveyors are useful for movement of materials between two fixed points for uniform loads. Materials move continuously with constant load in a fixed path. It can handle hazardous materials. The conveyors can carry materials at high temperature. The conveyors can be installed overheads. See Fig. 2, Fig. 3 and Fig. 4.

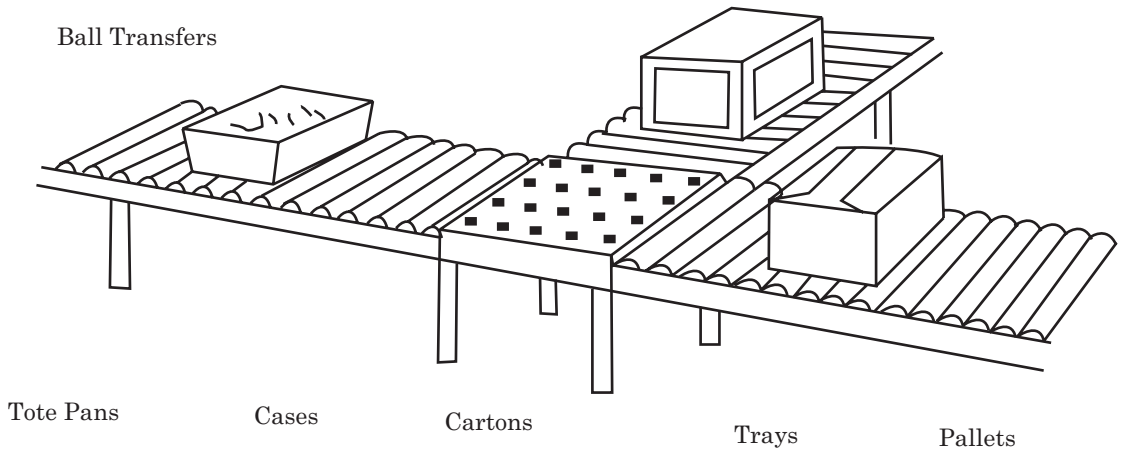


Fig. 3

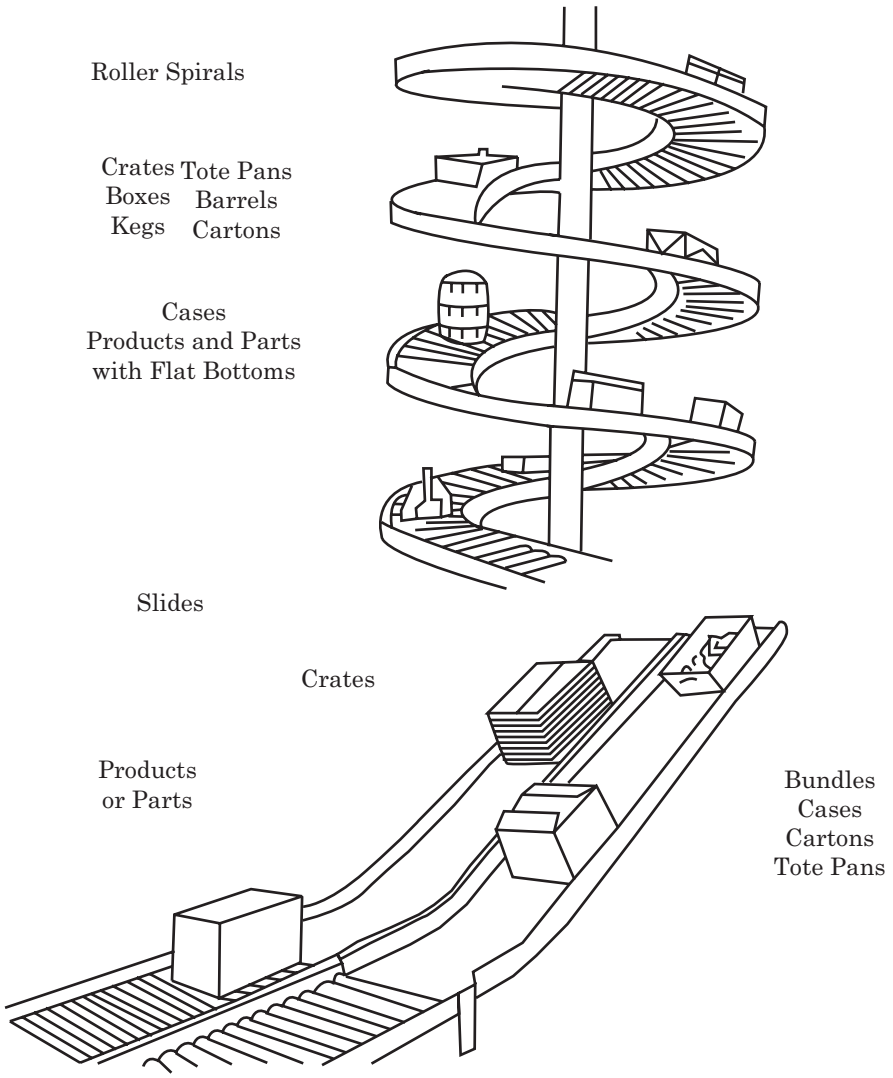


Fig. 4

2. Industrial Trucks: These are powered operated by using electricity, diesel, gasoline or propane. They are also hand operated. They are used for variable or fixed speeds and used for the movement of mixed or uniform loads over various paths having suitable running surfaces and clearances. Industrial trucks are more flexible than conveyors. They can be moved anywhere. They do not occupy fixed space. Since they can be transported anywhere they are very useful to carry materials and handling them in a manufacturing plant.

The various types of Industrial trucks used in materials handling are

(*i*) Two wheel hand trucks.

(*ii*) Fork lift trucks.(See Fig.5)

(*iii*) Hand Stacker. (See Fig. 6)

Fig. 5. Counterbalance forklift

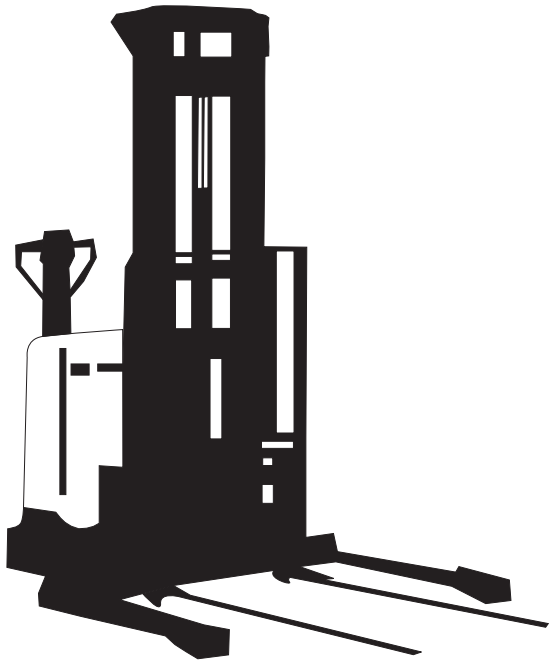


Fig. 6. Outrigger truck is ideal for narrow aisle storage applications. It is also available in a sit-down type. (Courtesy of Prime Mover, Inc.)

(*iv*) Walkie trucks.

(*v*) Tractor-trailer train.

(*vi*) Platform truck.

Industrial trucks are used to move the materials intermittently, stacking materials over racks and over different routes. Loading and unloading is also easy in these equipments.

3. Cranes and Hoists: the cranes and hoists are the material handling devices, which can move materials horizontally or vertically. They are overhead devices used for moving varying loads intermittently between points within an area, and can be moved in a fixed area of operation. They are supported and guided on rails. Their primary function is transferring materials. They can be used to move heavy loads and large items. They are flexible to move the materials. The various types of cranes and hoist used are given as follows. See Fig. 11, Fig. 12 and Fig.13.

(*i*) Overhead traveling cranes.

(*ii*) Gantry crane. (See Fig. 12)

(*iii*) Jib crane. (See Fig. 11)

(*iv*) Stacker crane.

(*v*) Mono rail.

(*vi*) Hoists. (See Fig. 13)

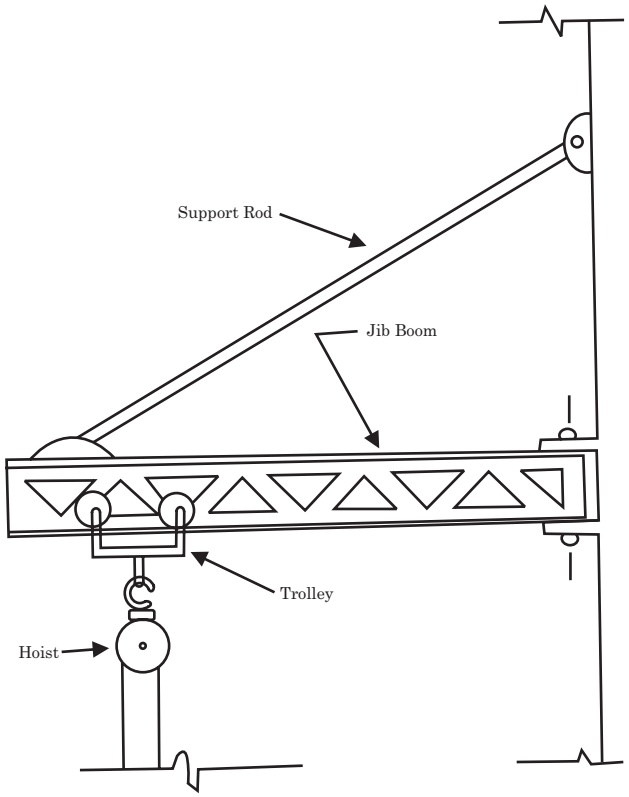


Fig. 11. Jib crane

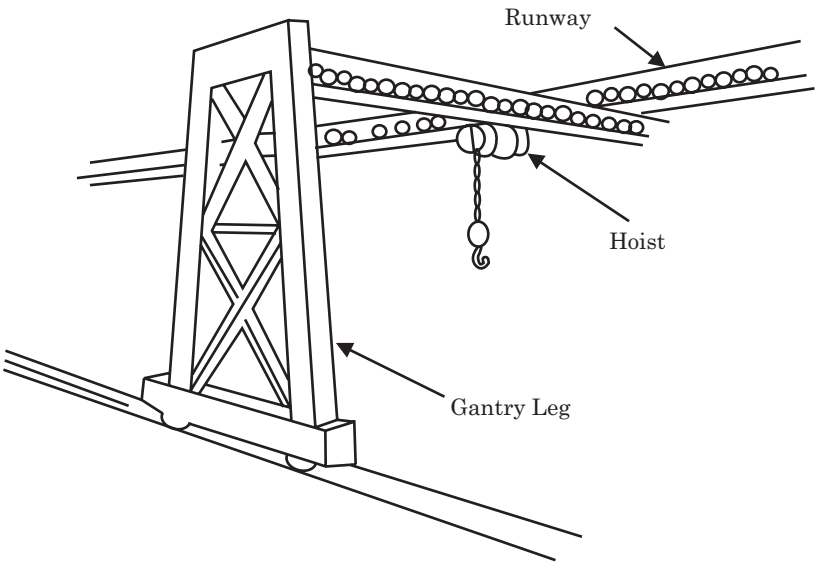


Fig. 12. Single-Leg Gantry Crane

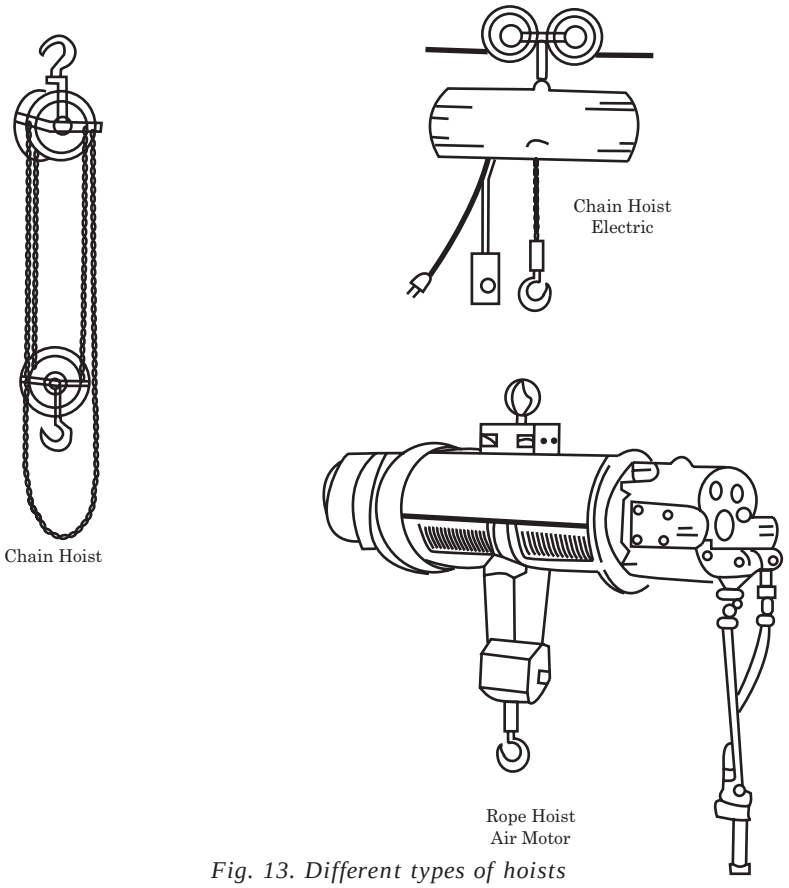


Fig. 13. Different types of hoists

Cranes and hoists are used for movement of materials in fixed area intermittently. They can handle variable load of different shape, size and weight of materials. It can transfer material from any location, which is within the range of the crane. Safety is very necessary in the area where cranes and hoists are operating. The safety devices must be used in their operation. See Fig. 7 and Fig. 8.

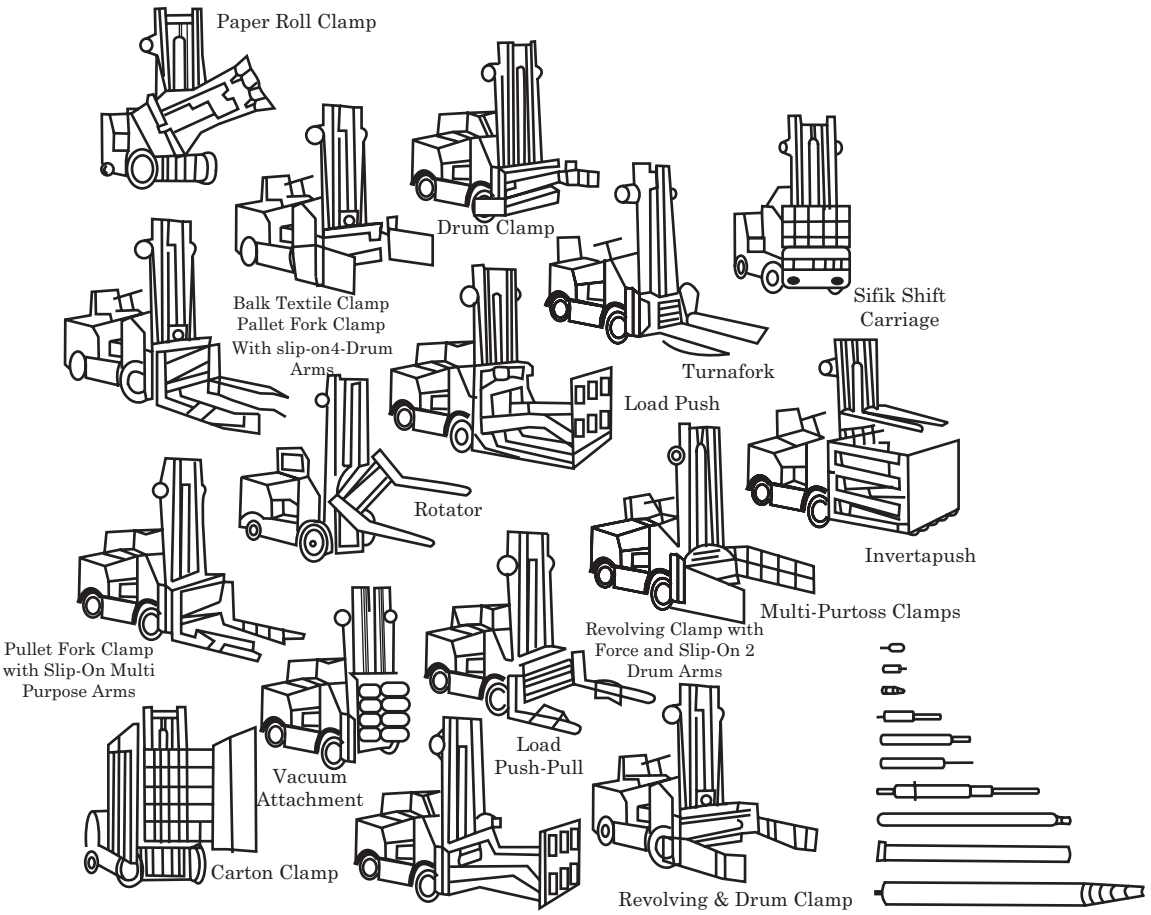


Fig. 7.

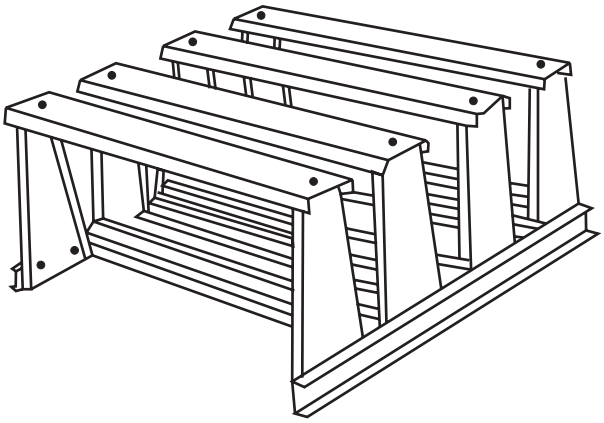
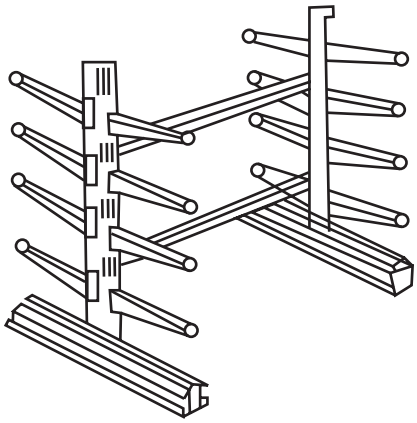
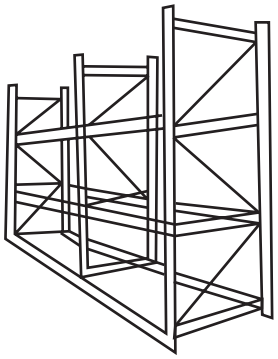


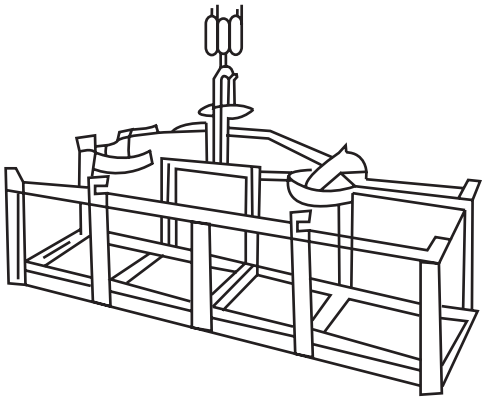
Plate Rack



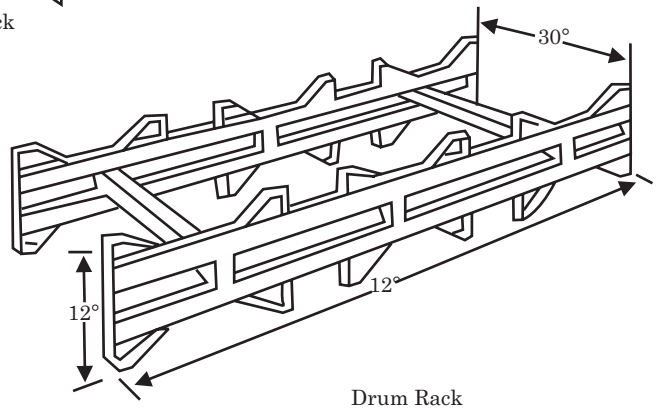
Cantilever Rack



Pallet Rack



Bar Rack



Drum Rack

Fig. 8. Various types of storage racks.

4. Auxiliary equipment: These equipments are devices or attachments used with material handling equipment to make its use more effective. See Fig. 4.

They are classified as:

(*i*) Pallets and skids.

(*ii*) Containers.

(*iii*) Below – the – hook devices (for cranes).

(*iv*) Lift truck attachment.

(*v*) Dock boards and levelers.

(*vi*) Pallet loaders and unloaders.

(*vii*) Positioners.

(*viii*) Ramps.

(*ix*) Weighing equipments.

They are again considered to classify on the basis of

(1) Their capabilities.

(2) Factors considered in analyzing material handling problems.

Basic Material Handling Systems

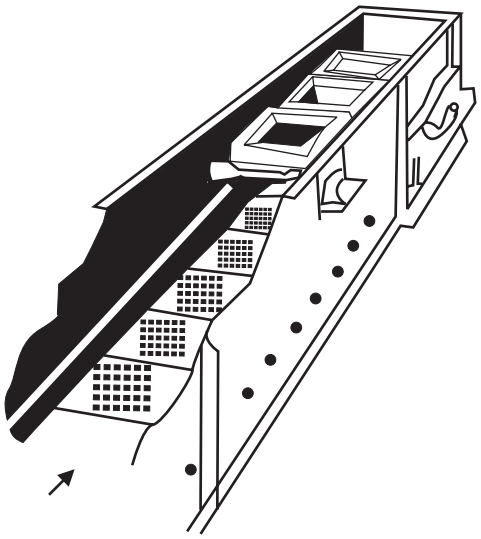
The group of related handling devices, commonly used in combination with each other is called Basic Material Handling Systems. They depend upon the material handling problems and situations like plant layout, processes, and volume of production, type of goods, shipping and receiving procedures used in the industry.

These systems are classified as follows:

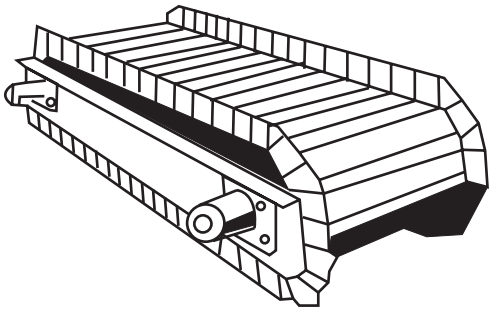
1. Equipment oriented systems: They are described in terms of the equipments as conveyors, cranes, hoists and industrial vehicles. They are given as follows.

(*i*) Conveyors system: They are used where items are of uniform size and shape and transported over the same path repeatedly or for long periods of time.

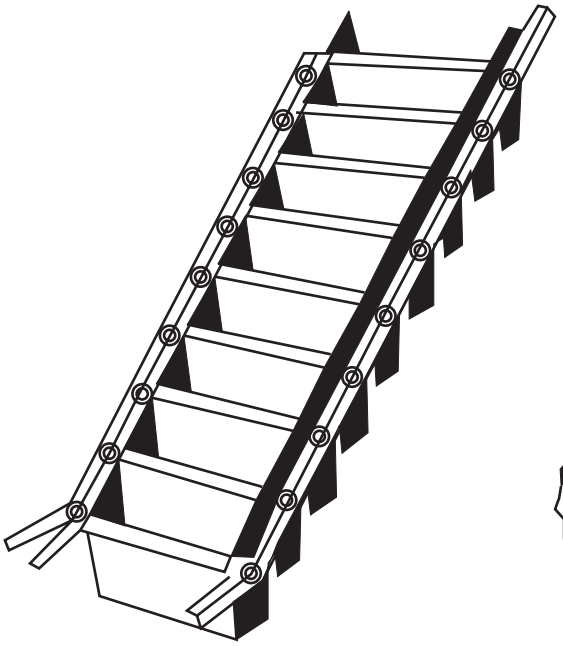
They are very useful in ware housing operations. Conveyor and automatic pallet elevators could deliver the loaded pallets to another floor or level. From there it might be picked up by forklift truck and taken to warehouse for storage. However, conveyors become less economical when they must be loaded and unloaded frequently. See Fig.9.



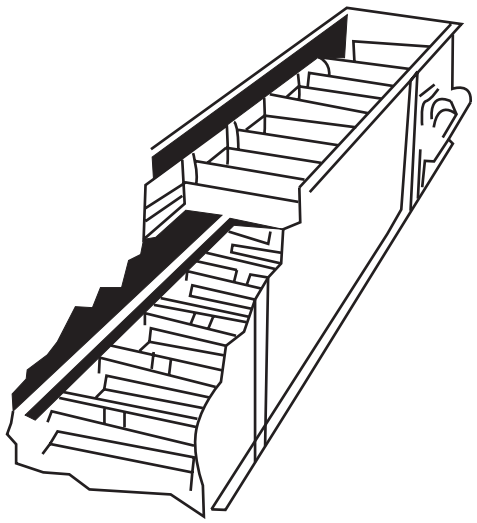
Drag conveyors



Apron conveyors



Deep Bucket Apron Conveyors



Flight Conveyors

Fig. 9. Conveying equipment for bulk materials. (Courtesy of Jarvis-Webb Company)

(*ii*) The fork truck and pallet system: It is similar to the platform truck and skid system. The forms permit use of pallets. Economic travel distance is about 65 meters. See Fig. 10.

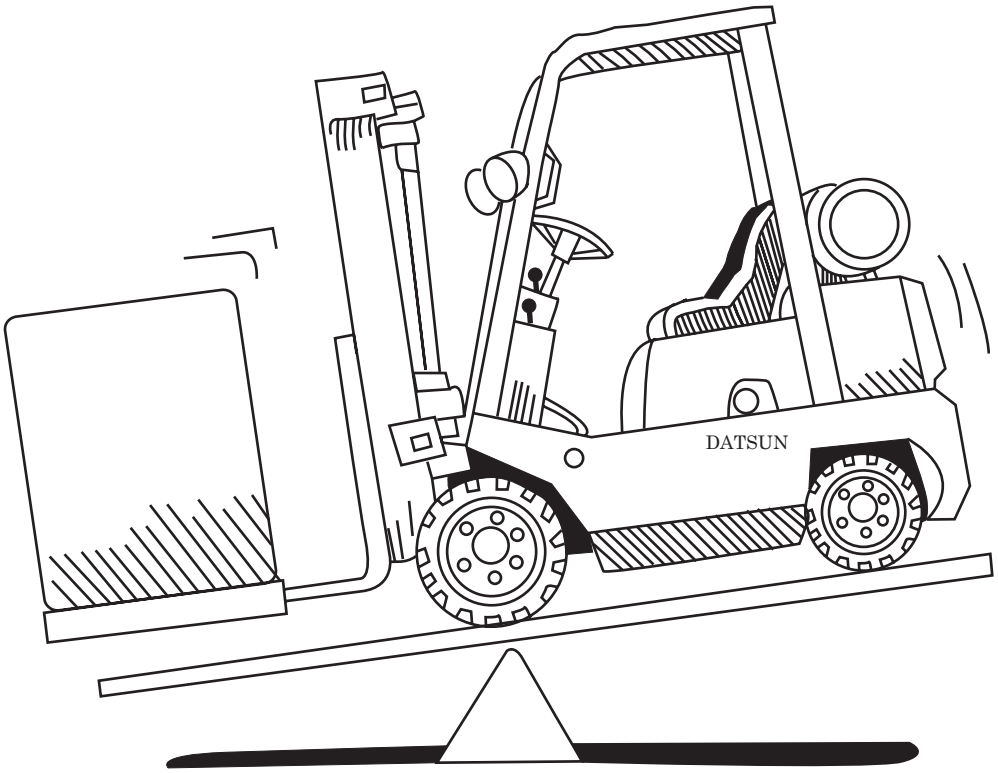


Fig. 10. Load capacity of forklift is different for various centers, as measured from front axle.

(*iii*) The tractor – trailer system: This system is more economical for handling larger quantities of materials for a distance over 65 meters to 100 meters. Loading and unloading have to be done by crane, hoist, and forklift truck or by hand.

(*iv*) Industrial truck system: The high-lift platform trucks and low lift trucks pickup, transport and set down skid-loaded materials. Low lift trucks are used for moving and high lift truck is used for stacking, maneuring and positioning.

(*v*) Overhead systems: These systems use cranes and monorail equipment for better floor space utilization and where paths are restricted.

2. Material Oriented Systems: They are also called load-oriented system and classified as unit handling, bulk handling and liquid handling system. In unit handling system a unit that may be a box, bale or roll of material will be handled. The unit load system is more flexible and requires less investment.

3. Method Oriented System: It is also known as production oriented system because it is used for the type of production such as manual, mechanical, job shop, mass or automated production.

(*i*) Manual system use manual handling methods.

(*ii*) Mechanized or automated system use sophisticated complex mechanical equipments like conveyors, automatic control and transfer devices.

(*iii*) Job shop handling system has small- volume operations. The unit load system combined with fixed and portable conveyors are used, They may be flexible and conventional type.

(*iv*) Mass production handling system: They are used to handle high volume of materials with complex handling machinery. They may have automatic controlling devices like mechanical, electrical, electronics, photo- electric or magnetic devices.

4. Functional Oriented System: They are classified according to function for which used as given below.

(*i*) Transportation system: It has horizontal motion, pulling, pushing, or surface riding vehicles.

(*ii*) Transferring system: It has horizontal or vertical compound motions through air or within limited areas.

(*iii*) Elevating systems: It has vertical, continuous, or intermittent motion.

(*iv*) Conveying systems: It has horizontal inclined or declined motions over fixed routes by gravity or power.

(*v*) Self loading system: It has intermittent motion with machine that picks up.

Based on the above types of Material handling system classifications the equipments, which are used for Materials Handling commonly, are described below.

1. *Conveyors:*

(*a*) Flat-belt conveyor: They are endless fabric, rubber; plastic, leather or metal belt operating over suitable drive. The materials, packages or objects are directly placed over them.

(*b*) Power and free conveyor: It is a combination of powered trolley conveyors and un powered monorail type free conveyor. It has two tracks upper track carries the powered trolley conveyor and lower is free monorail track. Load carrying free trolleys are engaged by pushers attached to the powered trolley conveyors

(*c*) Slat conveyor: Its carrying surface consists of spaced wood or metal slats fastened at their ends to two strands of chain running in a suitable track or guide.

(*d*) Tow conveyor: It has endless chain supported by trolleys from an overhead track running in a track flush with or on the floor or running in a track under floor.

(*e*) Trolley conveyor: A series of trolleys are supported from or within an overhead track connected by endless chain, cable or other linkages. Loads are usually suspended from the trolleys.

(*f*) Gravity chute: It is a slide made of metal or other material and shaped so that it guides objects or materials as they are moved from one location to other.

(*g*) Gravity and line roller conveyor: A conveyor which supports the load on a series of rollers turning on fixed bearings mounted between side rails at fixed intervals are called roller conveyors. They are moved manually by gravity or power. Line rollers have power applied to some or all rollers.

(h) Wheel conveyors: It is a conveyor which supports the load on a series of skate-like wheels mounted on common shaft in a frame or on parallel spaced rails and with the wheels spaced to accommodate the size of the load to be carried.

2. *Cranes, Hoists and Monorails:*

(*a*) Jib crane: It is a lifting device traveling on a horizontal boom that is mounted on a column or mostly fastened to floor, a top support wall bracket or rail.

(*b*) Bridge crane: It is a lifting device mounted on a bridge consisting of one or two horizontal girders, which are supported at each end by trucks riding on runways installed at right angles to the bridge. Run ways are installed on building columns, overhead trusses or frames. Lifting device moves along bridge while bridge moves along runway.

(*c*) Monorail conveyors: It is a handling system on which loads are suspended from wheeled carriers or trolleys that usually roll along the top surface of the lower flange of the rail forming the overhead track.

(*d*) Stake crane: It is a device with rigid upright supports suspended from a carriage mounted on an overhead traveling crane.

3. *Industrial Trucks:*

(*a*) Four wheel hand truck: It is a rectangular load carrying platform with 4 to 6 wheels used for manual pushing by means of rack or handle.

(*b*) Hand lift truck: It is a wheeled platform that can be rolled under a pallet or skid and equipped with a lifting device designed to raise load just high enough to clear the floor and permit moving the load.

(*c*) Fork lift truck: It is a self loading, self propelled wheeled vehicle carrying an operator who carries a load on a fork fastened to telescopic mask which is mounted ahead of the vehicle to permit lifting and stocking of loads.

(*d*) Plat form truck: It is a fixed level, non elevating, load carrying powered industrial truck supporting the load on a platform.

(*e*) Other types of trucks are:

(*i*) Narrow aisle truck: It is capable of operating in a narrow aisle.

(*ii*) Order picking truck: It is designed and adopted to facilitate the order picking process.

(*iii*) Side loading lift truck: It is a powered 4 wheeled truck that picks up the load from the side by means of a mast with forks centrally mounted.

(*iv*) Reach truck: It is a variation of the straddle trucking which the fork reaches out for the load on a pantograph type of device which permits the truck to travel forward to engage the load, lift it and then retract it to the mast for traveling.

(*v*) Straddle truck: It is a variation of the lift truck where vehicle is equipped with wheeled outrigger arms extending forward on the floor along either side of the load; arms perform the function of a counter balance and keep the truck from over turning.

(*vi*) Walkie truck: It is a power operated, with the operator walking and operating the truck by means of control on the handle.

(*f*) Tractor – trailer train: It is a handling system consisting of a 3 or 4 wheeled, self Propelled vehicle designed for pulling loaded carts or trailers. Common versions are

(*i*) Rider type (*ii*) Walkie type (*iii*) Electronically guided type. See Fig. 7.

Lift truck attachments: They are wide variety of devices designed for attaching to lift trucks.

4. *Auxiliary Equipments:*

(*i*) Dock board: It is a specially designed platform device to bridge the gap between the edge of the dock and carrier floor. Some times known as bridge plates.

(*ii*) Dock levelers: It is a platform like device, built in to the dock surface and hinged to permit raising and lowering to accommodate height when bridging the gap between dock and truck floor.

(*iii*) Shipping containers: It is a large container designed for consolidating materials or goods to facilitate shipment by common carrier.

(*iv*) Pallet: It is a horizontal platform device used as a base for assembling, storing and handling materials as unit load. Usually consists of two flat surfaces, separated by three stringers.

(*v*) Skid: It is a load-carrying platform supported from the floor by the floor by two parallel stringers or supports.

(*vi*) Rack: It is a framework designed to facilitate the storage of loads, usually consisting of outright columns and horizontal members for supporting the loads and diagonal bracing for stability. See Fig. 8.

Storage racks are usually fabricated from sheet metal, wire or structural steel shapes depending on strength and size. The various types of racks used are:-

(*a*) Pallet rack area is served by a fork lift or power equipment.

(*b*) Flow rack is used in First-in-first out system by gravity.

(*c*) Plate rack, cantilever rack and bar racks are used where cartons are stored.

(*d*) Drum racks are used for storing oils, solvents, lubricants, paints and gases in drums, cans and cylinders.

Automatic Storage and Retrieval Systems (AS/RS)

The computer operated automatic controlled electronic system of material storage and retrieval system (AS/RS) used in flexible manufacturing system using Computer Integrated Manufacturing (CIM) has Automatic Storage and Retrieval System (AS/RS).

It is having maximum efficiency, a unique cost effective method of storing and handling materials. It uses computer data of noduct code and provides all information about materials storage and issue. A mini computer is used for AS/RS operation to automatically feed these data in to company accounts.

This system is used in Computer Integrated Manufacturing where a vertical stacking robot with platform, which travels up and down on rails on both sides of aisles on a rail rack

full of bins are used. Robot travel by computer command down the aisle and retrieves a bin from the rack, which are conveyed on conveyors. The bins are picked up, replaced with materials and deposits on to the rack at its proper location and this cycle of storage and retrieval of material automatically repeats. The computer system tracks all possible storage location with 100% accuracy and instructs the robot where to store each material at the same time all records of materials are also updated. Automated guided vehicle system is used for materials handling and carrying them to machines.

Benefits of the AS/RS are given as follows:

(1) Accurate inventory data are available on computer.

(2) Reduction in space requirements.

(3) AS/RS can increase the number of picks by four times over the manual method.

(4) Cost saving will be done by avoiding duplication in facility, inventory and other operating costs.

(5) Improvements in materials handling and safe working.

(6) Access to the inventory is only through computer so no pilferage or unauthorized use of inventory.

(7) It is flexible.

(8) It has error free operation.

The Flexible manufacturing system using automatic storage and retrieval system is illustrated in the Fig. 14 given below:

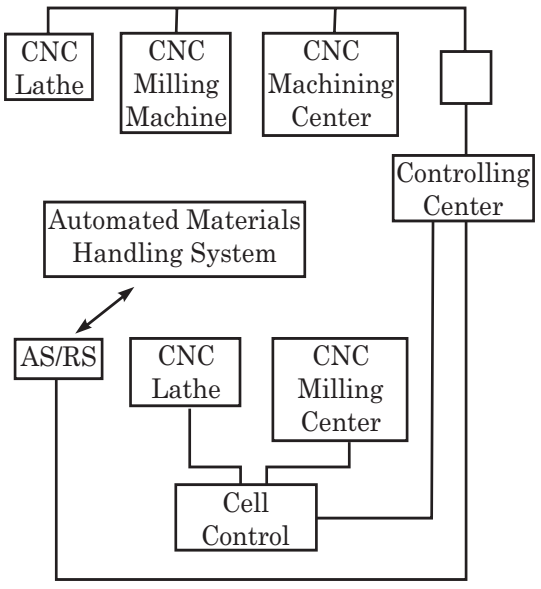


Fig. 14. Flexible Manufacturing System

A computer integrated flexible manufacturing system and materials handling system having automatic storage and retrieval.

QUESTIONS

1. Why material handling is needed in an Industry?
2. Why minimization of material handling is necessary?
3. What is the relationship between the materials handling and facility planning?
4. How will you design a material flow?
5. What are the advantages of planned materials flow?
6. Give the various types of Materials flow patterns used in plant layout and explain them.
7. What are the objectives of material handling?
8. What are the functions of material handling?
9. What are the principles of materials handling?
10. What is a unit load concept?
11. What are the materials handling system?
12. Give the materials handling methodology.
13. How will you select the material handling equipments?
14. Descrbe about various types of material handling equipments, which are used in manufacturing.
15. Classify different types of material handling equipments.
16. What are the conveyors? Why they are used?
17. Classify the different types of conveyors used in material handling?
18. Describe the different types of conveyors used in materials handling?
19. Why cranes, hoists, and monorails are used in materials handling?
20. Classify the various types of cranes used in materials handling and describe them.
21. Describe about the hoists and monorails used in materials handling.
22. What are the Industrial trucks? Why they are used?
23. Describe about the various types of Industrial trucks used in materials handling.
24. What are the auxiliary equipments used in materials handling?
25. Describe the various types of auxiliary equipments used in materials handling.
26. What is automatic storage and retrieval system(AS/RS) ?
27. Describe about AS/RS used in automatic manufacturing system using CIM.
28. What are the benefits of using AS/RS in materials handling?

CHAPTER XII

Just in Time

Introduction

In order to integrate the various functions of modern manufacturing methods, where advanced manufacturing technology like automation and CNC machines are used and the manufacturing processes and machines are controlled using computer to provide increased flexibility, efficiency and cost control. This type of manufacturing is called Computer Integrated Manufacturing (CIM), which uses CAD/CAM, CNC and Flexible Manufacturing System (FMS). These are advanced manufacturing techniques where computer aided facility planning and materials handling are also used.

The materials management, flow of materials, its storage and handling are also assisted using computer and computer-aided equipments. In order to save the cost and increase the production and efficiency in manufacturing, the recently developed technique Just In Time (JIT) has greatly helped the manufacturer to streamline flow and supply of materials exactly just in time when they are required. In Just in Time (JIT) manufacturing appropriate materials are made available to each operating station at the required time in the right quantity. JIT is a systematic material handling and manufacturing concept to avoid waste in materials and manpower. It has changed employee's attitude, work habits and awareness of quality assurance.

JIT technique has been first introduced in Japan and mostly used in automobile manufacturing Industries. It is a Japanese method of integrated philosophy by team approach. It is applicable not only to the various components of inventory but also used in manufacturing processes as daily activity. Taichi Ohrio applied this concept at Toyota manufacturing, and therefore it is also known as the Toyota production system. In this system, the customers pull their requirements from the shop floor, as against the conventional method of pushing the product to the market. By Integrating the Just in time cost with the total quality control system or a Kanban system at the shop floor level which is a culture developed by Japanese in their production system to make the product internationally competitive.

Product quality is one of the important aspects for every industry to day. It requires planning and organization of every manufacturing resource brought and managed on high quality and performance. Just in time is a method based on quality management is the approach, which helps the industries to achieve their target and attract their quality product to customer.

The JIT philosophy starts from purchasing the raw materials and is also used in the production of components, waste elimination and reduction of cost at every stage of production using quality concept.

Pioneers of JIT are UI Edwards Demings in Japan in 1950, J.M. Juran 1954, Kaoru Ishikawa and Nippon Wireless and Telegraph Company in 1962 used Ishakawa's suggestions successfully.

The Principles of JIT

1. Inventory and materials handling costs are as important as direct labor cost. They do not add to the value of product. The inventory carrying costs are as high as 30% of inventory cost. High technology industries such as missiles, air planes, computers and telecommunication incur higher inventory costs than consumer products, metal processing and industrial hard wares.

The Just in Time procurement of materials and reducing inventory level reduces this cost.

2. Material handling investment if reduced by effective manual handling which can preserve capital for more effective use which is possible by using JIT methods.

3. By installation of processing equipment with effective handling methods and upgrading materials handling systems with lesser cost reduces cost of production in JIT manufacturing.

4. The purpose of JIT is to eliminate waste which can be excess inventory, damaged materials, process defects, repetitive handling and waiting for materials avoiding long lead times and large in process inventory or stores.

Objectives of Just in Time

The objectives of JIT are to keep the processing time and cost to a minimum. This is possible by studying material supply and its production processing related problems and solving them.

The main objective of using JIT is to minimize the cost of the product by improving productivity and quality. The factors, which can be considered for these improvements, are

1. Product design,
2. Use of better technology.
3. Minimizing use of special equipment.
4. Reducing lead-time of manufacturing and supply of materials.
5. Reducing batch size.
6. Use of pull system.
7. Simplifying set up.

In order to meet the above objectives of JIT the following points are necessary to be considered in any organization.

1. It requires change in work culture, quality control and purchase of no defective items. Process control charts are used to find out defects in items.

2. Workers are motivated to take their own decisions regarding quality production and sense of ownership.

3. Selection of proper supplier for delivery of quality raw materials will reduce safety stock.

4. Small lots can be inspected easily and defects are also detected easily.

5. Timely delivery of materials and products is also necessary and it must be ensured

6. The main principles of JIT based quality management must be used in production. Make quality as everybody's responsibility. High level of quality control visibility and quality control commitments are necessary by management, therefore give responsibility of quality management to authority as well.

7. Flexibility in production scheduling, use of pull system, improved flexibility in workers, reduced lot size and set up, improved communication and cut off buffer stock will improve the production.

8. JIT will cut the purchasing cost, material-handling cost by purchasing from reliable supplier.

There is impact of JIT based quality management on quality control cost and for that there is significance of quality control programmes to be planned for continuous improvement.

The purchasing concept for JIT based quality management is purchase smaller lot size. There should be fewer suppliers. The supplier certification, design specification, competitive bidding and reduced paper work is necessary. Reduction in packaging cost is ensured.

Just in time eliminates all types of wastes and scrap. It leads to zero defects and lot size reduction. It identifies bottlenecks and streamlines production.

Requirements of JIT

The following factors are required to achieve the objectives of JIT.

(*i*) Use of total quality control to achieve quality in production.

(*ii*) Employee participation in all JIT activities to achieve the targets.

(*iii*) Small lot size manufacturing to remove all waste and scrap.

(*iv*) Principles of Industrial engineering are followed to achieve streamline flow of materials, operation and production.

(*v*) Identification of problems of bottlenecks and solving them.

Just in Time Methodology

(*i*) One piece lot size is followed in Just in Time.

(*ii*) It follows Group technology or cellular manufacturing system.

(*iii*) It uses total quality control, eliminates waste and inventory.

(*iv*) It adopts total preventive maintenance.

(*v*) JIT aims at zero inventories thereby minimizing inventory investment, reducing and shortening production lead-time and set up times. It reacts faster to demand changes.

(*vi*) It utilizes services of cross-trained workers along with working flexibility.

(*vii*) It utilizes Kanban cards for materials movements and production purposes. Work loading is uniform.

(*viii*) Decentralization in various departments of the manufacturing organization is used in JIT system.

Thus JIT methodology encourages employees in various JIT activities for increasing profit, improvements in working through cost reduction, inventory reduction (zero inventory) and quality control. Just in time production is when it is required, materials, parts, and components are supplied as and when required.

In case unusual event happens in production line worker stops it and asks for help to remove or eliminate the cause of stoppage. It is called Jidoka (self actuation).

Just in time production system utilizes the pull system rather than traditional push system. The pull system pulls work through from preceding operation, workers perform the required operation on materials or parts drawn from preceding work station at the essential time with the use of Kanban which is an instruction card. Two types of Kanbans are used. i) Withdrawal ii) Production ordering information. The work in process inventory is minimized or eliminated.

In this way JIT methodology works.

Zero Inventory (ZIN) System

The JIT system is similar to the conventional Job shop or makes – to – order procedure to produce as per demand of customers. At operational level of inventory management, this is also known as Zero Inventory or ZIN system, plasticized widely in American Industries.

In India Cycle – Manufacturing Industry in Punjab uses this type of system. The cycle parts are brought in the factory and complete cycle leaves the factory by the same transportation method. Practically no parts remain in inventory. This system is same as zero inventory (ZIN) system, which is similar to the concept of Just in Time used in Indian Industries. In automobile industries also similar type of JIT systems are used in our country.

KANBAN

The Kanban is the Japanese word for small card or tag, , which is attached to a bin of inventory. The Kanban is used for production management in Industry. The various types of Kanban used are as follows.

(*i*) **Production Kanban:** The production Kanban authorizes the preceding stage to produce the required quantity of components or subassemblies that are mentioned in it.

(*ii*) **Conveyance Kanban:** The conveyance Kanban is attached to the container, when it is transported from one stage to the next operation stage. Use of two Kanbans indicates production bottleneck, which may be solved.

(*iii*) **Job Card or Kanban:** The production control process starts with the insertion of the Job card or Kanban in each container of materials. The finished goods inventory of one production department becomes input material inventory to the next production department.

The rate of production of final assembly decides rate of production of its predecessors and all other production centers in turn.

Drawbacks of JIT

(1) The time required for introducing JIT system goes beyond the normal time requirements for implementation of the system.

(2) Workers attitude and culture should be improved to implement this system.

(3) Top Management must agree to implement the system but they will have to convince the employees about its benefits.

(4) It is difficult to achieve zero defects and zero inventory. Support from supplier of materials is necessary.

Advantages of implementation of JIT System

Using JIT system in industry claims the following advantages.

(1) It increases the operational efficiency, quality and organizational effectiveness.

(2) It increases awareness of problems and their costs.

(3) More profits are obtained by reducing lot sizes, less work in process inventories, less raw materials inventory and less indirect cost.

(4) The quality goods are produced because of reduced defects, waste and scrap.

(5) Participation of workers for improvement increases productivity and customer satisfaction is obtained by timely delivery of their demands.

(6) Overall working of production systems are improved and higher productivity is obtained.

The push system and pull system of parts handling are shown in Fig. 1 and Fig. 2. below.

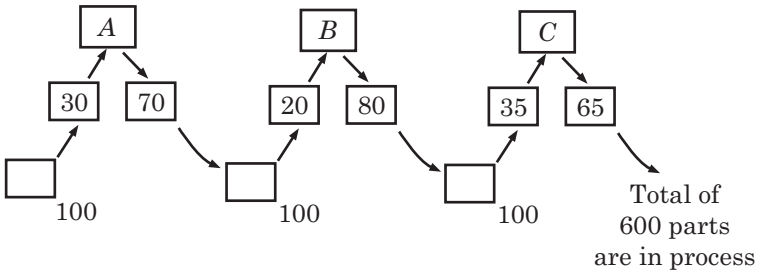


Fig. 1 A Push System of parts handling

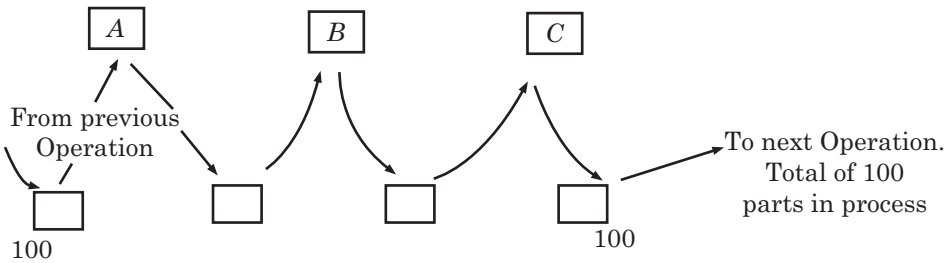


Fig. 2. A Pull System requiring low WIP and less floor space

Case Studies

The two case studies are given below which shows the implementation of Just in Time methodology suitable for Indian Industrial environment and culture where this Japanese method is Indianised to suit the Automobile Industries. These case studies show the benefits of implementation of JIT concept and philosophy in Industries. Case Study 1 is of four-wheeler Automobile Manufacturing Company and Case Study 2 is of two-wheeler Manufacturing Company near Delhi.

Case Study 1

A Company located near Delhi produces Cars, Jeeps, and Vans uses excellent contempory Japanese technique of Just in Time adopted to Indian conditions. It is Rs. 9600 crores company employs 4975 personnel and produces 1300-1500 vehicles per month. It has 250 dealers throughout India. This company has developed Japanese culture in Indian Automobile Sector using JIT. The self service (S.S.) activities were made compulsory for every one. Employees trained for quality control and methods of Statistical Quality Control (S.Q.C.). After strengthening Quality Control (QC) Programs Company assured Just in Time delivery system by implementing in-house designed supply chain applications 'Extranet' that linked both dealers and vendors. It monitors fund for both dealers and vendors. Ordering time is reduced as orders are placed online. By using Extranet 400 vendors of company are IT- enabled. Payments are deposited electronically in to vendor's bank accounts. Extranet not only decreased time and cost of purchasing but has developed customer database and reduced various costs. Communication using E-mail enabled dealers to formulate delivery plans and inform customers in advance.

The achievements of this company are its market share is about 60 %. It has export of 25464 units in 1999. Its production capacity is 400,000 units till now and total revenue of the company was Rs. 921960 crores in 2000-2001 and sold 335,0000 vehicles. It has net profit of Rs.55 crores in 2001-2002.

It has service network of 1400 centers over 550 cities. 80 % of total components are produced indigenously

Company culture is equality at work place, teamwork to achieve common goals and objectives. 'Quality Circle' uses employee's suggestions. Employee's attendance is 91 %.

Massive training to its workers are given to manage, operate and maintain various facilities of production. This case study illustrates Just in Time based management system in Indian context.

Case Study 2

A motorcycle manufacturing plant located near Delhi where Japanese company started production of motorcycles with collaboration of Indian company in 1980. Just in Time philosophy introduced in its press and welding shop. The company puts more focus on continuous flow processing, producing one item at a time. Total production maintenance activity reduced equipment failure, improved reliability and availability of machines. The continuous quality improvement programs were designed to develop the multiple skills in workers. They were held responsible for the quality of products, which were checked by control charts. Major problems faced by company were system and human problems, which were identified and rectified. They were sent to Japanese plants and trained. They were convinced to adopt Just in Time concepts.

These Case Studies show the advantages and benefits of implementation of JIT in the company in our country.

Toyota manufacturing company in Japan has introduced Just in Time. It has 250-primary first level, 2500-second level and 25,000- third level suppliers. The aims of subcontracting as much as possible instead of manufacturing every thing is the corporate philosophy used in JIT. The subcontracting companies or ancillaries are major supporting organization, which are manufacturing the items for major industries. The external Kanban is used between the ancillaries and the plant; the pull system is used with assembly of products by the production department of organization.

The difference between a traditional push system of parts handling and a pull system is shown in Fig. 1 and Fig. 2. In Fig 1 a push system is shown where a total of 600 parts are in process 300 as WIP and 300 are in stores. A pull system shown in Fig. 2 is requiring total of 100 parts in process. By using Pull system the WIP inventory is greatly reduced and thus the floor space required is also much less because less parts are to be handled.

Thus Just in Time system helps the manufacturer by the following things: -

(*i*) Distribution of various items, parts and components to subcontractor for their manufacture.

(*ii*) Stream lining the assembly process by line balancing and getting the parts in time.

(*iii*) Batch size reduction, reduced materials handling helps in better plant layout and facility planning.

(*iv*) It reduces lead-time in production by continuous flow process manufacturing and cell manufacturing.

(*v*) Cellular flow arrangement and cell processing increases equipment utilization and gives flexibility in production.

(*vi*) Using pull system in process reduces work in process inventory and reduces floor space required to store it. Use of automatic handling system increases rate of production.

(*vii*) Over all reduction in cost is possible because of reduced inventory, material handling and waste.

(*viii*) Trained workers and use of better methods of inspection and quality management improve quality of product because of using quality control methods.

QUESTIONS

1. What is the philosophy of Just in Time System?
2. How JIT enables cost reduction?
3. Give the principles of JIT.
4. What are the objectives of JIT?
5. Explain the JIT methodology.
6. What is ZIN system?
7. Expain the Kanban control system?
8. What are the drawbacks of JIT?

APPENDIX I

Format for inviting the quotations or tenders for supply of goods and materials

NAME OF THE COMPANY/ORGANISATION
INVITATION FOR QUOTATIONS FOR SUPPLY OF
GOODS UNDER NATIONAL SHOPPING PROCEDURES

Enquiry No: Date
Due Date:

To

_____
_____
_____
_____

Dear Sirs,

Sub.: **Invitation For Quotations For Supply of**

1. You are invited to submit your most competitive quotation for the following goods: -

Brief Description of the Goods	Specifications*	Quantity	Delivery Period	Place of Delivery	Installation Requirement if any

- Where ISI certification marked goods are available in market, procurement should generally be limited to goods with those or equivalent marking only. The warranty/ AMC if required must be specified.

2. The company or organization has the right to accept or reject any of the quotations and negotiate for any payments under the contract for which this invitation for quotations is issued.

3. **Bid Price**

(a) The contract shall be for the full quantity as described above. Corrections, if any, shall be made by crossing out, initialing, dating and re writing.

(b) All duties, taxes, AMC Charges and other levies payable by the contractor under the contract shall be included in the total price. Price should be quoted for net FOB, Name of the organization. However the Excise/Custom Duties, sales Tax and other incidental charges must be mentioned separately. (In the Format Enclosed). There should not be any hidden cost.

(c) The rates quoted by the bidder shall be fixed for the duration of the contract and shall not be subject to adjustment on any account. The Prices should be quoted in Indian Rupees only.

(d) Technical Compliance Statement must be submitted with the offer.

4. Each bidder shall submit only one quotation.

5. **Validity of Quotation**

Quotation shall remain valid for a period not less than 30 days after the deadline date specified for submission.

6. **Eligibility criteria required for Vendor/Supplier/Manufacturer**

The following points can be considered for the Qualification / Eligibility Criteria of the Vendors

(*i*) The Company/Manufacturer should be ISO certified.

(*ii*) The Company / Manufacture should have a minimum turnover of —— per year in the last three years

(*iii*) If the quote is through a dealer then it should have an authorization certificate from the manufacture.

(*iv*) The dealer must have supplied similar item to the tune of ——— lacs/corers in the last three years.

(*v*) The completion certificate must be submitted for the last three/five orders within the period of last three years.

(*vi*) Details of the office and relevant infrastructure in Name of the place and state.

(*vii*) Detailed Client list with address & telephone No (preferably in name of the place and state.

(*viii*) The list of Machineries and other expertise available.

(*ix*) The details of the Expert manpower available.

7. **Evaluation of Quotations**

The Purchaser will evaluate and compare the quotations determined to be substantially responsive i.e. which

(a) Are properly signed;

(b) Confirm to the eligibility criteria of the vendor; and

(c) Confirm to the terms and conditions, and technical specifications.

(d) The Quotations would be evaluated for all the item together/would be evaluated separately for each item. *[Select one of the options].*

8. **Award of contract**

8.1 The Purchaser will award the contract to the bidder whose quotation has been determined to be substantially responsive and who has offered the lowest evaluated quotation price.

8.2 Notwithstanding the above, the Purchaser reserves the right to accept or reject any quotations and to cancel the bidding process and reject all quotations at any time prior to the award of contract.

8.3 The Purchaser prior to expiration of the quotation validity period will notify the bidder whose bid is accepted of the award of contract. The terms of the accepted offer shall be incorporated in the purchase order.

8.4 Payment shall be made within 30 days of installation & acceptance of the Goods/Items.

8.5 The payment for AMC shall be staggered over the period of AMC and shall be made at the end of each year.

9. Normal commercial warranty/ guarantee shall be applicable to the supplied goods. A performance Bank Guarantee 2.5% of the basic value is required for the warranty period.
10. The tenderer should avoid the use of vague term such as "Extra as applicable". Such offers shall be treated as non-responsive.
11. The Company/Organization/Institute reserves the right to accept /reject all or any offer without assigning any reason thereof.
12. All disputes arising out of this should be submitted to the jurisdiction of Courts of Name of the place only.
13. You are requested to provide/submit your offer latest by. ……Hours on..... (Date) at Stores & Purchase Section of the Company/Organization.
14. The envelope of quotation shall be super scribe as "Quotation No and Item quoted" with the Due date".
15. We look forward to receiving your quotations and thank you for your interest in this project.

(Purchaser)

Name .....

Address: .....

.....

Tel. No .....

Fax No .....

APPENDIX II

FORMAT OF QUOTATION *

Sl. No.	*Description Goods*	*Specifications*	*Qty*	*Unit*	*Quoted Unit Rate in Rs.*	*Excise/ Custom duty*	*Sales*	*Total Amount*	
								In Figures	*In Words*

Gross Total Cost: Rs.....

We agree to supply the above goods in accordance with the technical specifications for a total contract price of Rs..... (amount in figures) (Rs...amount in words) within the period specified in the Invitation for Quotations.

We also confirm that the normal commercial warrantee/guarantee of..... months shall apply to the offered goods.

Signature & Seal of Supplier

* *Applicable while the bids are being invited for more than one item and would be evaluated for all the items together. Modify where evaluation would be made for each item separately.*

APPENDIX III

Price Schedule for Annual Maintenance and Repair Cost after warranty period

Item Description	*Quantity*	*Annual Maintenance Repair Cost for each unit per year (Rs. per year)*	*Total Maintenance Charge for .... Year in Rs.*

Signature & Seal of Supplier

APPENDIX IV

Suggested Format of Bid Evaluation Report for Goods & Equipment (NCB)

1. Scope of contract and approximate cost:
   - Outline brief description of Goods and services covered by the invitation.
   - Furnish estimated cost at the time of appraisal and the actual cost for the proposed contract.

   Bidding document:
2. Briefly discuss and indicate:
   - Details of approval by Bank/ Govt. –
   - Variations from the approved document, if any –
   - Specifications (approval reference, if any) –
   - Requirement of accessories/spares, if any –
   - Delivery requirements
   - Important bidding conditions such as:
     - Price adjustment
     - Loading for

       (a) Delivery schedule –

(*b*) Payment schedule –

(*c*) Performance and productivity –

(*d*) Operating and maintenance costs. –

[Enclose copy of bidding documents and amendments if any, if not sent earlier Annexure I)]

3. Bid invitation process: Furnish the following details:
   - Date of publication of general procurement notice
   - Bid invitation advertisement in national newspapers and dates of publication
   - Period in which the bidding documents were made available for sale

     Number of firms who purchased the bidding documents and their nationality
   - Date of closing and extensions, if any
   - Pre-bid conference, minutes of meeting and resulting amendments, if any
   - Date and time of public bid opening, attendance, highlights of the bid opening meeting –

     [Enclose copies of Prebid minutes (Annexure II) and minutes of bid opening (Annexure III)] –
4. Bid response:
   - State number of offers received and the nationality –
   - Furnish details of offers received:

     (i) In time –

     (ii) Late –

     Total –
   - Furnish Table of bid prices as read out at bid opening (in ascending order):

Sl.No.	*Name of bidder*	*Nationality*	*Bid price as read out*	*Remarks*

5. Clarification obtained, if any
6. Preliminary examination of bids:
   - Discuss preliminary examination for eligibility (ITB Clause 2), arithmetical errors, completeness, legal validity (has been properly signed and has submitted power of attorney etc.), bid validity, bid security and substantial responsiveness to commercial and technical aspects of bidding documents. –
   - List arithmetical errors and corrected bid prices –
   - Furnish details of all bids in Annexure IV –
   - List the bids rejected as non-responsive

Sl.No.	*Name of bidder*	*Bid price*	*Brief reasons*

7. Evaluation of substantially responsive bidders:
   - State evaluation criteria, methodology cross-referencing to bid documents, assumptions, if any, made in evaluation (Annexure V) –

- Discuss briefly offers and adjustment, if any, for: –
  - Commercial aspects:
  - Omissions
  - Inland transportation
  - Delivery
  - Deviation in payment schedule
  - Spare parts
  - Operation and maintenance
  - Performance and productivity etc.
  - Technical criteria:
  - Efficiency
  - Productivity
  - Training etc.
- Prepare evaluation table showing all adjustments and ranking as under:

Rank	*Name of bidder/ Manufacturer/Agent*	*Evaluated CIP destination price*

(Details in Annexure VI) -

- Brief discussion of offers
- Determination of the lowest evaluated responsive bidder

8. Post qualification:
   - State criteria, if any, outlined in the bid document.Discuss actual qualification of selected bidder to demonstrate whether the selected lowest evaluated responsive bidder is qualified to satisfactorily perform the contract. (If the determination is negative, lowest bid will have to be rejected and the next lowest evaluated bid considered for a similar determination of bidder's capability to perform satisfactorily)

     (Details in Annexure VII) -
9. Recommendations:
   - Furnish important features of recommended bid such as:

     Bidders name

     Model,

     Total Quantity

     Basic Machine Price

     Total cost as quoted

     List of tools

     List of special accessories

     List of 3 years AMC after warranty

     Other Services

     Total Bid Value

- Source of origin –
  - Payment terms –
  - Agency commission –
  - Delivery –
  - Inspection –
  - Insurance –
  - Freight –
  - Performance security –
  - Specifications –
  - Other important terms and conditions
- Date of expiry of validity of the selected bid –

(Enclose contract information sheet of selected bidder, Annexure VIII) –

Signature of Evaluating Officer

Signature of competent Authority

Enclosures (enclose only those which were not forwarded earliest):

1. Copy of bidding document (Annex I)
2. Prebid minutes (Annex II)
3. Minutes of bid opening (Annex III)
4. Details of assessment of bids (Annex IV)
5. Assumptions made in evaluation (Annex V)
6. Evaluated bid prices of offers (Annex VI)
7. Details of post-qualification (Annex VII)
8. Contract information of selected bidder (Annex VIII)

APPENDIX V

Glossary/Abbreviations

AGVS	:	Automated Guided Vehicle System
AS/RS	:	Automatic Storage and Retrieval System
BPO	:	Blanket Purchase Order
BEA	:	Break Even Analysis
BEP	:	Break Even Point
BC	:	Bin Card
BOM	:	Bill Of Materials
BS	:	Bonded Stores
CAD	:	Computer Aided Design
CAM	:	Computer Aided Manufacturing
CCM	:	Classification and Coding of Materials
CIF	:	Cost of Insurance and Freight paid
CIM	:	Computer Integrated Manufacturing
CNC	:	Computer Numerically Controlled Machine Tools
CP	:	Centralized Purchasing
CRP	:	Capacity Requirements Planning
CS	:	Comparative Statement, Cold Storage
DAS	:	Double Area System
DCP	:	De centralized Purchasing
EBS	:	Economic Batch Size
EDI	:	Electronic Data Interchange
ELT	:	Economic Lot Size
EOQ	:	Economic Order Quantity
ERP	:	Enterprise Resources Planning
ETC	:	Economic Total Cost
FAS	:	Free Along Side Ship, Final Assembly Scheduling
FG	:	Finished Goods
FIFO	:	First In First Out
FMS	:	Flexible Manufacturing System
FOB	:	Free On Board
FOR	:	Free On Rail
FP	:	Forecasting and Planning
GFS	:	Gravity Feed System
GRR	:	Goods Receipt Register

HCV	:	High Cost Value
HIFO	:	Highest In First Out
IC	:	Inventory Control
IE	:	Industrial Engineering
IMM	:	Integrated Materials Management
ISO	:	International Standard Organization
IP	:	Inventory Planning
JIT	:	Just In Time
LCV	:	Low Cost Value
LIFO	:	Last In First Out
LLT	:	Long Lead Time
MBD	:	Make and Buy Decisions
MFM	:	Materials and Financial Management
MH	:	Materials Handling
MHE	:	Materials Handling Equipments
MIR	:	Materials Issue Requisitions
MM	:	Materials Management
MMO	:	Materials Management Organizations
MPS	:	Master Production Schedule
MRN	:	Materials Return Note, Materials Received Note
MRO	:	Maintenance, Repair and Operating Items
MRP–I	:	Materials Requirements Planning
MRP–II	:	Manufacturing Resources Planning
MRS	:	Materials Requisition Slip
MTN	:	Materials Transfer Not
MUSIC 3D	:	Multi Unit Selective Inventory Control – Three Dimensional Approach
NIFO	:	Next In First Out
OMP	:	Operations Management Planning
PAC	:	Production Activity Control
PE	:	Purchasing enquiry
PO	:	Purchase Order
PPC	:	Production Planning and Control
PPP	:	Purchasing Policy and Procedure
PR	:	Purchase Requisitions, Purchase Release
QA	:	Quality Assurance
QC	:	Quality Control, Quality Circle
QS	:	Quarantine Store

RC	:	Rate Contract
RM	:	System Contract
SCL	:	Supply Chain Link
SCM	:	Supply Chain Management
SCO	:	Supply Chain Organization
SF	:	Sales Forecasting
SIC	:	Stores Identification Card
SICT	:	Selective Inventory Control Techniques
ABC	:	A items, B items, C items Always Better Control
HML	:	High, Medium and Low value items
XYZ	:	X –higher, Y- medium and Z –lower value items
VED	:	Vital, Essential and Desirable items
VEIN	:	Vital, Essential, Important and Normal items
SDE	:	Scares, Difficult to obtain, Easy to obtain
FSN	:	Fast, Slow and Non-moving items
MNG	:	Moving, Non moving and Ghost items
GOLF	:	Govt., Open market, local and Foreign materials
SOS	:	Seasonal and Off seasonal materials
FAN	:	Failure Analysis
SIM	:	Storing an Issue of Materials
SLT	:	Short Lead Time
SK	:	Store Keeping, Store Keeper
SL	:	Stores Ledger
SM	:	Scientific Management, Stores Management
SMC	:	Stores Management and Control
SP	:	Spare Parts
SQC	:	Statistical Quality Control
SSM	:	Standardization and Simplification of Materials
SV	:	Stores Vocabulary
TMP	:	Top Management Planning
TQM	:	Total Quality Management
TR	:	Traveling Requisitions
TS	:	Temporary or Transit Stores
TSA	:	Time Series Analysis
VA	:	Value Analysis
VE	:	Value Engineering
WIP	:	Work In Process Inventory
ZIN	:	Zero Inventory System

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