COURSE MATERIAL

II Year B. Tech I- Semester

MECHANICAL ENGINEERING

Production and Operations Management

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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

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UNIT-I

INTRODUCTION TO OPERATIONS MANAGEMENT

Operation Management is a way or means through which the listed objectives of an operating system is achieved. There is always a confusion between the word OM & PM (Production Management). It is accepted norm that OM includes techniques which are enabling the achievement of operational objectives in an operation system.

The operation system includes both manufacturing sector as well as service sector, but when you use the word PM, you should be careful to note that it refers to the manufacturing sector but not the service sector. Suppose, you are designing a layout for the hospital you should say that you are applying Operations Management Technique not the Production Management Technique.

When you design a layout for a manufacturing sector you can say that you are applying Production Technique or Operation Technique or vice versa. From, the above discussion we can come to a conclusion that production management is a subset of Operations Management.

Operation managers are concerned with planning, organizing, and controlling the activities which affect human behavior through models.

Planning

Activities that establishes a course of action and guide future decision-making is planning.
The operations manager defines the objectives for the operations subsystem of the organization, And the policies, and procedures for achieving the objectives. This stage includes clarifying the Role and focus of operations in the organization's overall strategy. It also involves product Planning, facility designing and using the conversion process.

Organizing

Activities that establishes a structure of tasks and authority. Operation managers establish a Structure of roles and the flow of information within the operations subsystem. They determine The activities required to achieve the goals and assign authority and responsibility for carrying

Them out.

Controlling

Activities that assure the actual performance in accordance with planned performance. To Ensure that the plans for the operations subsystems are accomplished, the operations manager Must exercise control by measuring actual outputs and comparing them to planned operations Management. Controlling costs, quality, and schedules are the important functions here.

Behavior

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

OBJECTIVES OF OPERATIONS MANAGEMENT

Objectives of operations management can be categorized into customer service and resource Utilization.

Customer service

The first objective of operating systems is the customer service to the satisfaction of customer Wants. Therefore, customer service is a key objective of operations management. The operating System must provide something to a specification which can satisfy the customer in terms of cost And timing. Thus, primary objective can be satisfied by providing the 'right thing at a right price At the right time'.

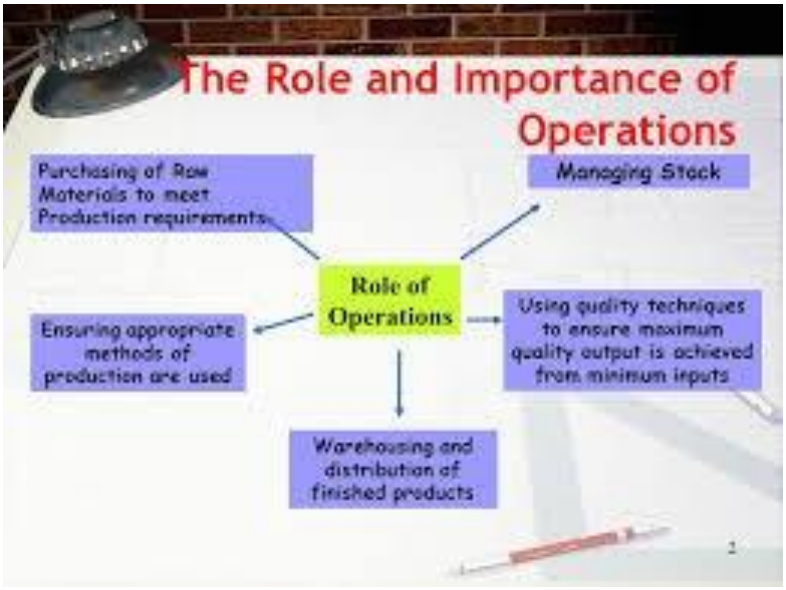
Resource utilization

Another major objective of operating systems is to utilize resources for the satisfaction of Customer wants effectively, i.e., customer service must be provided with the achievement of Effective operations through efficient use of resources. Inefficient use of resources or inadequate Customer service leads to commercial failure of an operating system.

Operations management is concerned essentially with the utilization of resources, i.e., obtaining Maximum effect from resources or minimizing their loss, underutilization or waste. The extent Of the utilization of the resources' potential might be expressed in terms of the proportion of Available time used or occupied, space utilization, levels of activity, etc. Each measure indicates The extent to which the potential or capacity of such resources is utilized. This is referred as the Objective of resource utilization.

ROLE OF OPERATION MANAGEMENT

Operations Management concern with the conversion of inputs into outputs, using physical resources, so as to provide the desired utilities to the customer while meeting the other organizational objectives of effectiveness, efficiency and adoptability. It distinguishes itself from other functions such as personnel, marketing, finance, etc. by its primary concern for 'conversion by using physical resources'.



Operations management functions:

1. Location of facilities
2. Plant layouts and material handling
3. Product design
4. Process design
5. Production and planning control
6. Quality control
7. Materials management
8. Maintenance management.

1. Location of facilities

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

The selection of location is a key-decision as large investment is made in building plant and Machinery. An improper location of plant may lead to waste of all the investments made in plant And machinery equipment's. Hence, location of plant should be based on the company's expansion.

2. Plant layout and material handling

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

3. Product design

Product design deals with conversion of ideas into reality. Every business organization have to Design, develop and introduce new products as a survival and growth strategy. Developing the

New products and launching them in the market is the biggest challenge faced by the organizations.

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

4. Process design

Process design is a macroscopic decision-making of an overall process route for converting the Raw material into finished goods. These decisions encompass the selection of a process, choice Of technology, process flow analysis and layout of the facilities. Hence, the important decisions In process design are to analyze the workflow for converting raw material into finished product And to select the workstation for each included in the workflow.

5. PRODUCTION PLANNING AND CONTROL

Production planning and control can be defined as the process of planning the production in advance, setting the exact route of each item, fixing the starting and finishing dates for each item, to give production orders to shops and to follow up the progress of products according to orders. The principle of production planning and control lies in the statement 'First Plan Your Work And then Work on Your Plan'. Main functions of production planning and control includes Planning, routing, scheduling, dispatching and follow-up.

Planning is deciding in advance what to do, how to do it, when to do it and who is to do It. Planning bridges the gap from where we are, to where we want to go. It makes it possible For things to occur which would not otherwise happen.

Routing may be defined as the selection of path which each part of the product will follow, Which being transformed from raw material to finished products. Routing determines the most Advantageous path to be followed from department to department and machine to machine till Raw material gets its final shape. Scheduling determines the programmed for the operations.

Scheduling may be defined as 'the fixation of time and date for each operation' as well as it determines the sequence of operations to be followed.

Dispatching is concerned with the starting the processes. It gives necessary authority so As to start a particular work, which has already been planned under 'Routing' and 'Scheduling'. Therefore, dispatching is 'release of orders and instruction for the starting of production for any Item in acceptance with the route sheet and schedule charts'.

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

QUALITY CONTROL

Quality Control (QC) may be defined as 'a system that is used to maintain a desired level of Quality in a product or service'. It is a systematic control of various factors that affect the quality Of the product. Quality control aims at prevention of defects at the source, relies on effective Feedback system and corrective action procedure.

Quality control can also be defined as 'that industrial management technique by means of which Product of uniform acceptable quality is manufactured'. It is the entire collection of activities which ensures that the operation will produce the optimum quality products at minimum cost.

The main objectives of quality control are:

- To improve the companies income by making the production more acceptable to the
- Customers i.e., by providing long life, greater usefulness, maintainability, etc.
- To reduce companies cost through reduction of losses due to defects.
- To achieve interchangeability of manufacture in large scale production.
- To produce optimal quality at reduced price.
- To ensure satisfaction of customers with productions or services or high quality level, to
- Build customer goodwill, confidence and reputation of manufacturer.
- To make inspection prompt to ensure quality control.
- To check the variation during manufacturing.

MATERIALS MANAGEMENT

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

The main objectives of materials management are:

- To minimize material cost.
- To purchase, receive, transport and store materials efficiently and to reduce the related cost.
- To cut down costs through simplification, standardization, value analysis, import substitution, etc.
- To trace new sources of supply and to develop cordial relations with them in order to
- Ensure continuous supply at reasonable rates.
- To reduce investment tied in the inventories for use in other productive purposes and to
- Develop high inventory turnover ratios.

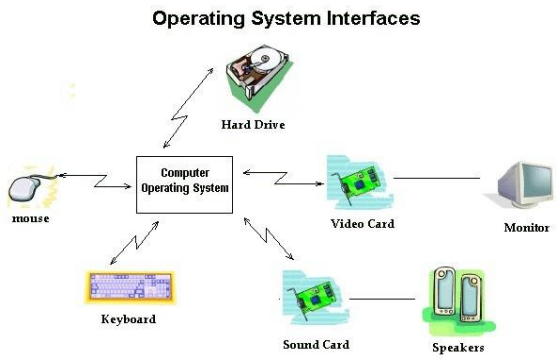
MAINTENANCE MANAGEMENT

In modern industry, equipment and machinery are a very important part of the total productive Effort. Therefore, their idleness or downtime becomes are very expensive. Hence, it is very Important that the plant machinery should be properly maintained.

The main objectives of maintenance management are:

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

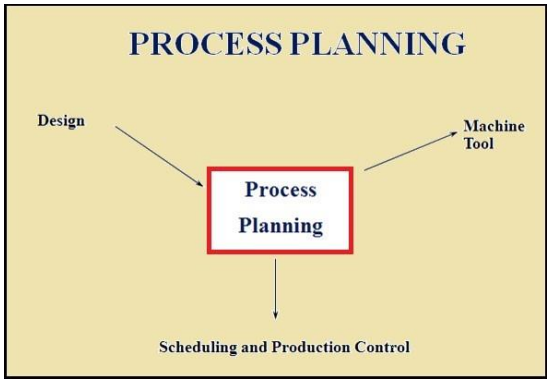
INTERFACE BETWEEN THE OPERATION SYSTEMS AND SYSTEMS OF OTHER FUNCTIONAL AREAS



PROCESS PLANNING

A process is described as a set of steps that result in a specific outcome. It converts input into output. Process planning is also called manufacturing planning, material processing, process engineering, and machine routing.

Process planning determines how the product will be produced or service will be provided. Process planning converts design information into the process steps and instructions to powerfully and effectively manufacture products.



Principles of Process Planning

General principles for evaluating or enhancing processes are as follows:

1. First define the outputs, and then look toward the inputs needed to achieve those outputs.
2. Describe the goals of the process, and assess them frequently to make sure they are still appropriate. This would include specific measures like quality scores and turnaround times.
3. When mapped, the process should appear as a logical flow, without loops back to earlier steps or departments.
4. Any step executed needs to be included in the documentation. If not, it should be eliminated or documented, depending on whether or not it's necessary to the process.
5. People involved in the process should be consulted, as they often have the most current information.

Major steps in process planning: Process planning has numerous steps to complete the project that include the definition, documentation, review and improvement of steps in business processes used in a company.

PROCESS DESIGN

Process design is concerned with the overall sequence of operations required to achieve the product specifications. It specifies the type of work stations that are to be used, the machines and equipment necessary and the quantities in which each are required.

The sequence of operations in the manufacturing process is determined by

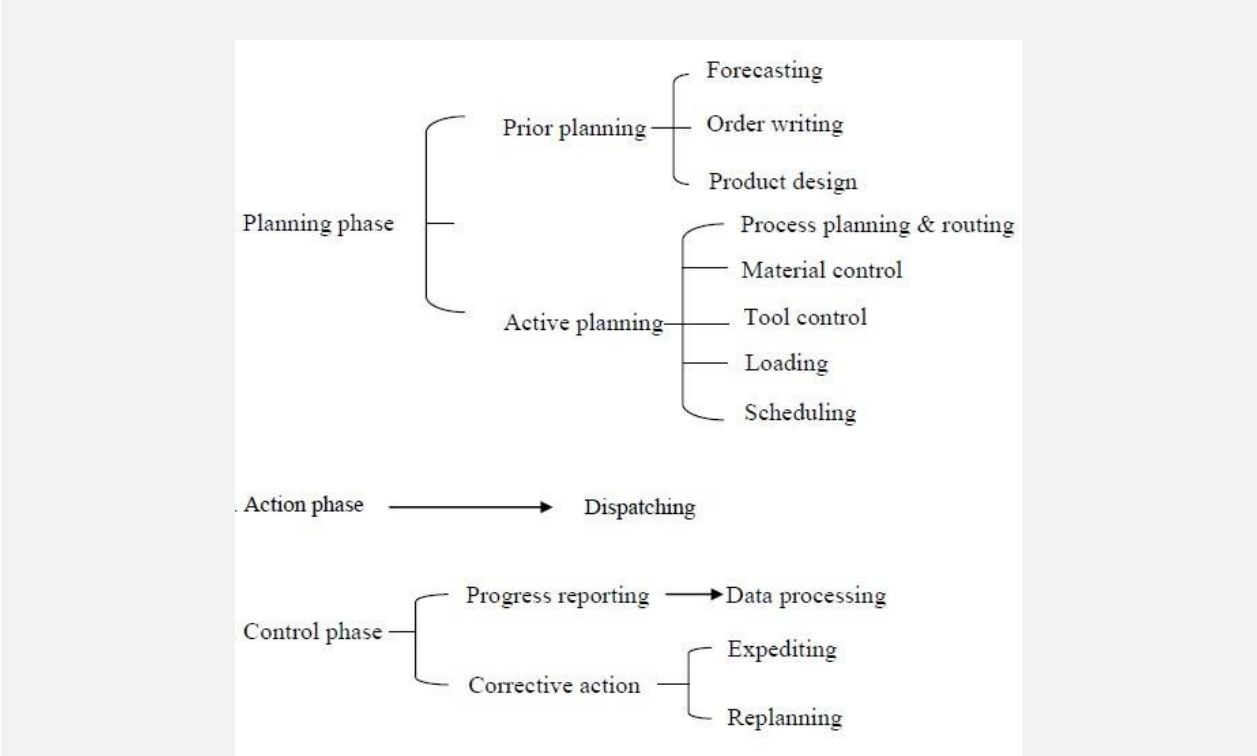
1. The nature of the product
2. The materials used
3. The quantities being produced
4. The existing physical layout of the plant.

PRODUCTION PLANNING AND CONTROL

Production planning and control the process of planning the production in advance. Setting the exact route of each item and fixing the starting and finishing date for each

item is the key operation. Giving the production orders to different shops and observing the progress of products according to order.

- **THE VARIOUS FUNCTIONS OF PPC :**



PRODUCTION CYCLE

The production cycle is a recurring set of business activities and related data processing operations associated with the manufacturing of products. The first function of the AIS is to support the effective performance of the organization's business activities.

Production Cycle Activities

1. Product design
2. Planning and scheduling
3. Production operations
4. Cost accounting

1. Product design: The objective of this activity is to design a product that meets customer requirements for quality, durability, and functionality while simultaneously minimizing production costs.

2. Planning and scheduling: a production plan efficient enough to meet existing orders and anticipate short-term demand without creating excess finished goods inventories.

3. Production operations: Every firm needs to collect data about the following four facets of its production operations: 1. Raw materials used 2. Labor-hours expended 3. Machine operations performsed 4. Other manufacturing overhead costs incurred

4. Cost accounting: three principal objectives of the cost accounting system? 1. To provide information for planning, controlling, and evaluating the performance of production operations 2. To provide accurate cost data about products for use in pricing and product mix decisions 3. To collect and process the information used to calculate the inventory and cost of goods sold values

CHARACTERISTICS OF PROCESS TECHNOLOGIES

Every process inside a client's plant is unique and has special characteristics. Process technology services are divided into process technologies and process engineering. The characteristics are;

1. **The degree of automation of the technology**: the ratio of technology to human effort it employs is sometimes called capital intensity of the process technology.
2. **The scale or scalability of the technology**: the ability to shift to a different level of useful capacity quickly and cost effectively.
3. **The degree of coupling or connectivity of the technology**: linking together of separate activities within a single piece of process technology to form an interconnected processing system.

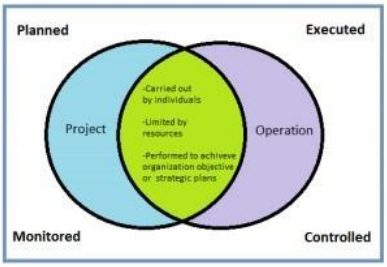
PROJECT

A Project is a temporary endeavor (attempt with lot of effort) undertaken to create a unique product, service or result.

Temporary means having a definite beginning and end. The end is reached when the project's objectives have been achieved, or if the project is terminated for any reason.

Temporary does not mean short in nature, and it could well be a mammoth project – like a 10 year project – for example, sending a man to moon, sending Curiosity to Mars, Building the Taj Mahal or the Pyramids (I visited the amazing Pyramids today, as I am in Cairo this week to conduct a series of corporate training in Egypt, and it was absolutely fantastic…)

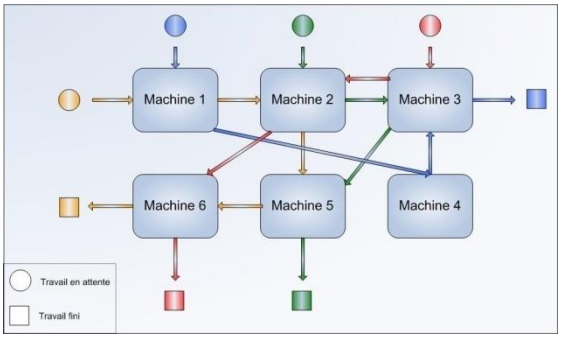
Secondly, each project creates a unique product, service or result. Sure, there may be some repetitive elements present in each project, but the output must be unique – like similar housing projects in the same area with the same design may be similar, but each will have unique challenges, different contractors, issues, etc. that will make them each unique.



JOB SHOP

A **job shop** is a type of manufacturing process in which small batches of a variety of custom products are made. In the **job shop** process flow, most of the products produced require a unique set-up and sequencing of process steps.

Examples of job shops include a wide range of businesses—a machine tool shop, a machining center, a paint shop, a commercial printing shop, and other manufacturers that make custom products in small lot sizes.



CHARACTERISTICS OF A JOB SHOP: Layout, Routing, Employees, Information, Scheduling.

Layout

In the job shop, similar equipment or functions are grouped together, such as all drill presses in one area and grinding machines in another in a process layout. The layout is designed to minimize material handling, cost, and work in process inventories. Job shops use general purpose equipment rather than specialty, dedicated product-specific equipment.

Routing

When an order arrives in the job shop, the part being worked on travels throughout the various areas according to a sequence of operations. Not all jobs will use every machine in the plant. Jobs often travel in a jumbled routing and may return to the same machine for processing several times.

Employees

Employees in a job shop are typically highly skilled craft employees who can operate several different classes of machinery. These workers are paid higher wages for their skill levels. Due to their high skill level, job shop employees need less supervision.

Information

Information is the most critical aspect of a job shop. Information is needed to quote a price, bid on a job, route an order through the shop, and specify the exact work to be done. Information begins with quoting, then a job sheet and blueprint are prepared before the job is released to the floor.

Scheduling

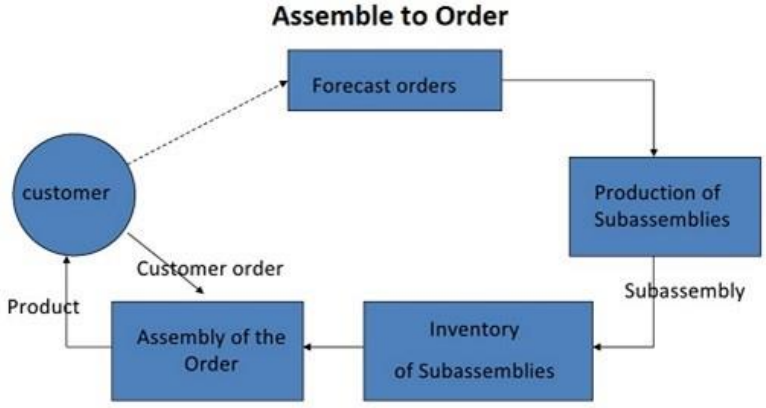
A job is characterized by its route, its processing requirements, and its priority. In a job shop the mix of products is a key issue in deciding how and when to schedule jobs.

- **ASSEMBLY**

An **assembly** line is a manufacturing process in which interchangeable parts are added to a product in a sequential manner to create an end product..... Thanks to the **assembly** line, production periods shortened, equipment costs accelerated, and labor and **management** alike endeavored to keep up with the changes.

1. An arrangement of workers, machines, and equipment in which the product being assembled p asses consecutivelyfrom operation to operation until completed. Also called *production line*.

2. A process in which finished products are turned out in a mechanically efficient, though impers onal, manner: *auniversity that functions as a sports assembly line.*



BATCH AND CONTINUOUS PROCESS OPERATIONS

Continuous production is a flow production method used to manufacture, produce, or **process** materials without interruption.....**Continuous processing** is contrasted

with **batch** production.

Batch processing

This involves the processing of bulk material in batches through each step of the desired process. Processing of subsequent batches must wait until the current batch is finished. This method seems effective at first glance, but in most cases falls short of continuous flow.

Continuous flow

This processing involves moving one work unit at a time between each step of the process with no breaks in time, sequence, substance or extent.

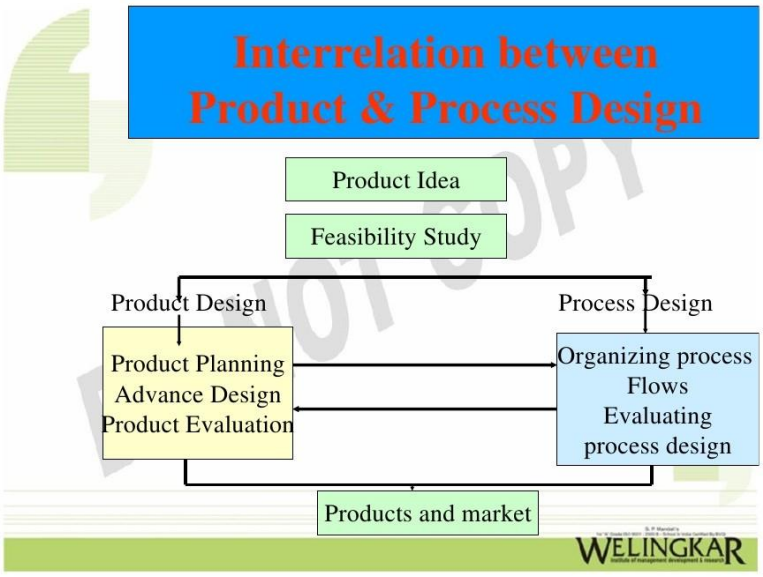
For most applications, continuous flow saves time, energy and costs. When implemented correctly, continuous flow processing:

- Reduces waste.
- Saves money by reducing inventory and transportation costs.
- Increases productivity – more units completed in less time.
- Improves quality by making it easier to spot and correct errors.
- Cuts down on overhead via increased stability and reduced lead times.
- Adapts to customer needs more effectively than batch processing.

RELATIONSHIP BETWEEN PRODUCT LIFE CYCLE AND PROCESS LIFE CYCLE

- A process life cycle normally refers only to the development process for developing and testing a product up to the point that the product is released to the market.

- A product life cycle is much broader and covers the entire life of the product and all it's revisions and enhancements until the product is ultimately retired.



The **Product-Process** Matrix. The **process life cycle** has been attracting increasing attention from business managers and researchers over the past several years. Just as a **product** and market pass through a series of major stages, so does the

production **process** used in the manufacture of that **product**.

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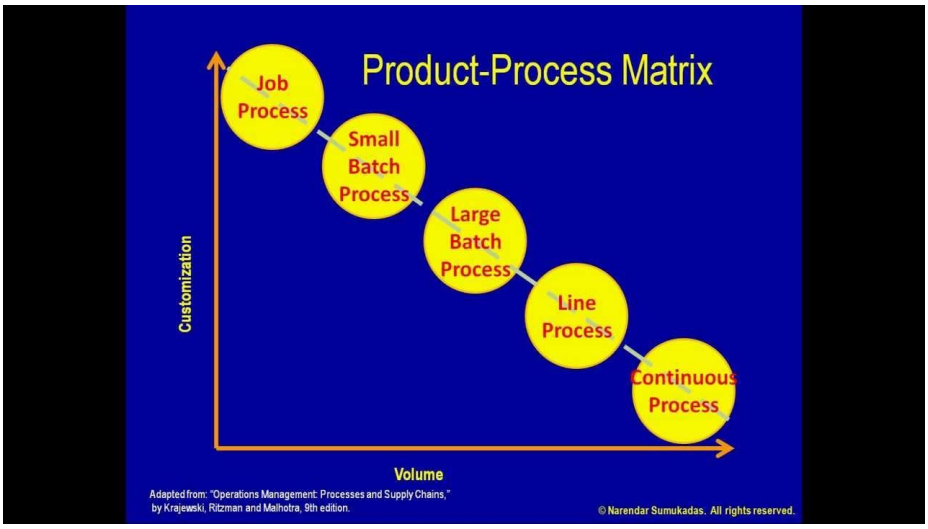
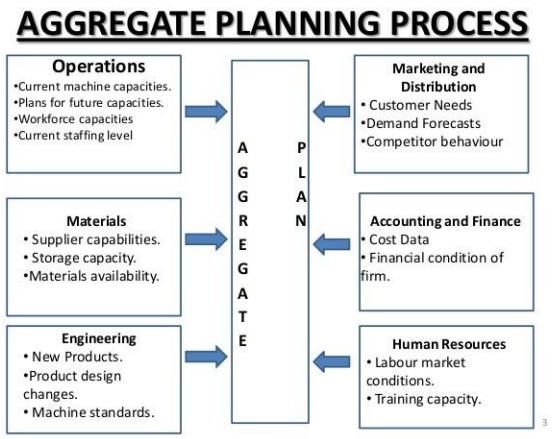


UNIT-2

AGGREGATE PLANNING:

Aggregate planning' is a marketing activity that does an aggregate plan for the production process, in advance of 6 to 18 months, to give an idea to management as to what quantity of materials and other resources are to be procured and when, so that the total cost of operations of the organization is kept to the minimum over that period.

The quantity of outsourcing, subcontracting of items, overtime of labour, numbers to be hired and fired in each period and the amount of inventory to be held in stock and to be backlogged for each period are decided. All of these activities are done within the framework of the company e thics, policies, and long term commitment to the society, community and the country of operation.



Aggregate Plan Strategies Level plans

- Use a constant workforce & produce similar quantities each time period
- Use inventories and back-orders to absorb demand peaks & valleys
- Use inventories in better way to absorb the peak of demand and valleys

Aggregate Plan Strategies Chase plans

- Minimize finished goods inventories by trying to keep pace with demand fluctuations
- Matches demand varying either work force level or output rate.

Advantages of Aggregate Planning

1. Aggregate planning is a forecasting technique that businesses use in an attempt to predict the supply and demand of their products and services
2. Mainly, this is done in an effort to save money, streamline operations and increase productivity.

3. To accomplish this, businesses use an aggregate planning model to develop a game plan that will assist them with determining their staffing requirements, materials needed, estimated timelines and budget costs so they can better plan ahead.

Disadvantages of Aggregate Planning

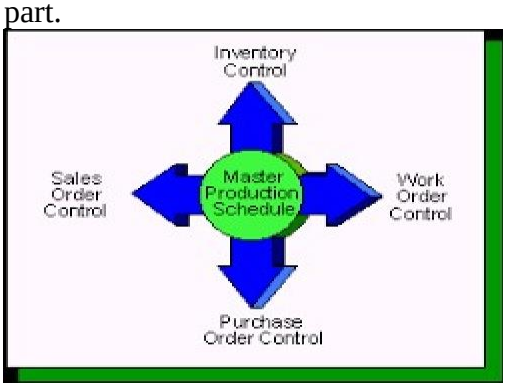
1. Planning for changes in demand months in advance ensures that the change of production schedules can occur with little effort.
2. Aggregate production planning is a general approach to altering a company's production schedule to respond to forecasted changes in demand.

MASTER PRODUCTION SCHEDULE (MPS)

A master production schedule (MPS) is a plan for individual commodities to be produced in each time period such as production, staffing, inventory, etc. It is usually linked to manufacturing where the plan indicates when and how much of each product will be demanded.

This plan quantifies significant processes, parts, and other resources in order to optimize production, to identify bottlenecks, and to anticipate needs and completed goods. Since an MPS drives much factory activity, its accuracy and viability dramatically affect profitability. Typical MPSs are created by software with user tweaking.

The MPS translates the customer demand (sales orders, PIR's), into a build plan using planned orders in a true component scheduling environment. Using MPS helps avoid shortages, costly expediting, last minute scheduling, and inefficient allocation of resources. Working with MPS allows businesses to consolidate planned parts, produce master schedules and forecasts for any level of the Bill of Material (BOM) for any type of part.



Advantages of Master production schedule

- Give production, planning, purchasing, and management the information to plan and control manufacturing
- The overall business planning and forecasting to detail operations
- Enable marketing to make legitimate delivery commitments to warehouses and customers
- Increase the efficiency and accuracy of a company's manufacturing

OPERATIONS SCHEDULING

Operations scheduling helps in the confirmation or the revision of the tentative delivery date that has been promised in the original quotation. Sometimes during the operations scheduling of the work order, it may be discovered that the delivery date originally and tentatively promised cannot be met.

All this may be due to the several problems like the materials that are required may not be available at that particular time or may not be available immediately. This problem can also occur due to the increased plant loading while the customer is deciding whether or not to award the quoted job to this company.

Objectives of the Operations Scheduling –

1. Making efficient use of the labor.
2. Making best possible use of the equipment's that are available for the use.
3. Increasing the profit.
4. Increasing the output.
5. Improving the service level.
6. Maximizing the delivery performance i.e. meeting the delivery dates.
7. Minimizing the inventory.
8. Reducing the manufacturing time.
9. Minimizing the production costs.
10. Minimizing the worker costs.

Functions of the operations scheduling –

1. Allocation of the resources.
2. Shop floor control.
3. Making maximum use of the plant at minimum possible cost.
4. Ensure that the needs of the manpower are optimum.
5. Determination of the sequence of the jobs.
6. Specifying the start and the end time for each job (actively scheduled).
7. Getting quick feedback from the shops regarding the delays and the various interruptions.
8. Possess up – to – date information for the availability of the materials, expected delivery dates etc.
9. Possess up – to – date data on the machine regarding its breakdown, servicing etc.
10. Keep itself abreast of the hiring, dismissals, holidays etc. of the work force.

Inputs of the Operations Scheduling

1. Performance standards
2. Unit of the measurement
3. Unit of the loading and the scheduling
4. Effective capacity per work centre
5. Extent of the rush orders

6. Overlapping of the operations
7. Loading charts

PRODUCT SEQUENCING

The product sequencing model is the evolution of knowledge to new product introductions over time in technology intensive or operationally complex organizations.
Product sequencing is one way to reduce cost and improve product quality for multistage manufacturing systems (MMS). However, systematically evaluating the influence of product sequence on quality performance for MMS is still a challenge.
By considering the rate of incoming conforming product, manufacturing system quality transition between batch to batch, and quality propagation along stages, this paper investigates the appropriate batch policies and product sequencing for MMS so that satisfied quality performance can be achieved.

PLANT CAPACITY

Plant capacity is the maximum amount of production for a specific production facility.

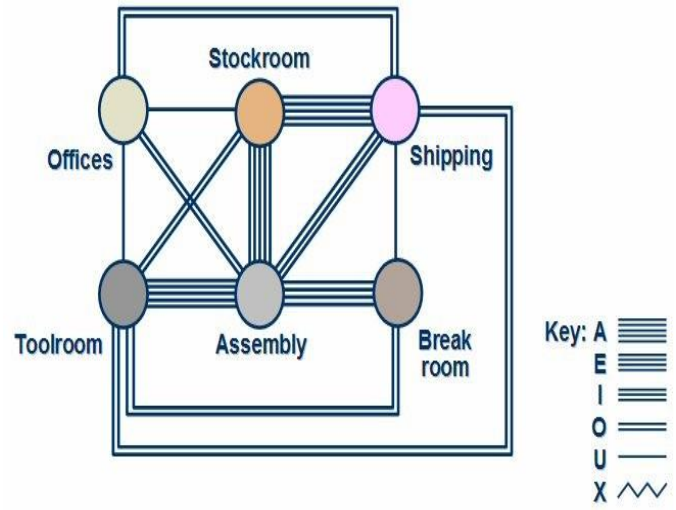
- **Factors affecting determination of Plant Capacity**

(a) Market demand for a product/service.
(b) The amount of capital that can be invested.
(c) Degree of automation desired.
(d) Level of integration (i.e. vertical integration).
(e) Type of technology selected.
(f) Dynamic nature of all factors affecting determination of plant capacity, viz., changes in the product design, process technology, market conditions and product life cycle, etc.
(g) Difficulty in forecasting future demand and future technology.
(h) Obsolescence of product and technology over a period of time.
(i) Present demand and future demand both over short-range, intermediate-range and long-range time horizons.
(j) Flexibility for capacity additions.

PLANT LAYOUT

Plant layout design has become a fundamental basis of today's industrial **plants**which can influence parts of work efficiency. It is needed to appropriately plan and position employees, materials, machines, equipment, and other manufacturing supports and facilities to create the most effective **plant layout**.

Plant layout is the most effective physical arrangement, either existing or in plans of industrial facilities i.e arrangement of machines, processing equipment and service departments to achieve greatest co-ordination and efficiency of 4M's (Men, Materials, Machines and Methods) in a plant.



Facility Layout Planning

IMPORTANCE OF PLANT LAYOUT:

- The layout of a plant is quite important in view of the above definition but the importance of a layout may greatly vary from industry to industry.The Weight, Volume or Mobility of the Product
- Complexity of the Final Product
- The Length of the Process in relation to Handling Time
- The Extent to which the Process Tends towards Mass Production

TYPES OF PLANT LAYOUT

1. Product or Line Layout.
2. Process or Functional Layout.
3. Fixed Position Layout.
4. Combination type of Layout.

1. PRODUCT OR LINE LAYOUT:

If all the processing equipment and machines are arranged according to the sequence of operations of a product, the layout is called product type of layout. In this type of layout, only one product or one type of products is produced in an operating area. This product must be standardized and produced in large quantities in order to justify the product layout.

The raw material is supplied at one end of the line and goes from one operation to the next quite rapidly with a minimum work in process, storage and material handling. Fig. 3.3 shows product layout for two types of products A and B.

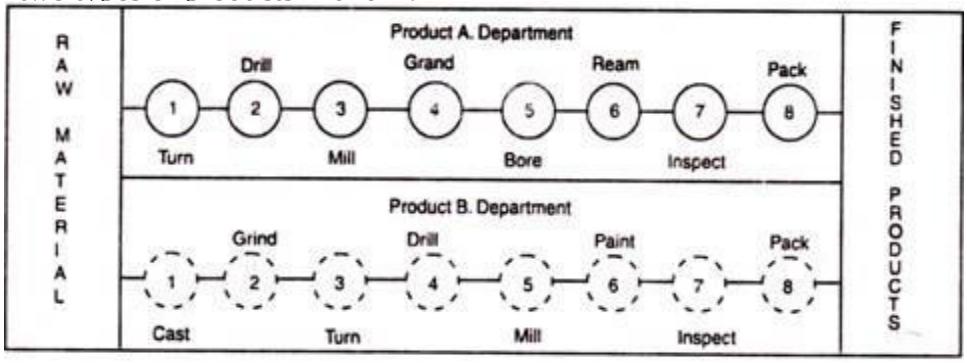


Fig. 8.3.

Advantages offered by Product Layout:

(i) Lowers total material handling cost.
(ii) There is less work in processes.
(iii) Better utilization of men and machines,
(iv) Less floor area is occupied by material in transit and for temporary storages.
(v) Greater simplicity of production control.
(vi) Total production time is also minimized.

Limitations of Product Layout:

(i) No flexibility which is generally required is obtained in this layout.
(ii) The manufacturing cost increases with a fall in volume of production.
(iii) If one or two lines are running light, there is a considerable machine idleness.
(iv) A single machine break down may shut down the whole production line.
(v) Specialized and strict supervision is essential.

PROCESS OR FUNCTIONAL LAYOUT:

The process layout is particularly useful where low volume of production is needed. If the products are not standardized, the process layout is more low desirable, because it has creator process flexibility than other. In this type of layout, the machines and not arranged according to the sequence of operations but are arranged according to the nature or type of the operations.
This layout is commonly suitable for non repetitive jobs.
Same type of operation facilities are grouped together such as lathes will be placed at one place, all the drill machines are at another place and so on. See Fig. 8.4 for process layout. Therefore, the process carried out in that area is according to the machine available in that area.

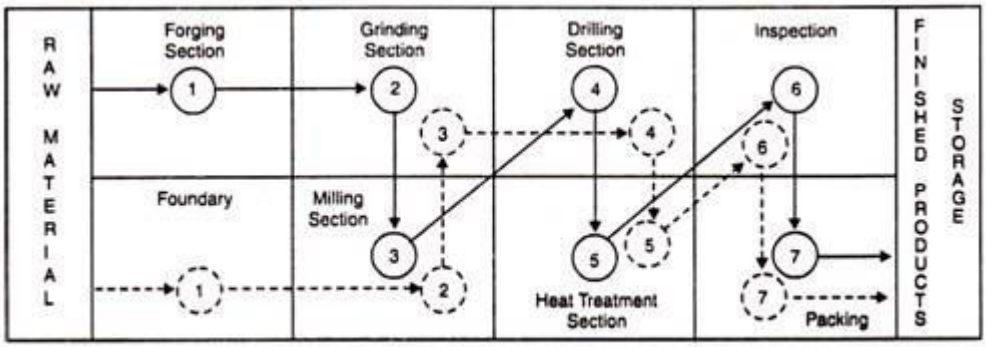


Fig. 8.4.

- **Advantages of Process Layout:**

(i) There will be less duplication of machines. Thus, total investment in equipment purchase will be reduced.
(ii) It offers better and more efficient supervision through specialization at various levels.
(iii) There is a greater flexibility in equipment and man power thus load distribution is easily controlled.
(iv) Better utilization of equipment available is possible.
(v) Break down of equipment can be easily handled by transferring work to another machine/work station.
(vi) There will be better control of complicated or precision processes, especially where much inspection is required.

- **Limitations of Process Layout:**

(i) There are long material flow lines and hence the expensive handling is required.
(ii) Total production cycle time is more owing to long distances and waiting at various points.
(iii) Since more work is in queue and waiting for further operation hence bottle necks occur.

(iv) Generally, more floor area is required.
(v) Since work does not flow through definite lines, counting and scheduling is more tedious.
(vi) Specialization creates monotony and there will be difficult for the laid workers to find job in other industries.

FIXED POSITION LAYOUT:

This type of layout is the least important for today's manufacturing industries. In this type of layout the major component remain in a fixed location, other materials, parts, tools, machinery, man power and other supporting equipment's are brought to this location.

The major component or body of the product remain in a fixed position because it is too heavy or too big and as such it is economical and convenient to bring the necessary tools and equipment's to work place along with the man power. This type of layout is used in the manufacture of boilers, hydraulic and steam turbines and ships etc.

- Advantages Offered by Fixed Position Layout:

(i) Material movement is reduced
(ii) Capital investment is minimized.
(iii) The task is usually done by gang of operators, hence continuity of operations is ensured
(iv) Production centers are independent of each other. Hence, effective planning and loading can be made. Thus total production cost will be reduced.
(v) It offers greater flexibility and allows change in product design, product mix and production volume.

- Limitations of Fixed Position Layout:

(i) Highly skilled man power is required.
(ii) Movement of machines equipment's to production centre may be time consuming.
(iii) Complicated fixtures may be required for positioning of jobs and tools. This may increase the cost of production.

COMBINATION TYPE OF LAYOUT:

Now a days in pure state any one form of layouts discussed above is rarely found. Therefore, generally the layouts used in industries are the compromise of the above mentioned layouts. Every layout has got certain advantages and limitations. Therefore, industries would to like use any type of layout as such.

LOCATION FOR PRODUCTION

location for production will include some or all of the following ingredients:

1. Closeness to point of sale. The higher the sales revenue - the higher the productivity will be.
2. Closeness to raw materials.
3. Away from centers of population - for noisy, environmentally unfriendly plant.
4. Near to skilled labour source.
5. Have room for expansion.
6. Have good communication links.

FACTORS INFLUENCING INDUSTRIAL LOCATION

Generally, location of industries is influenced by economic considerations though certain non- economic considerations also might influence the location of some industries. Maximisation of profit which also implies cost minimization is the most important goal in their choice of particular places for the location of industries. There are several factors which pull the industry to a particular place. Some of the major factors influencing location are discussed below:

1. Availability of raw materials: In determining the location of an industry, nearness to sources of raw material is of vital importance. Nearness to the sources of raw materials would reduce the cost of production of the industry. For most of the major industries, the cost of raw materials form the bulk of the total cost. Therefore, most of the agro-based and forest-based industries are located in the vicinity of the sources of raw material supply.

2. Availability of Labour: Adequate supply of cheap and skilled labour is necessary for and industry. The attraction of an industry towards labour centres depends on the ratio of labour cost to the total cost of production which Weber calls 'Labour cost of Index'. The availability of skilled workers in the interior parts of Bombay region was one of the factors responsible for the initial concentration of cotton textile industry in the region.

3. Proximity to Markets: Access to markets is an important factor which the entrepreneur must take into consideration. Industries producing perishable or bulky commodities which cannot be transported over long distance are generally located in close proximity to markets. Industries located near the markets could be able to reduce the costs of transport in distributing the finished product as in the case of bread and bakery, ice, tins, cans manufacturing, etc. Accessibility of markets is more important in the case of industries manufacturing consumer goods rather than producer goods.

4. Transport Facilities: Transport facilities, generally, influence the location of industry. The transportation with its three modes, i.e., water, road, and rail collectively plays an important role. So the junction points of water-ways, roadways and railways become humming centres of industrial activity. Further, the modes and rates of transport and transport policy of Government considerably affect the location of industrial units. The heavy concentration of cotton textile industry in Bombay has been due to the cheap and excellent transportation network both in regard to raw materials and markets.

5. Power: Another factor influencing the location of an industry is the availability of cheap power. Water, wind, coal, gas, oil and electricity are the chief sources of power. Both water and wind power were widely sought at sources of power supply before the invention of steam engine. During the nineteenth century, nearness to coal-fields became the principal locating influence on the setting up of new industries, particularly, for heavy industries. With the introduction of other sources of power like electricity, gas, oil, etc. the power factor became more flexible leading to dispersal and decentralization of industries.

6. Site and Services: Existence of public utility services, cheapness of the value of the site, amenities attached to a particular site like level of ground, the nature of vegetation and location of allied activities influence the location of an industry to a certain extent. The government has classified some areas as backward areas where the entrepreneurs would be granted various

incentives like subsidies, or provision of finance at concessional rate, or supply of power a cheaper rates and provision of education and training facilities. Some entrepreneurs induced by such incentives may come forward to locate their units in such areas.

7. Finance: Finance is required for the setting up of an industry, for its running, and also at the time of its expansion. The availability of capital at cheap rates of interests and in adequate amount is a dominating factor influencing industrial location. For instance, a review of locational history of Indian cotton textile industry indicates that concentration of the industry in and around Bombay in the early days was mainly due to the presence of rich and enterprising Parsi and Bhatia merchants, who supplied vast financial resources.

8. Natural and Climatic Considerations: Natural and climatic considerations include the level of ground, topography of a region, water facilities, drainage facilities, disposal of waste products, etc. These factors sometimes influence the location of industries. For instance, in the case of cotton textile industry, humid climate provides an added advantage since the frequency of yarn breakage is low. The humid climate of Bombay in India and Manchester in Britain offered great scope for the development of cotton textile industry in those centres.

9. Personal Factors: In deciding location of industrial units, sometimes an entrepreneur may have personal preferences and prejudices against certain localities. For instance, Mr. Ford started to manufacture motor cars in Detroit simply because it was his home-town. In such cases, personal factor dominates other considerations. However, this kind of domination is rare.

10. Strategic Considerations: In modern times, strategic considerations are playing a vital role in determining industrial location. During war-time a safe location is assuming special significance. This is because in times of war the main targets of air attacks would be armament and ammunition factories and industries supplying other commodities which are required for war. The Russian experience during the Second World War provides and interesting example.

11. External Economies: External economies also exert considerable influence on the location of industries. External economies arise due to the growth of specialized subsidiary activities when a particular industry is mainly localized at a particular centre with port and shipping facilities. External economies could also be enjoyed when a large number of industrial units in the same industry were located in close proximity to one another.

MAINTENANCE MANAGEMENT

The maintenance s managments knoledge and experinces if there is then will be the maintainance s materials needed if itis ok then the badest manpower if they are active then experince managments availability of maintainance materials then active manpower there will be no any maintenance objectives what do you need more to run the maintenance department.

OBJECTIVES OF MAINTENANCE MANAGEMENT:

1. Minimizing the loss of productive time because of equipment failure (i.e. minimizing idle time of equipment due to break down)
2. Minimizing the repair time and repair cost.
3. Minimizing the loss due to production stoppages.
4. Efficient use of maintenance personnel and equipments.
5. Prolonging the life of capital assets by minimizing the rate of wear and tear.

6. To keep all productive assets in good working conditions.
7. To maximize efficiency and economy in production through optimum use of facilities.
8. To minimize accidents through regular inspection and repair of safety devices.
9. To minimize the total maintenance cost which includes the cost of repair, cost of preventive maintenance and inventory carrying costs, due to spare parts inventory.
10. To improve the quality of products and to improve productivity.

FAILURE CONCEPT

Event in which any part of an equipment or machine does not perform according to its operational specifications. Failures are classified into several categories: dependent failure, non- c ritical failure, random failure, etc.

RELIABILITY

The ability of an apparatus, machine, or system to consistently perform its intended or required f unction or mission, on demand and without degradation or failure.

TYPES OF MAINTENANCE

1. Breakdown maintenance

It means that people waits until equipment fails and repair it. Such a thing could be used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.

2. Preventive maintenance (1951)

It is a daily maintenance (cleaning, inspection, oiling and re-tightening), design to retain the healthy condition of equipment and prevent failure through the prevention of deterioration, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into **periodic maintenance** and **predictive maintenance**. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance.

2a. Periodic maintenance (Time based maintenance - TBM)

Time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.

2b. Predictive maintenance

This is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.

3. Corrective maintenance (1957)

It improves equipment and its components so that preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improve reliability or improving maintainability

4. Maintenance prevention (1960)

It indicates the design of a new equipment. Weakness of current machines are sufficiently studied (on site information leading to failure prevention, easier maintenance and prevents of defects, safety and ease of manufacturing) and are incorporated before commissioning a new equipment.

❖ Preventive maintenance

A preventive maintenance program looks for triggers that identify when a problem is likely to occur. It relies on testing, both online and offline, of any equipment that falls under the program. Preventive maintenance discovers any issues before a catastrophic failure. Preventive maintenance involves routine equipment testing and maintenance when identifying a problem.
Applying an effective preventative maintenance program saves money by replacing or rebuilding a failing part.

❖ Breakdown maintenance

Breakdown maintenance is perhaps the least desirable of the three different types of maintenance programs. This type of maintenance involves repairing or rebuilding the equipment, just as the other maintenance programs. The trigger event, though, is the actual breakdown of the equipment. Breakdown maintenance can be beneficial if it's used with preventive and predictive maintenance. It may still be necessary, at times, to use breakdown maintenance as a program when unexpected events take place. If it is the only type of maintenance in place, yet, it tends to be the most costly option.

❖ Replacement Policies

Basic to the implementation of virtual memory is the concept of **demand paging**. This means that the operating system, and not the programmer, controls the swapping of pages in and out of main memory as they are required by the active processes. When a non-resident page is needed by a process, the operating system must decide which resident page is to be replaced by the requested page. The part of the virtual memory which makes this decision is called
the **replacement policy**.

❖ Classification/Types of Policies (Timing)

All replacement policies can be considered to fall into two broad categories in regards to the timing of the replacement, as follows:

- Preventive Replacement Policy
- Failure Replacement Policy

Listed below are some of the primary replacement strategies that can be applied to different types of assets.

Group 1: Preventive Replacement

- Constant-Interval Replacement Policy (**CIRP**)
- Age-Based Replacement Policy (**ABP**)
- Time-Based Replacement Policy
- Inspection Replacement Policy **(IRP**)
- Just-in-Time Replacement Policy (**JITP**)
- Modified-Age Replacement Policy (**MARP**)
- Block Replacement Policy (**BRP**)

Group 2: Failure Replacement:

- Run to Failure (**RTF**)
- Unintended Failure Replacement (**UFR**)

There are many approaches to the problem of deciding which page to replace but the object is the same for all--the policy which selects the page that will not be referenced again for the longest time. Examples:

First In First Out (FIFO):The page to be replaced is the "oldest" page in the memory, the one which was loaded before all the others

Least Recently Used (LRU): The page to be replaced is the one which has not been referenced since all the others have been referenced

Last In First Out (LIFO):

The page to be replaced is the one most recently loaded into the memory

Least Frequently Used (LFU):

The page to be replaced is the one used least often of the pages currently in the memory

Optimal (OPT or MIN):

The page to be replaced is the one that ***will not be*** used for the longest period of time. This algorithm requires future knowledge of the reference string which is not usually available. Thus, this policy is used for comparison studies

UNIT-3

QUALITY CONTROL

Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer.

QC is similar to, but not identical with, quality assuranceQA is defined as a procedure or set of procedures intended to ensure that a product or service under development (before work is complete, as opposed to afterwards) meets specified requirements. QA is sometimes expressed together with QC as a single expression, quality assurance and control (QA/QC).

In order to implement an effective QC program, an enterprise must first decide which specific standards the product or service must meet. Then the extent of QC actions must be determined (for example, the percentage of units to be tested from each lot). Next, real-world data must be collected (for example, the percentage of units that fail) and the results reported to management personnel. After this, corrective action must be decided upon and taken (for example, defective units must be repaired or rejected and poor service repeated at no charge until the customer is satisfied). If too many unit failures or instances of poor service occur, a plan must be devised to improve the production or service process and then that plan must be put into action. Finally, the QC process must be ongoing to ensure that remedial efforts, if required, have produced satisfactory results and to immediately detect recurrences or new instances of trouble.

ISO 9000 - Quality management

The ISO 9000 family addresses various aspects of quality management and contains some of ISO's best known standards. The standards provide guidance and tools for companies and organizations who want to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved.

ISO 9001:2015

ISO 9001:2015 sets out the criteria for a quality management system and is the only standard in the family that can be certified to (although this is not a requirement). It can be used by any organization, large or small, regardless of its field of activity. In fact, there are over one million companies and organizations in over 170 countries certified to ISO 9001.

This standard is based on a number of quality management principles including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement. These principles are explained in more detail in the pdf Quality Management Principles. Using ISO 9001:2015 helps ensure that customers get consistent, good quality products and services, which in turn brings many business benefits.

A quality circle or quality control circle is a group of workers who do the same or similar work, who meet regularly to identify, analyze and solve work-related problems. Normally small in size, the group is usually led by a supervisor or manager and presents its solutions to management; where possible, workers implement the solutions themselves in order to improve the performance of the organization and motivate employees. Quality circles were at their most popular during the 1980s, but continue to exist in the form of Kaizen groups and similar worker participation schemes..

The 3 Types of Quality Defects

Defects are classified into three main categories – **minor**, **major** and **critical**. Based on the level applied, there will be an allowable number of defects for each category, within a given sample size.

Minor defects are small, typically insignificant issues that do not affect function or form of the item. If evident, it likely would not cause the customer to return the item to the store. Your order can fail inspection, however, if the number of minor defects found exceeds the limit set by the acceptable quality level.

Major defects are considered those which could adversely affect performance of the product. Such a defect would likely cause a customer to return the product.

Critical defects are those which would render the item unusable, or could cause harm to the user or someone in the vicinity of the product. An item will often fail product inspection if a single critical defect is found within the order. According to estimates from the U.S. Consumer Product Safety Commission (CPSC), there were about 256,700 toy-related injuries treated by emergency personnel in 2013, many resulting in product recalls.

STATISTICAL QUALITY CONTROL

The Statistical Quality Control is the application of statistical techniques to decide whether to accept or reject the product produced or to control the process of production to maintain product quality, while the product is being produced. The former is known as acceptance sampling while the latter is known as Statistical Process Control (SPC).

Acceptance sampling is based upon the assumption that, as 100% inspection is time consuming and costly, it is possible to select scientifically a part of the lot or sample in such a way that it represents all the characteristics of the lot. It is the process of evaluating a portion of the product material in a lot for the purpose of accepting or rejecting the lot as, either conforming or not conforming to quality specifications. Acceptance sampling implies selection of a sample and carefully inspecting it to identity defects. After inspection if any defects are found the lot is rejected, but, if the number of defects is small, it may be accepted.

Statistical Process Control (SPC) is an effective method of monitoring a process through the use of control charts. Much of its power lies in the ability to monitor both process centre and its variation about that centre. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. It has an emphasis on early detection and prevention of problems.

Advantages of SQC

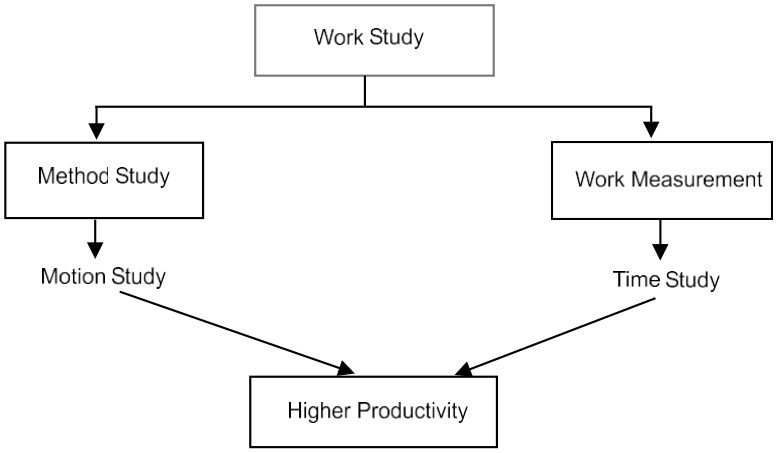
Following are several advantages of SQC:

- Helps in preventing defects. The causes giving rise to deviations from standards are detected and removed thus reworking, rejection and scrap are avoided

- Helps in avoiding risk of accepting a bad lot
- Reduces the task of inspecting the whole lot
- Helps in maintaining high standards of quality and promotes goodwill about the organization
- Aims at reducing inspection expenses so as to produce the final product at minimum costs tandard quality helps in maintaining standard price
- Promotes feeling of responsibility among the workers

WORKSTUDY:

"**Work study** is a generic term for those techniques, method study and work measurement which are used in the examination of human work in all its contexts. And which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement."



Framework of work study

Work study is a means of enhancing the production efficiency (productivity) of the firm by elimination of waste and unnecessary operations. It is a technique to identify non-value adding operations by investigation of all the factors affecting the job. It is the only accurate and systematic procedure oriented technique to establish time standards. It is going to contribute to the profit as the savings will start immediately and continue throughout the life of the product.

Method study and work measurement is part of work study. Part of method study is motion study; work measurement is also called by the name 'Time study'.

ADVNATAGES OF WORKSTUDY:

Following are the advantages of work study:

1. It helps to achieve the smooth production flow with minimum interruptions.
2. It helps to reduce the cost of the product by eliminating waste and unnecessary operations.
3. Better worker-management relations.
4. Meets the delivery commitment.

5. Reduction in rejections and scrap and higher utilisation of resources of the organization.
6. Helps to achieve better working conditions.
7. Better workplace layout.
8. Improves upon the existing process or methods and helps in standardisation and simplification.
9. Helps to establish the standard time for an operation or job which has got application in manpower planning, production planning.

METHODSTUDY:

Method study enables the industrial engineer to subject each operation to systematic analysis. The main purpose of method study is to eliminate the unnecessary operations and to achieve the best method of performing the operation.

Method study is also called **methods engineering or work design.** Method engineering is used to describe collection of analysis techniques which focus on improving the effectiveness of men and machines.

According to British Standards Institution (BS 3138): "Method study is the systematic recording and critical examination or existing and proposed ways or doing work as a means or developing and applying easier and more effective methods and reducing cost." Fundamentally method study involves the breakdown of an operation or procedure into its component elements and their systematic analysis. In carrying out the method study, the rightattitude of mind is important.

The method study man should have:

1. The desire and determination to produce results.
2. Ability to achieve results.
3. An understanding of the human factors involved.

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

1. Manufacturing operations and their sequence.
2. Workmen.
3. Materials, tools and gauges.
4. Layout of physical facilities and work station design.
5. Movement of men and material handling.
6. Work environment.

OBJECTIVES OF METHOD STUDY:

1. Improved layout and design of workplace.
2. Improved and efficient work procedures.
3. Effective utilisation of men, machines and materials.
4. Improved design or specification of the final product.

The objectives of method study techniques are:

1. Present and analyse true facts concerning the situation.
2. To examine those facts critically.
3. To develop the best answer possible under given circumstances based on critical examination of facts.

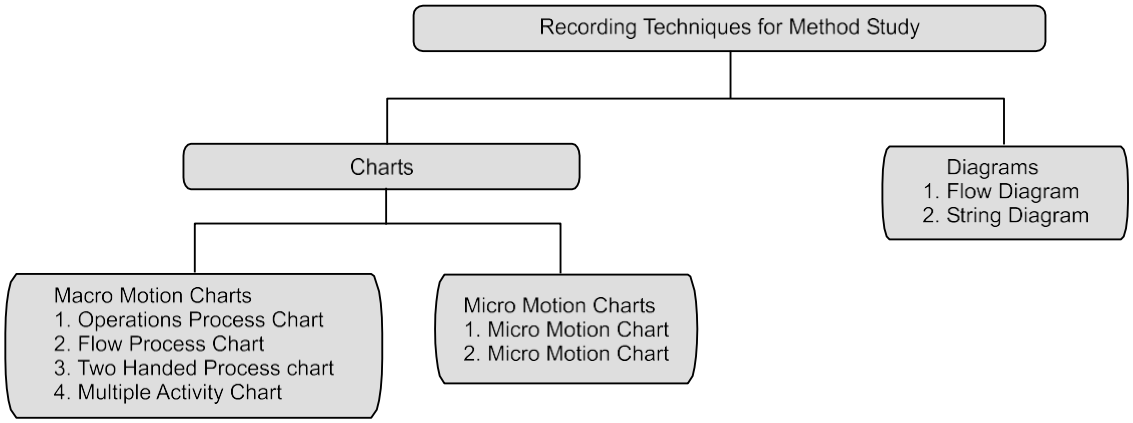
SCOPE OF METHOD STUDY:

1. To improve work methods and procedures.
2. To determine the best sequence of doing work.
3. To smoothen material flow with minimum of back tracking and to improve layout.
4. To improve the working conditions and hence to improve labour efficiency.
5. To reduce monotony in the work.
6. To improve plant utilisation and material utilisation.
7. Elimination of waste and unproductive operations.
8. To reduce the manufacturing costs through reducing cycle time of operations.

RECORDING TECHNIQUE FOR METHOD STUDY:

The next step in basic procedure, after selecting the work to be studied is to record all facts relating to the existing method. In order that the activities selected for investigation may be visualised in their entirety and in order to improve them through subsequent critical examination, it is essential to have some means of placing on record all the necessary facts about the existing method. Records are very much useful to make before and after comparison to assess the effectiveness of the proposed improved method.

The recording techniques are designed to simplify and standardise the recording work. For this purpose charts and diagrams are used.



CHARTS USED IN METHODS STUDY

This is the most popular method of recording the facts. The activities comprising the jobs are recorded using method study symbols. A great care is to be taken in preparing the charts so that

the information it shows is easily understood and recognized. The following information should be given in the chart. These charts are used to measure the movement of operator or work (*i.e.*, in motion study).

(a) Adequate description of the activities.
(b) Whether the charting is for present or proposed method.
(c) Specific reference to when the activities will begin and end.
(d) Time and distance scales used wherever necessary.
(e) The date of charting and the name of the person who does charting.

Types of Charts

It can be broadly divided into (A) Macro motion charts and (B) Micro motion charts.

Macro motion charts are used for macro motion study and micro motion charts are used for micro motion study.

Macro motion study is one which can be measured through 'stop watch' and micro motion study is one which cannot be measured through stop watch.

(A) MACRO MOTION CHARTS

Following four charts are used under this type:

1. Operation Process Chart

It is also called outline process chart. An operation process chart gives the bird's eye view of the whole process by recording only the major activities and inspections involved in the process. Operation process chart uses only two symbols, *i.e.*, operation and inspection. Operation, process chart is helpful to:

(a) Visualise the complete sequence of the operations and inspections in the process.
(b) Know where the operation selected for detailed study fits into the entire process.
(c) In operation process chart, the graphic representation of the points at which materials are introduced into the process and what operations and inspections are carried on them are shown.

2. Flow Process Chart

Flow process chart gives the sequence of flow of work of a product or any part of it through the work centre or the department recording the events using appropriate symbols. It is the amplification of the operation process chart in which operations; inspection, storage, delay and transportation are represented. However, process charts are of three types:

(a) Material type—Which shows the events that occur to the materials.
(b) Man type—Activities performed by the man.
(c) Equipment type—How equipment is used.

The flow process chart is useful:

(a) to reduce the distance travelled by men (or materials).
(b) to avoid waiting time and unnecessary delays.
(c) to reduce the cycle time by combining or eliminating operations.
(d) to fix up the sequence of operations.

(e) to relocate the inspection stages.

Like operation process chart, flow process chart is constructed by placing symbols one below another as per the occurrence of the activities and are joined by a vertical line. A brief description of the activity is written on the right hand side of the activity symbol and time or distance is given on the left hand side.

3. Two Handed Process Chart

A two handed (operator process chart) is the most detailed type of flow chart in which the activities of the workers hands are recorded in relation to one another. The two handed process chart is normally confined to work carried out at a single workplace. This also gives synchronised and graphical representation of the sequence of manual activities of the worker. The application of this charts are:

- To visualise the complete sequence of activities in a repetitive task.
- To study the work station layout.

4. Multiple Activity Chart

It is a chart where activities of more than subject (worker or equipment) are each recorded on a common time scale to show their inter-relationship. Multiple activity chart is made:

- to study idle time of the man and machines,
- to determine number of machines handled by one operator, and
- to determine number of operators required in teamwork to perform the given job.

Diagrams Used in Method Study

The flow process chart shows the sequence and nature of movement but it does not clearly show the path of movements. In the paths of movements, there are often undesirable features such as congestion, back tracking and unnecessary long movements. To record these unnecessary features, representation of the working area in the form of flow diagrams, string diagrams can be made:

1. To study the different layout plans and thereby; select the most optimal layout.
2. To study traffic and frequency over different routes of the plant.
3. Identification of back tracking and obstacles during movements. Diagrams are of two types: 1. Flow diagram and 2. String diagram.

1. FLOW DIAGRAM

Flow diagram is a drawing, of the working area, showing the location of the various activities identified by their numbered symbols and are associated with particular flow process chart either man type or machine type.

The routes followed in transport are shown by joining the symbols in sequence by a line which represents as nearly as possible the path or movement of the subject concerned.

Following are the procedures to make the flow diagram:

1. The layout of the workplace is drawn to scale.
2. Relative positions of the machine tools, work benches, storage, and inspection benches are marked on the scale.
3. Path followed by the subject under study is tracked by drawing lines.

4. Each movement is serially numbered and indicated by arrow for direction.
5. Different colours are used to denote different types of movements.

2. STRING DIAGRAM

The string diagram is a scale layout drawing on which, length of a string is used to record the extent as well as the pattern of movement of a worker working within a limited area during a certain period of time. The primary function of a string diagram is to produce a record of a existing set of conditions so that the job of seeing what is actually taking place is made as simple as possible.

One of the most valuable features of the string diagram is the actual distance travelled during the period of study to be calculated by relating the length of the thread used to the scale of drawing. Thus, it helps to make a very effective comparison between different layouts or methods of doing job in terms of the travelling involved.

The main advantages of string diagram compared to flow diagram is that respective movements between work stations which are difficult to be traced on the flow diagram can be conveniently shown on string diagram.

Folloging are the procedures to draw string diagram:

1. A layout of the work place of factory is drawn to scale on the soft board.
2. Pins are fixed into boards to mark the locations of work stations, pins are also driven at the turning points of the routes.
3. A measured length of the thread is taken to trace the movements (path).
4. The distance covered by the object is obtained by measuring the remaining part of the thread and subtracting it from original length.

Symbols Used in Method Study

Graphical method of recording was originated by Gilberth, in order to make the presentation of the facts clearly without any ambiguity and to enable to grasp them quickly and clearly. It is useful to use symbols instead of written description.

(A) METHOD STUDY SYMBOLS

- OPERATION
- □ INSPECTION
- TRANSPORTATION
- D DELAY
- STORAGE

Operation O

An operation occurs when an object is intentionally changed in one or more of its characteristics (physical or chemical). This indicates the main steps in a process, method or procedure.

An operation always takes the object one stage ahead towards completion. Examples of operation are:

- Turning, drilling, milling, etc.

- A chemical reaction.
- Welding, brazing and riveting.
- Lifting, loading, unloading.
- Getting instructions from supervisor.
- Taking dictation.

Inspection □

An inspection occurs when an object is examined and compared with standard for quality and quantity. The inspection examples are:

- Visual observations for finish.
- Count of quantity of incoming material.
- Checking the dimensions.

Transportation □

A transport indicates the movement of workers, materials or equipment from one place to another.

Example: Movement of materials from one work station to another, Workers travelling to bring tools.

Delay D: Delay (Temporary Storage)

A delay occurs when the immediate performance of the next planned thing does not take place.

Example: Work waiting between consecutive operations.

Workers waiting at tool cribs.

Operators waiting for instructions from supervisor.

Storage □

Storage occurs when the object is kept in an authorised custody and is protected against unauthorised removal. For example, materials kept in stores to be distributed to various work.

WORK MEASUREMENT:

Work measurement is also called by the name ‘time study’. Work measurement is absolutely essential for both the planning and control of operations. Without measurement data, we cannot determine the capacity of facilities or it is not possible to quote delivery dates or costs. We are not in a position to determine the rate of production and also labour utilisation and efficiency. It may not be possible to introduce incentive schemes and standard costs for budget control.

OBJECTIVES OF WORK MEASUREMENT:

1. Comparing alternative methods.

2. Assessing the correct initial manning (manpower requirement planning).
3. Planning and control.
4. Realistic costing.
5. Financial incentive schemes.
6. Delivery date of goods.
7. Cost reduction and cost control.
8. Identifying substandard workers.
9. Training new employees.

TECHNIQUES OF WORK MEASUREMENT:

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

1. **Repetitive work:** The type of work in which the main operation or group of operations repeat continuously during the time spent at the job. These apply to work cycles of extremely short duration.

2. **Non-repetitive work:** It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

Various techniques of work measurement are:

1. Time study (stop watch technique),
2. Synthesis,
3. Work sampling,
4. Predetermined motion and time study,
5. Analytical estimating.

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

1. **Time study:** A work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analysing the data so as to determine the time necessary for carrying out the job at the defined level of performance. In other words measuring the time through stop watch is called time study.

2. **Synthetic data:** A work measurement technique for building up the time for a job or pans of the job at a defined level of performance by totalling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data.

3. **Work sampling:** A technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.

4. Predetermined motion time study (PMTS): A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as **Methods Time Measurement (MTM).**

5. **Analytical estimating:** A work measurement technique, being a development of estimating, whereby the time required to carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.

The work measurement techniques and their applications are shown in Table 7.2.

Work measurement techniques and their application

Techniques	*Applications*	*Unit of measurement*
1. Time study	Short cycle repetitive jobs. Widely used for direct work.	Centiminute (0.01 min)
2. Synthetic Data	Short cycle repetitive jobs.	Centi minutes
3. Working sampling	Long cycle jobs/heterogeneous operations.	Minutes
4. MTM	Manual operations confined to one work centre.	TMU (1 TMU = 0.006 min)
5. Analytical estimation	Short cycle non-repetitive job.	Minutes

ALLOWANCES:

The normal time for an operation does not contain any allowances for the worker. It is impossible to work throughout the day even though the most practicable, effective method has been developed. Even under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances must also be made to enable the worker to attend to his personal needs. The allowances are categorised as: (1) Relaxation allowance, (2) Interference allowance, and (3) Contingency allowance.

1. RELAXATION ALLOWANCE

Relaxation allowances are calculated so as to allow the worker to recover from fatigue. Relaxation allowance is a addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on nature of the job.

Relaxation allowances are of two types: fixed allowances and variable allowances.

Fixed allowances constitute:

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

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

2. VARIABLE ALLOWANCE

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job.

The variable fatigue allowance is added to the fixed allowance to an operator who is

engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organization to organization.

3. INTERFERENCE ALLOWANCE

It is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him. This allowance is applicable for machine or process controlled jobs.

Interference allowance varies in proportion to number of machines assigned to the operator. The interference of the machine increases the work content.

4. CONTINGENCY ALLOWANCE

A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays. The precise measurement of which is uneconomical because of their infrequent or irregular occurrence.

This allowance provides for small unavoidable delays as well as for occasional minor extra work:

Some of the examples calling for contingency allowance are:

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

5. POLICY ALLOWANCE

Policy allowances are not the genuine part of the time study and should be used with utmost care and only in clearly defined circumstances.

The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions.

The policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, *e.g.*, work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstances. Policy allowances are sometimes made as imperfect functioning of a division or part of a plant.

ng data: Average time for machine elements = 6 min

Average time for manual elements = 4 min
Performance rating = 110%

Allowances = 10%

SOLUTION:

Normal time = Machinery time + Manual time × Rating
= 6 + 4 × 1.1
= 6 + 4.4 = **10.4 min**

 Standard time = Normal time + Allowances
= 10.4 + 10.4 × $\frac{10}{}$

$= 10.4\ (1 + 0.1) =$ **11.44 min.**

UNIT – IV

RESOURCE REQUIREMENT PLANNING

Course Objective: To remember the importance of material management

Course Outcome: Get conversant with various documents procedural aspects and preparation of orders for various MRP.

NO OF LECTURE HOURS: 8

LECTURE	LECTURE TOPIC	KEY ELEMENTS	LEARNING OBJECTIVES (2 to 3 objectives)
1.	Resource requirement planning	Steps involved in Resource Requirement Planning	Understanding of resource requirement planning
2.	Material requirement planning	Introduction to Material requirement planning system	Understanding of MRP system MRP objectives
3.	Manufacturing resource planning	Flow chart of Manufacturing resource planning	Learning of levels involved in manufacturing resource planning
4.	General overview of MRP and definition of terms used in MRP	Terms used in MRP	Familiarize different terms used in MRP
5.	MRP inputs and outputs	Inputs and outputs for MRP system	Understanding inputs required and outputs attained from MRP system

6.	MRP computational procedure	Procedure required for MRP and a case study	Familiarize procedure for Material resource planning with a case study
7.	Enterprise Resource Planning	Introduction and scope of Enterprise resource planning	Understanding of Enterprise Resource Planning
8.	Benefits, Applications of Enterprise Resource Planning	Enterprise Resource Planning benefits and applications, case study	Acquaint of Enterprise Resource Planning with a case study

RESOURCE REQUIREMENT PLANNING

Resource requirement planning is directed at the determination of the amount and timing of production resources such as personnel, materials, cash and production capacity needed to produce the finished products or end items as per the master production schedule.

Resource requirements planning is also known as rough-cut capacity planning. It can be used to evaluate the feasibility of a trial master production schedule. It is an aggregate planning tool that is used to sum up and evaluate the workload that a production plan (MPS) imposes either on all work centres or on only selected key work centres where resources are limited, expensive or difficult to obtain from outside sources (sub-contractors). This step ensures that a proposed MPS does not overload any key work centres or departments or machines thus making the MPS unworkable. Rough-cut capacity planning is usually applied to the critical work centres which are most likely to be bottlenecks.

Steps involved in rough-cut capacity planning are:

1. Developing a trial production plan (or trial master production schedule) that indicates the company's products that are planned for production during each week or month of the planning horizon.
2. Computing the work load that this production plan will impose on each key work centre and key subcontractors for each period (week or month) of the planning horizon. The load profile i.e., the load on each work centre over time, is evaluated for feasibility, by comparing the load with the available capacity in each of the key work centres or key sub-contractors.
3. If the trial production plan does not appear to be feasible or does not make optimal use of the resources in the key work centres, the plan may be revised.
4. The capacity requirements of the revised production plan (revised MPS) can then be evaluated to determine the feasibility of the plan.
5. Step No. 4 and 5 are repeated until a plan considered to be satisfactory is developed.

There are two main elements of resource requirements planning systems namely

(a) Material requirements planning (MRP)

(b) Capacity requirements planning (CRP)

MATERIAL REQUIREMENT PLANNING (MRP OR MRP I)

For a manufacturing company to produce end items to meet demands, the availability of sufficient production capacity must be co-ordinate with the availability of all raw materials and purchased items from which, the end items are to be produced. In other words, there is a need to manage the availability of dependent demand items from which the products are made. Dependent-demand items are the components i.e. materials or purchased items, fabricated parts or sub-assemblies that make up the end product.

One approach to manage the availability of dependent-demand items is to keep a high stock of all the items that might be needed to produce the end items and when the on-hand stock dropped below a present re-order level, the items are produced or bought as the case may be to replenish the stock to the maximum level. However, this approach is costly due to the excessive inventory of components, fabricated parts and sub-assemblies to ensure high service level (i.e. availability of dependent demand items at a short notice)

An alternative approach to managing dependent-demand items is to plan for procurement or manufacture of the specific components that will be required to produce the required quantities of end products as per the production schedule indicated by the master production

schedule (MPS). The technique is known as material requirements planning (MRP) technique.

MRP is a computer-based system in which the given MPS is exploded into the required amounts of raw materials, parts and sub-assemblies, needed to produce the end items in each time period (week or month) of the planning horizon. The gross requirement of these materials is reduced to net requirements by taking into account the materials that are in inventory or on order.

A schedule of orders is developed for purchased materials and in-house manufactured items over the planning horizon based on the knowledge of lead items for procurements or in-house production.

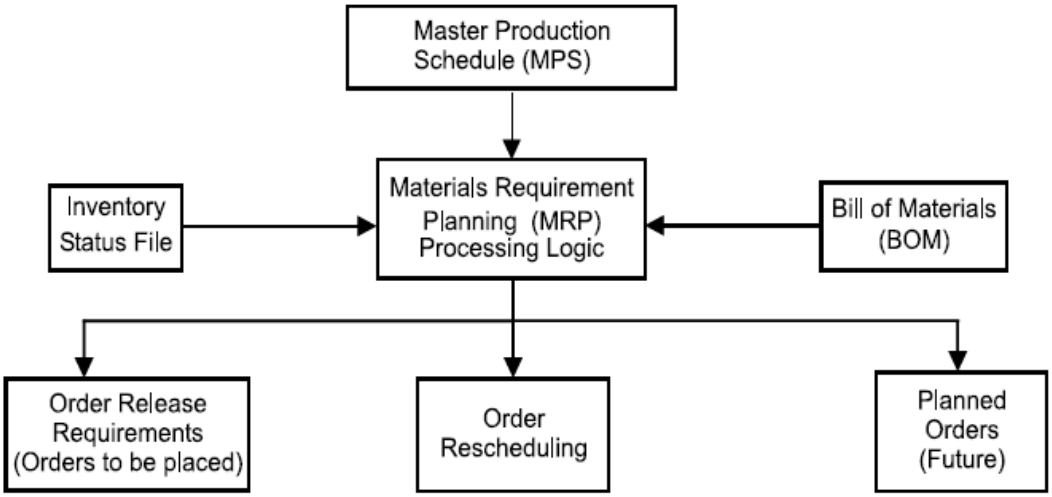


Fig – 4.1 MRP System

MRP objectives

The main theme of MRP is “getting the right materials to the right place at the right time”. Specific organizational objectives often associated with MRP design and implementation may be identified among three main dimensions, namely: inventory, priorities and capacity:

Table 4.1: Three main dimensions of MRP design and implementation

Dimension	Objective specifics
Inventory	- Order the right part - Order the right quantity - Order at the right time
Priorities	- Order with the right due date - Keep the due date valid
Capacity	- Plan for a complete load - Plan for an accurate load - Plan for an adequate time to view future load

Objectives of MRP should be identified with regard to inputs and outputs associated with it. Inputs are delineated with master production schedule, bill of materials, etc. Therefore, a clear specification of MRP objectives should be associated with a respectively clear description of objectives of MRP inputs as well as MRP outputs.

MANUFACTURING RESOURCE PLANNING (MRP II)

Manufacturing Resource Planning (MRP II) has been developed by manufacturing manages to address the planning and controlling of a manufacturing process and all of is related support functions. It encompasses logically correct planning and control activities related to materials, capacity, finance, engineering, sales and marketing. MRP II is universally applicable to any manufacturing organization, regardless of its size, location, product or process.

MRP II is a management process for taking the business plan and breaking it down into specific, detailed tasks that people evaluate, agree upon and are held accountable for. It involves all departments viz., materials departments, engineering department that must maintain bill of materials, sales/marketing department that must keep sales plan up to date, purchasing and manufacturing departments that must meet due dates for bought-out items and in-house manufactured items respectively.

From MRP I to MRP II: Manufacturing resourced planning (MRP II) is a natural outgrowth of materials requirements planning (MRP I). Whereas, MRP I focuses upon priorities of materials, CRP is concerned with time. Both material and time requirement are integrated

within the MRP system (i.e., MRP I). Beyond this, MRP II has been coined to ‘close the loop’ by integrating financial, accounting, personnel, engineering and marketing information along with the production planning and control activities of basic MRP systems. MRP II is the heart of the corporate management information system for many manufacturing firms.

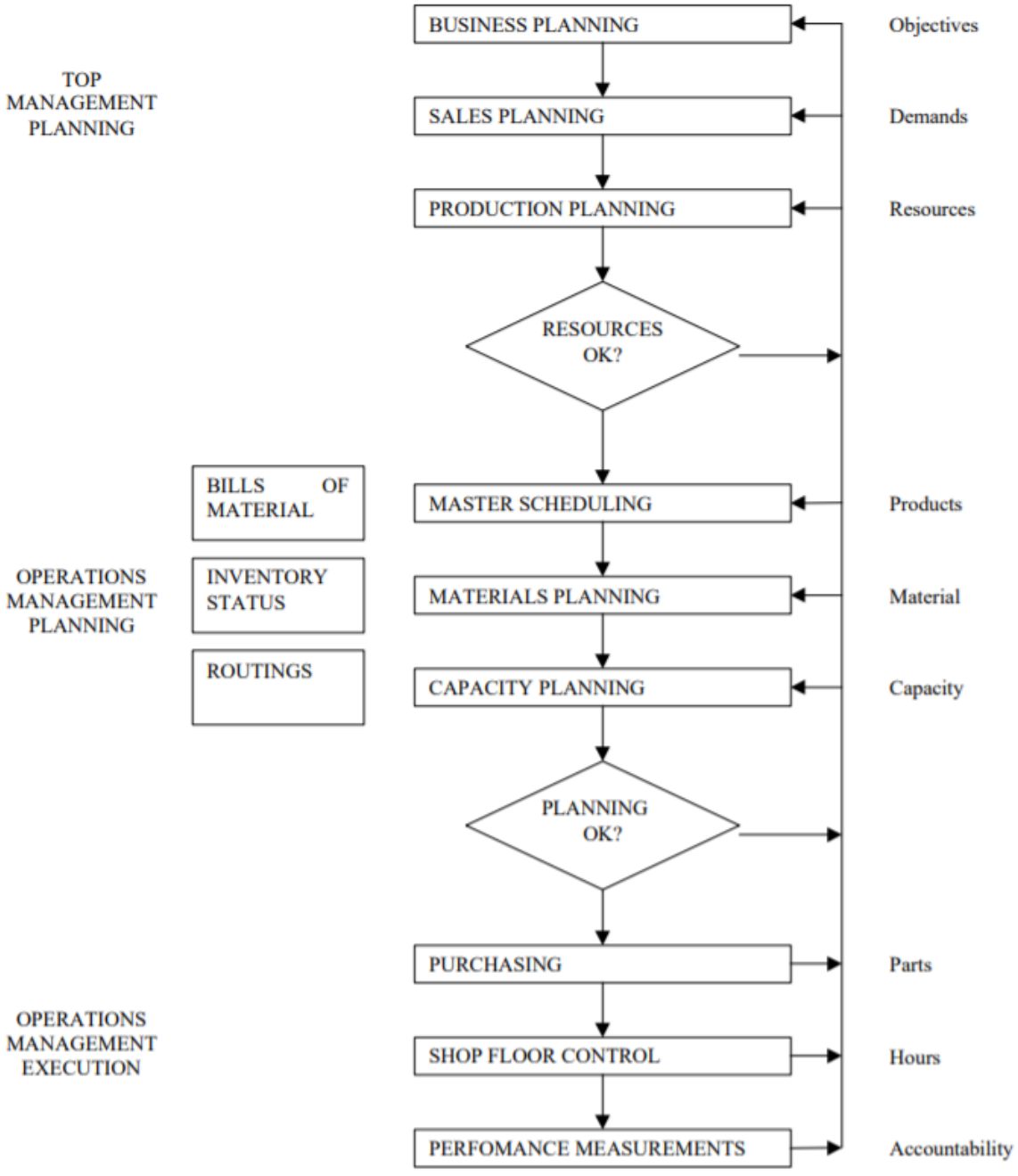


Fig 4.2: Manufacturing Resource Planning (MRPII)

General Overview of MRP

Basically, MRP consists of a set of computer programs that are run periodically (once a week or once a month) to incorporate the latest schedule of production requirements MRP performs three important functions viz.

- Order planning and control, i.e. when to release orders and for what quantity?
- Priority planning and control i.e., comparison of expected date of availability with the need date of each item.
- Provision of a basis for planning capacity requirements and development of broad business plans.

MRP is applicable primarily to companies that carry out the fabrication of parts and assembly of standard products in batch quantities.

The entire MRP system is driven by the MRP. The bill of materials file and inventory status file are fed in to the MRP computer program to generate the output.

Definitions of terms used in MRP systems

MASTER PRODUCTION SCHEDULE (MRP): This is the schedule of the quantity and timing of all end products to be produced over a specific planning horizon. MPS is developed from customer's firm orders or from forecasts of demand or both. It is an input to the MRP system.

2. PRODUCT STRUCTURE: Indicates the level of components required to produce an end product.

3. BILLS OF MATERIAL: A list indicating the quantities of all raw materials, parts, components, sub assemblies and major assemblies that go into an end product. It gives details of the build up of a product. It may also be called as indented parts list.

4. BILLS OF MATERIAL FILE: A bills of material file, also known as product-structure file, is a computerized file listing all finished products, the quantity of raw materials, parts sub-assemblies and assemblies in each product. The bills of materials file must be kept up-to-date as and when the products are redesigned or modified with addition/deletion of some parts, components and sub-assemblies.

5. INVENTORY STATUS FILE: It is a computerized file with a comprehensive record of each and every material held in inventory. The information included in this file are, materials on hand or on order, planned orders, planned order releases, allocated materials, lot sizes, lead times, safety stock levels, costs and suppliers for each material. The inventory file must

kept up-to-date taking into consideration the daily inventory transactions such as receipts, issues, scrapped materials, planned orders and order releases.

6. MRP COMPUTER PROGRAM: It is a computer program, which processes the MRP information. Its inputs are the MPS, inventory status file and bills of materials file. The primary outputs are: planned order schedule, planned order releases and changes to planned orders.

7. AVAILABLE INVENTORY: Materials that are held in inventory of which are on order, but are not either safety stock or allocated to other uses.

8. ALLOCATED INVENTORY: Materials that are held in inventory or on order but which have been allocated to specific production orders.

9. ON-HAND INVENTORY: The quantity of a material, physically held in inventory at a point of time. It may include safety stock and allocated inventory except materials on order.

10. PLANNING HORIZON: The number of time periods (days, weeks or months) included in the MPS, CRP, MRP and departmental schedules.

11. ACTION BUCKET: The unit of time measurement in MRP systems. It is a particular period of time in the planning horizon. For example, Bucket # 10 means the tenth period (usually a week in duration) of the planning horizon.

12. GROSS REQUIREMENTS: The total quantity of an item at the end of a period to meet the panned output levels, not considering any availability of the item in inventory or scheduled receipts.

13. SCHEDULED RECEIPTS: The quantity of an item that will be received at the beginning of a time period from a supplier as a result of orders already placed (open orders).

14. PLANNED ORDER RECEIPTS: The quantity of an item that us planned to be ordered so that, it will be received at the beginning of the time period to meet the net requirements for that time period. The order is yet to be placed.

15. PLANNED ORDER RELEASES: The quantity of an item that is planned to be ordered and the planned time period for releasing this order, so that, the item will be received when needed. This time schedule is determined by off-setting the planned order receipts schedule to allow for lead times. When this other is released, it becomes a schedule receipt.

16. NET REQUIREMENTS: The quantity of an item that must be procured to meet the scheduled output for the period.

17. LOW-LEVEL CODING: It is the coding of each material at the lowest level in ay product structure that it appears. A component can appear at more than one level in the product structure. Because MRP computer programs process net requirements calculations

for all products, level by level from end items, down to the raw materials, low level coding avoids redundant net requirements calculations.

18. LOT-SIZING DECISIONS: Whenever there is a need for the net requirement of a material, a decision must be taken regarding the quantity of material to be ordered (either purchase order or production order). Lot sizing decisions include both the batch or lot-size (quantity) as well as the timing of these lots.

19. DEPENDENT DEMAND: Demand for raw material, part or a component, that is dependent on the demand for the end product in which these materials are used.

20. INDEPENDENT DEMAND: Demand for a materials that is independent of the demands for other materials. For example, demand for end products re independent of demand for parts, raw materials or components as their demands are determined, by customers outside the organizations.

21. LUMPY DEMAND: If the demand for the materials varies greatly from time period o time period (say week to week), the demand is said to be ‘lumpy demand’.

22. CAPACITY REQUIREMENT PLANNING: The process of reconciling the Master Production Schedule to the available capacities of production departments (viz., machine and labour capacities) over the planning horizon.

23. PLANNED ORDER RELEASES: Number in ‘planned order releases’ row indicate when orders should be placed to meet the requirement for the item. The time period at which the order should be released is found by subtracting the lead time from the ‘net requirement’ period (this procedure is called ‘offsetting’ by lead time).

MRP System Inputs

MRP is to translate the requirement of end products stated in MPS into the requirement of components and materials. MPS is the most direct input to MRP. Other input data include inventory status, bill of material (BOM), fundamental data in item master file, and shop calendar.

- MPS

  MPS is the schedule for end items. It states the quantity and timing of production of specific end items. Master production scheduling is a procedure to determine the production schedules and the available-to-promise (ATP) of the end products. Based on MPS, MRP calculates the replenishment plans from the items in the level below th end products down to the raw materials

- BOM

  BOM describes the structure of the products. It states, from level to level, the components needed to make the parent items. By using BOM, the requirements of end products are expanded to include the requirements of the components, and hence the requirements of all the lower level materials.

- Fundamental data in item master file

The attributes of all items including raw materials, works-in-process, semi-finished goods, or finished goods, are expressed in the item master file. Part number, lead-time, safety stock, lot-sizing rule, low level code, etc. are required by the MRP processor. Low level code is used to determine the sequence of MRP calculation. Safety stock and lot-sizing rule are used to decide the quantity of the material replenishments. Lead-time is used to decide the time to replenish the required materials.

- Shop Calendar

MRP systems are time-phased. Time bucket is an interval used to break time into discrete chunks. The length of a time bucket is defined according to the characteristics of a business. Commonly used time bucket includes week and day, i.e., numbered-week calendar (00-99) and numbered-day calendar (M-day calendar, 000-999). Planning horizon is the amount of time the master schedule and MRP extend into the future. The planning horizon should cover at least the cumulative lead-time to produce a product.

MRP System Outputs

Two primary outputs are:

1. Planned order schedule which is a plan of the quantity of each material to be ordered in each time period.

The order may be a purchase order on the suppliers or production orders for parts and sub-assembles on production departments.

2. Changes in planned orders – i.e., modification of previous planned orders. The secondary output are:

1. Exception reports which list items requiring management attention to control

2. Performance reports regarding how well the system is operating – e.g. inventory turnovers, percentage of delivery promises kept and stock out incidences.

3. Planning reports such as inventory forecasts, purchase commitment reports, etc.

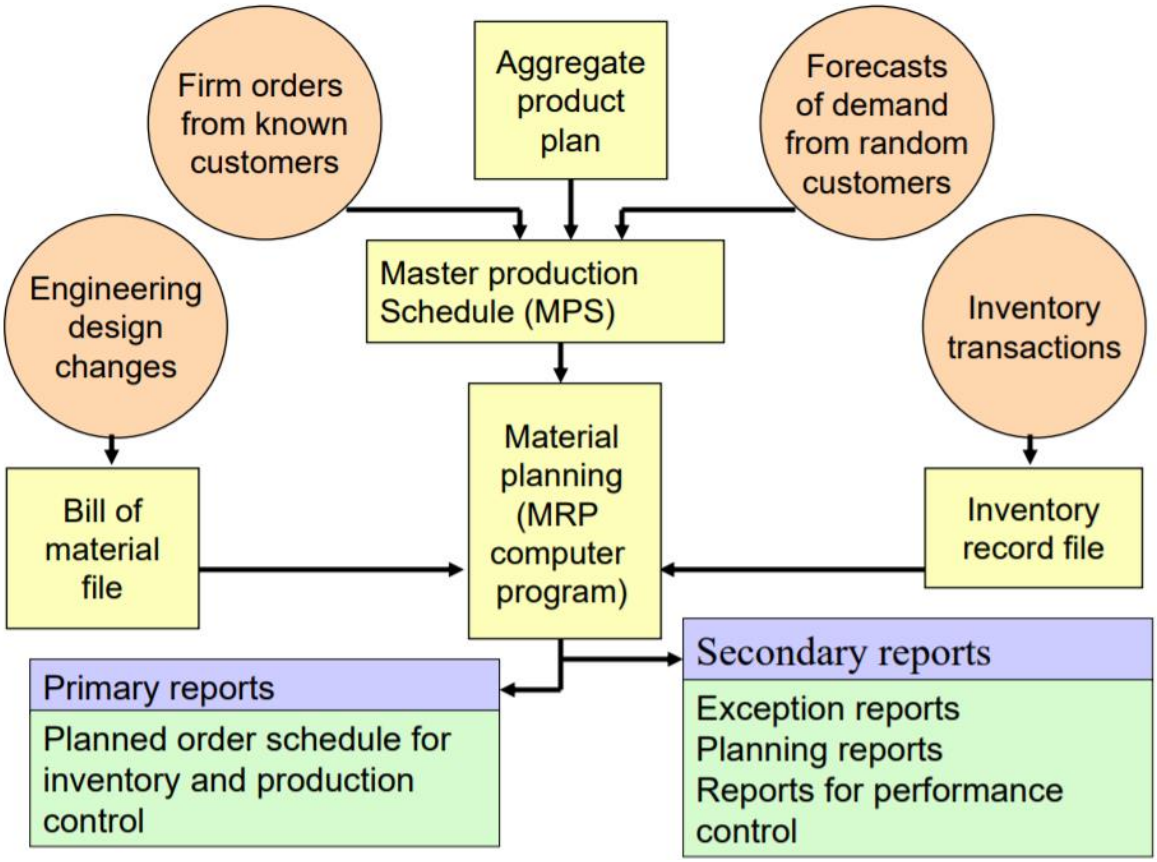


Fig 4.3 - Overall View of the Inputs to a Standard Material Requirements Program and the Reports Generated by the Program

MRP Computational Procedure

MPS procedure consolidates the independent demands of forecasts and customer orders to determine the requirements of the end products in each time bucket in the planning horizon. After netting the on-hand and on-order inventory, and offsetting the lead-time, the production schedule of the end products, MPS, is determined. In MPS procedure, the available-to-promise (ATP) is also determined. MPS is then fed into the MRP procedure to determine the requirements of the lower level components and raw materials.

The gross requirements of components are determined by calculating the planned order releases (POR) of the parents via single level BOM explosion. The net requirements are calculated by subtracting the on-hand inventory and scheduled receipts (on-order) in each time bucket. After the consideration of lot-size, the net requirements are transformed into the planned order receipts. Planned order receipts appear in every period. Lead-time

offsetting shifts the planned order receipts backward and derives the POR which are the MRP result of current item. The MRP procedure continues to explode the POR to obtain the gross requirements of its components. The MRP repeat the procedure until the POR of all the items are determined. The flow chart of the MRP procedure is described in Figure 4.4.

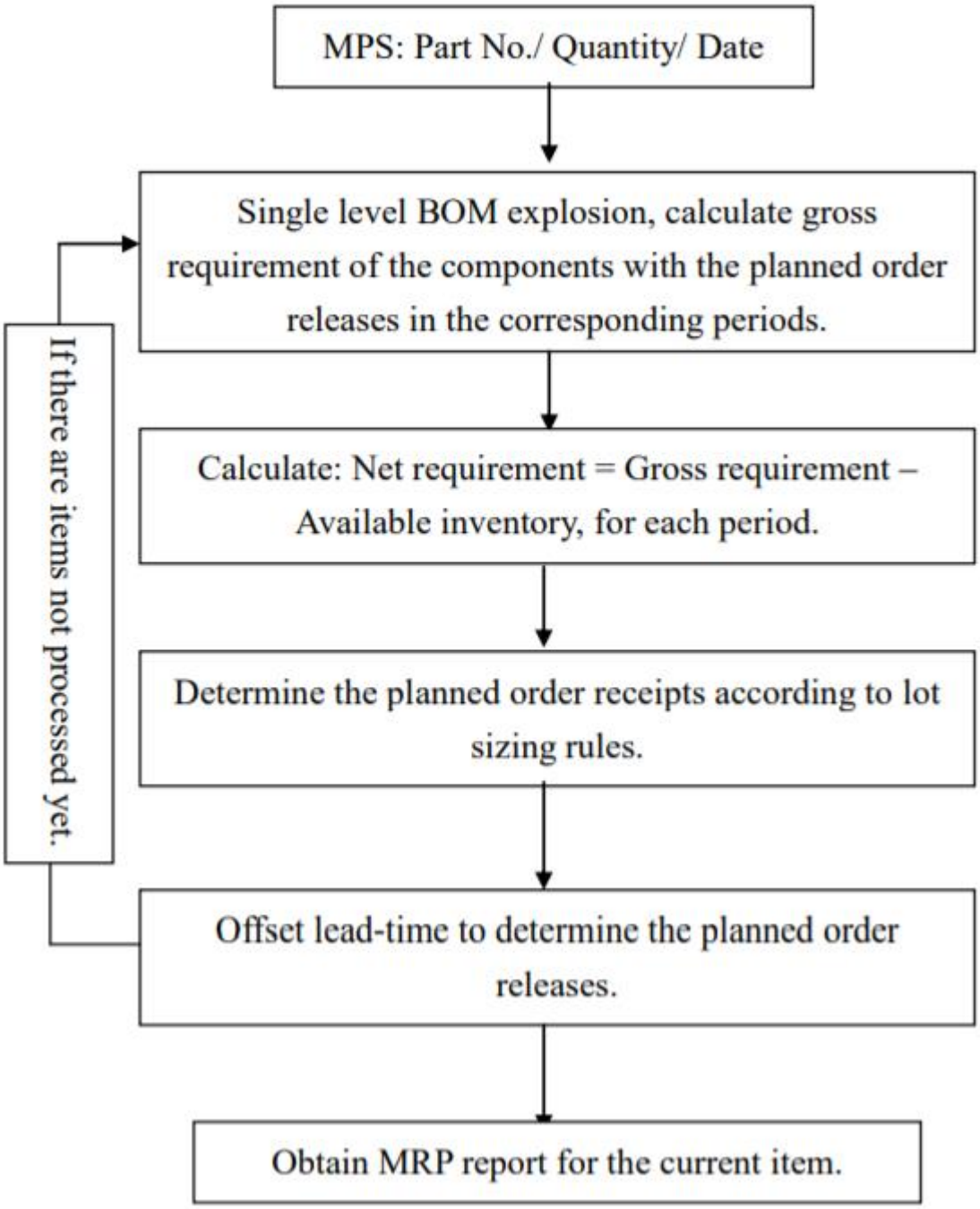


Fig 4.4: MRP Procedure

The net requirement in a period is determined in MRP procedure by the following formula,
Net requirement = Gross requirement – Available inventory

The available inventory for the first period is
Available inventory = On hand inventory + Scheduled receipts of the first period – Allocations – Backorders – Safety stock.

And, for the other periods
Available inventory = Projected available balance at the end of last period + Scheduled receipts of the current period

If the calculated net requirement is positive, then it is the net requirement of that item in that period. In this case, the projected on-hand balance at the end of that period is less than the safety stock, and the projected available balance is the projected on-hand balance plus the planned order receipt in that period. If the calculated net requirement is negative, then it is the projected available balance at the end of that period.

Activity	Months												Brief activity description (% in parenthesis represent pertition of the total manpower effort)
	1	2	3	4	5	6	7	8	9	10	11	12	
Assessment of the present situation													Includes all activities associated with description and modeling of business practice with respect to inventory management, ordering of materials, and manufacturing planning. (20 %)
Production Scheduling													Formalization of production scheduling procedures. (15 %)
Design BOM													Design and implementation of the Bills of Materials into company's information system*. (15%)
Design of MRP/MRPII processes and system.													Includes the design of the MRPII system (often this may be based on adapting commercial software to company specifics). (30%)
Design of MRP/MRPII system interfaces													MRP should link with other organizational information resources (i.e., ERP system). (10%)
Test and evaluation													Assessment of system before it is introduced in the workplace. Often this activity feedbacks to Design. (10%)

Fig 4.5: Process model for implementing MRP

*If the company lacks information system implementation then generic model of implementation should be modified. Often in cases in which the company starts from zero MRP comes as part of an integrated information system platform (such as SAP) and implementation is associated with extensive reengineering of business processes.

MRPII implementation is broader and likely to incorporate components that are not confined to production planning and scheduling. However, tasks listed above are present in MRPII implementation; effort may increase but percentages may not change.

Material attributes	Product characteristics		
	Make to stock (high demand profile products)	Make to order (low demand profile products with high setup cost)	Assemble to order (low demand profile products with low setup cost)
Just-in-Time high demand high value steady consumption close cooperation with supplier short delivery	MRP system should exhibit Just in Time performance characteristics. Use cost and time measures.		
Reorder point high demand medium value varying consumption close cooperation with supplier short delivery			
MRP high demand medium value varying consumption long delivery			
EOQ* low value steady consumption			

*Economic Order Quantity

Fig 4.7: Tool for defining MRP performance metrics.

Let us examine a MRP case.

MRP Case: Sunglasses Sets

Suppose a goggle sunglasses set is illustrated as in Figure 4.8.

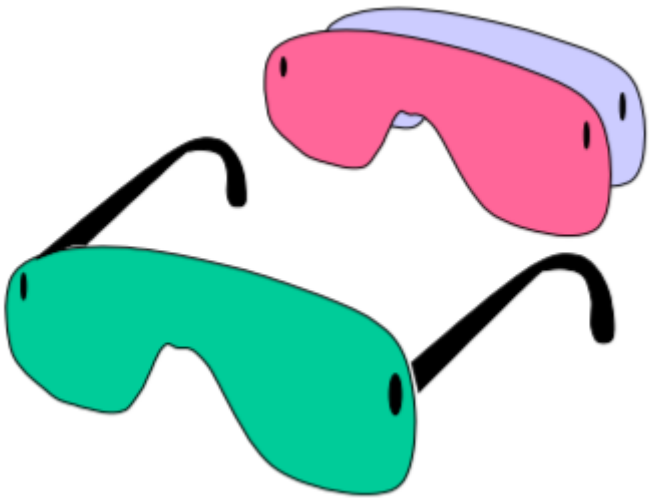


Fig 4.8: Sunglasses Set

In the end product, two temples are assembled to a single-piece lens to make a pair of sunglasses. Two spare lenses are sold along with the sunglasses. They are put in a plastic bag to form a sunglasses set. We ignore the plastic bag in the end product. The item master file is shown in Table 4.2.

Table 4.2: Item Master File of the Sunglasses Set

P_No	Name	LLC	LT	On-hand
A	Sunglasses set	0	1	5
B	sunglasses	1	1	40
C	lens	2	2	0
D	temple	2	3	50

In Figure 4.9, the quantities of the components required by per parent are expressed in the parentheses. For example, a sunglasses set is made of a pair of sunglasses and two lenses, and a pair of sunglasses is made of a lens and two temples. The data structure in a BOM file is shown in Table 4.3.

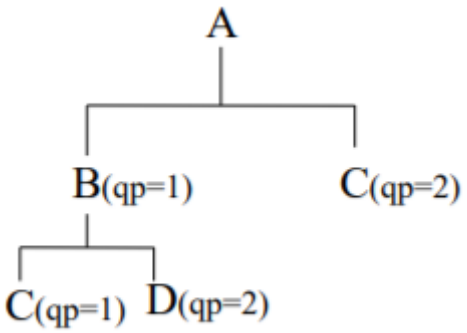


Fig 4.9: Product Structure for Sunglasses Set

Table 4.3: BOM File

Parent	Component	Qty-per
A	B	1
A	C	2
B	C	1
B	D	2

The requirements of the sunglasses set are shown in Table 4.4. The scheduled receipts for lenses and temples are shown in Table 4.5.

Table 4.4: Independent Demand for Sunglasses Sets

Period	1	2	3	4	5	6	7	8
A		40			50			50

Table 4.5: Schedule Receipts for Lenses and Temples

Period	1	2	3	4	5	6	7	8
C	100							
D		50						

The MPS/MRP procedure starts from the items with zero low level code, i.e., the end products. The calculations of MRP from the top level end product to the lowest level materials are shown in Table 4.6 to Table 4.9, and the summary of the MRP results is shown in Table 4.10.

Table 4.6: MPS Calculation for A

Period		1	2	3	4	5	6	7	8
GR			40			50			50
SR									
NR	5	-5	35			50			50
POR		35			50			50	

Table 4.7: MRP Calculation for B

Period		1	2	3	4	5	6	7	8
GR		35			50			50	
SR									
NR	40	-5	-5	45			50		50
POR				45			50		

Table 4.8: MRP Calculation for C

Period		1	2	3	4	5	6	7	8
GR		70		45	100		50	100	
SR		100							
NR	0	-30	-30	15	100		50	100	
POR		15	100		50	100			

Table 4.9: MRP Calculation for D

Period		1	2	3	4	5	6	7	8
GR				90			100		
SR			50						
NR	50	-50	-100	-10	-10	-10	90		
POR				90					

Table 4.10: Summarized MRP Report

P_No	source	1	2	3	4	5	6	7	8
A	make	35			50			50	
B	make			45			50		
C	purchase	15	100		50	100			
D	purchase			90					

ENTERPRISE RESOURCE PLANNING

An Enterprise resource planning system is a fully integrated business management system covering functional areas of an enterprise like Logistics, Production, Finance, Accounting and Human Resources. It organizes and integrates operation processes and information flows to make optimum use of resources such as men, material, money and machine.

Enterprise resource planning promises

- one database,
- one application,
- one user interface

for the entire enterprise, where once disparate systems ruled manufacturing, distribution, finance and sales.

Evolution of ERP

ERP systems evolved out of MRP and MRP II systems. MRP systems addressed the single task of materials requirements planning. MRP II extended the scope to the entire manufacturing function. The manufacturing industry traditionally had a better climate to use computers. First of all the manufacturing community being dominated by engineers had no computer phobia. Second the extensive use of Computer Aided Drafting (CAD), Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) had prepared the manufacturing function to use computers well, in fact exceptionally well. In fact manufacturing engineers contributed significantly to the theoretical computer science by way of contributions in the areas of graphics, computational geometry, significant visualization, feature recognition etc.

Large corporations like General Motors (GM), Ford, Hewlett Packard (HP), and Digital primarily viewed themselves as manufacturing companies until the 1980s. Naturally complex MRP systems were considered the ultimate in enterprise information systems. The investments in hardware and software to manage such complex manufacturing solutions gave these systems a visibility unparalleled in the industry. Compared to these systems accounting systems, financial systems or personnel information systems were relatively inconsequential to the organization.

With the globalization of operations and the proliferation of computer networks, it was important that the manufacturing organizations extend their information system across the supply chain. The supplier's information system spread across continents with complex combinations of hardware and software need to be integrated. Similarly the dealer-distributor network had to be integrated with the manufacturing information systems. The reduction in product life cycle necessitated a quick response manufacturing system that had its ears tuned to the market.

This forced manufacturing information systems to have a tighter integration with marketing information systems. The manufacturing flexibility had translated into mass customization calling for further integration of information systems. The opening up of several world economies including that of the Asian giants like China and India, the emergence of trade blocks and consolidated markets such as European Union paved the need for accounting and finance functions to be tightly integrated with manufacturing functions. It was not sufficient anymore just to manufacture and sell but organizations had to arrange for finance, comply with complex trade restrictions, barriers, and quotas.

The balance sheets needed to account for multiple currencies, multiple export import rules and regulations, multiple accounting codes, practices, accounting periods. This necessitated further integration of accounting and financial information systems with manufacturing systems. In fact with large capacities built around the world particularly in Asian countries, outsourcing and contract manufacturing became viable alternative even in the high-tech industries like semi conductor manufacturing.

Suddenly the need was for an Enterprise Information System that looks beyond the manufacturing function to address inbound logistics, outbound logistics, manufacturing, materials managements, project management, quality management, accounting, finance, sales and personnel management. It was nearly impossible to integrate individual modules of information systems. What was necessary was a system that addressed the enterprise needs from the design stage. ERP systems were the natural choice in this changed scenario.

Scope of ERP

Enterprise Resource Planning (ERP) is a modular and robust system designed for small-sized, mid-sized & large-sized enterprises. It supports inventory, purchasing, supply chain, sales and material management, quality, research and finance, human resource, production and service functions.

ERP software indeed covers the complete business operating functional range.

Manufacturing: It means manufacturing and production process such as such as scheduling, planning and tracking supplies, parts and products before, throughout the production and after the manufacturing procedure.

Managing: It means the entire management of the organization such as purchasing, HR, financials, IT, quality and other things the organization do. The information should be conveyed at the right time in a correct form to facilitate the suggested correct decision-making by directors, managers, and executives of the enterprise.

Selling & Delivery: This segment manages the entire process from marketing, quoting, estimating, engaging and ordering products and services. It ensures to timely deliveries of good supplies and a profitable sale of products.

Servicing to customers: Offering satisfied and proper customer services is significant to future relations and sales of the enterprises. To get a complete feedback for your customers, knowing your product and how it is fulfilling the needs of the customers in the market means expanding the life span of your relationships with your customer.

It helps the company to control the day-to-day activities, makes easier the processes and provides better coordination amongst all the segments of the organization. Although all the modules are the essential to the existence of an ERP but manufacturing module is the main and important module. It provides various benefits to the businesses.

Below is a list of the significant areas where an ERP is vastly in use:

- Manufacturing and Production

  Manufacturing Process, Cost Management, Scheduling, Engineering, Bills of Material, Capacity, Work flow Management, Quality Control, Manufacturing Projects etc.

- Supply Chain Management

  Purchasing, Supply Chain Planning, Order Entry, Product Configuration, Inventory, Supplier Scheduling, Inspection of goods, Commission Calculation and many more.

- Financials

  Cash Management, General Ledger, Accounts Receivable & Payable, Fixed Assets and many more.

- Projects

  Costing, Billing, Time and Expense, Activity Management

- Human Resources (HR) management

  Payroll, Training, Human Resources,Attendance & Time, other Benefits etc.

- CRM management (Customer Relationship Management)

  Service, Sales and Marketing, Customer Contact, Commissions, and Call Center support etc.

- Data Warehouse management

Several Self-Service interfaces for Suppliers, Employees and Customers etc.

Thus, ERP software in the modern time fulfills all the business requirements of all sized Free Articles, typed business organizations.

Fig 4.10: ERP FUNCTION

Benefits of ERP:

(a) Business integration: The first and the most important advantage lie in the promotion of integration. The reason ERP packages are called integrated is the automatic data up gradation between related business components, since conventional company information systems were aimed at the optimization of independent business functions in business units, almost all were weak in terms of the communication and integration of information that transcended the different business functions in the case of large companies in particular, the timing of system structure and directives differs from each product and department / functions and sometimes they are disconnected. For this reason, it has become an obstacle in the shift to new product and business classification. In the case of ERP packages the data of related business functions is also automatically updated at the time a transaction occurs. For this reason, one is able to grasp business details in real time, and carry out various types of management decisions in a timely manner based o that information.

(b) Flexibility: The second advantage of ERP packages is their flexibility. Diverse multi functional environments such as language, currency, accounting standards and so on are covered in one system and functions that comprehensively managed multiple locations that span a company are packaged and can be implemented automatically. To cope with company globalization and system unification, this flexibility is essential, and one could say that it has major advantages, not simply for development and maintenance, but also in terms of management.

(c) Better analysis and planning capabilities: Yet another advantage is the boosting of planning type functions. By enabling the comprehensive and unified management of related business and its data, it becomes possible to fully utilize many types of decision support systems and stimulation systems. Furthermore, since it becomes possible to carry out flexibility and in real time the feeling and analysis of data from a variety of dimensions, one is able to give decision makers the information they want, thus enabling them to make better and informed decisions.

(d) Use of latest technology: The fourth advantage is the utilization of latest developments in information technology (IT). The ERP vendors were very quick to realize that in order to grow and to sustain that growth: they have to embrace the latest developments in the field of information technology. So they quickly adopted their systems to take advantages of the latest technologies like open systems, client server technology, internet/ intranet, computer aided acquisition and logistics support, electronic commerce etc. It is this quick adaptation to the latest changes in information technology that makes the flexible adaptation to changes to

future business environments possible. It is this flexibility that makes the incorporation of the latest technology possible during the system customization, maintenance and expansion phases.

(e) Reduced inventory and inventory carrying cost: The manufacturing nature of many ERP users makes the issue of process and material costs savings paramount. The main factor behind these savings is that implementation of the ERP system allows customers to obtain information on cost, revenues and margins, which allow it to better, manage its overall material cost structure. This ability to manage costs is best seen in savings that organizations can obtain in their inventory systems. Customers can perform a more complete inventory planning and status checking with the ERP system. These checks and plans reveal existing surpluses or shortages in supplies. Improved planning and scheduling practices typically lead to inventory reductions to the order of 20 per cent or better. This provides not only a one time reduction in assets (cost of the material stocked), but also provides ongoing savings of the inventory carrying costs. The cost of carrying inventory includes not only interest but also the costs of warehousing, handling, obsolescence, insurance, taxes, damage and shrinkage.

(f) Reduced manpower cost: Improved manufacturing practices lead to fever shortages and interruptions and to less rework and overtime. Typical labor savings from a successful ERP system are a 10 per cent reduction in direct and indirect labor costs. By minimizing rush jobs and parts shortages, less time is needed for expediting, material handling, extra setups, disruptions and tracking splits lots odd jobs that have been set aside. Production supervisors have better visibility of required work and can adjust capacity or loads to meet schedules. Supervisors have more time for managing, directing and training people. Production personnel have more time to develop better methods and improve quality.

(g) Reduced material costs: Improves procurement practices lead to better vendor negotiations for prices, typically resulting in cost reductions of 5 per cent or better. Valid schedules permit purchasing people to focus on vendor negotiations and quality improvements rather than spending their time on shortages and getting material at premium prices. ERP systems provide negotiation information, such as projected material requirements by commodity group and vendor performance statistics. Giving suppliers better visibility of future requirements help them achieve efficiencies that can be passed on as lower material costs.

(h) Improves sales and customer service: Improved coordination of sales and production leads to better customer service and increased sales. Improvements in managing customer contacts, making and meeting delivery promises, and shorter order to ship lead times, lead to

higher customer satisfaction, goodwill and repeat orders. Sales people can focus on selling instead of verifying or apologizing for late deliveries. In custom product environment, configurations can be quickly identified and prices, often by sales personnel or even the customer rather than the technical staff. Taken together, these improvements in customer service can lead to fewer lost sales and actual increase in sales, typically 10 per cent or more. ERP systems also provide the ability to react to changes in demand and to diagnose delivery problems. Corrective actions can be taken early such as determining shipment priorities, notifying customers of changes to promise delivery dates, or altering production schedules to satisfy demand.

(i) Efficient financial management: Improves collection procedures can reduce the number of days of outstanding receivables, thereby providing additional available cash. Underlying these improvements is fast, accurate invoice creation directly from shipment transactions, timely customer statements and follows through on delinquent accounts. Credit checking during order entry and improved handling of customer inquires further reduces the number of problem accounts. Improved credit management and receivable practices typically reduce the days of outstanding receivables by 18 per cent or better. Trade credit can also be maximized by taking advantage by supplier discounts and cash planning, and paying only those invoices with matching recipients. This can lead to lower requirements for cash-on hand.

The benefits from ERP come in three different forms i.e. in the short-term, medium-term and long-term. When initially implemented, in a year of the organization going live with ERP, it helps in streamlining the operational areas such as purchase, production, inventory control, finance and accounts, maintenance, quality control, sales and distribution, etc. This benefit is in form of ‘automating’ the transactions which promises accuracy, reliability, availability and consistency of data.

Applications of ERP

Inventory management: Also known as material management, inventory modules help with measuring stock targets, standardizing replenishments, and tracking items in your organization with serial numbers.

Purchasing: These modules manage procurement processes and work closely with inventory and SCM modules.

Sales and Marketing: These modules handle sales workflows, ranging from inquiries and quotes to sales orders and invoicing. With more advanced implementations, it’s also possible

to track shipments and integrate tax rules. This works closely with CRM modules to speed the sales cycle to generate more profit.

Manufacturing: Also referred to as Production or Engineering, this module aims to make manufacturing more efficient. It features product planning and forecasting, daily production monitoring, and more. It is integrated with SCM and inventory modules.

Financial management: This module manages capital, allowing you to more easily see the money coming into and going out of the business. It addresses standard accounting transactions including expenditures, balance sheet, tax management, bank reconciliation and more. It can also generate financial reports for any department.

Customer relationship management (CRM): This module aims to improve customer service and profit per capita. It manages leads, customer issues, and customer opportunities. In an ERP setup, it works closely with the sales module to speed up conversions.

Supply chain management (SCM): This module addresses your supply chain, including areas such as purchase order management, process automation, and production flow from production to consumer, and back again in the case of recalls or returns.

Human resource management (HRM): This addresses your staff and includes things like time sheets, employee records, performance reviews, payroll systems, and job profiles.

Automated reporting: These modules work with others to make reporting easy across all departments. Staff will no longer spend time pulling reports from each system.

Business intelligence (BI): These modules make it easier to use business intelligence to make data-driven decisions for the future of the company. Typically, you'll only find BI modules in large ERP packages.

Project Management: This module connects project activities with company financials to make it easy to report on the success or failure of projects. Use it to see how well you're working on completing projects on time and on budget.

Compliance monitoring: This module works to make sure your business stays in compliance with industry regulations. It addresses compliance with local law, security measures, and documentation requirements.

IT optimization: This module works to optimize your IT structure, to keep systems running smoothly.

Asset management: This module aims to manage your physical assets, such as your building, manufacturing equipment, and more.

E-commerce: This module integrates management of multiple online sales channels with other areas of your ERP.

Fig 4.11: ERP Applications

ERP Case : International Airport Services

When an aircraft arrives at an international airport, a towing tractor marshals the aircraft to an indicated gate. Ramp services and cabin services are proceeded during the period when the aircraft stays. Ramp services include the toilet cleaning, gas refueling, etc. Cabin services include catering load, garbage dumping, etc. Figure 4.12 is a simplified aircraft services flow chart.

Fig 4.12: Simplified Aircraft Services

Since the times for the aircraft arrival and departure are scheduled, the marshaling services must be performed at predetermined times. The other services can be scheduled between the earliest start time (EST) and the latest start time (LST) as shown in Figure 4.13.

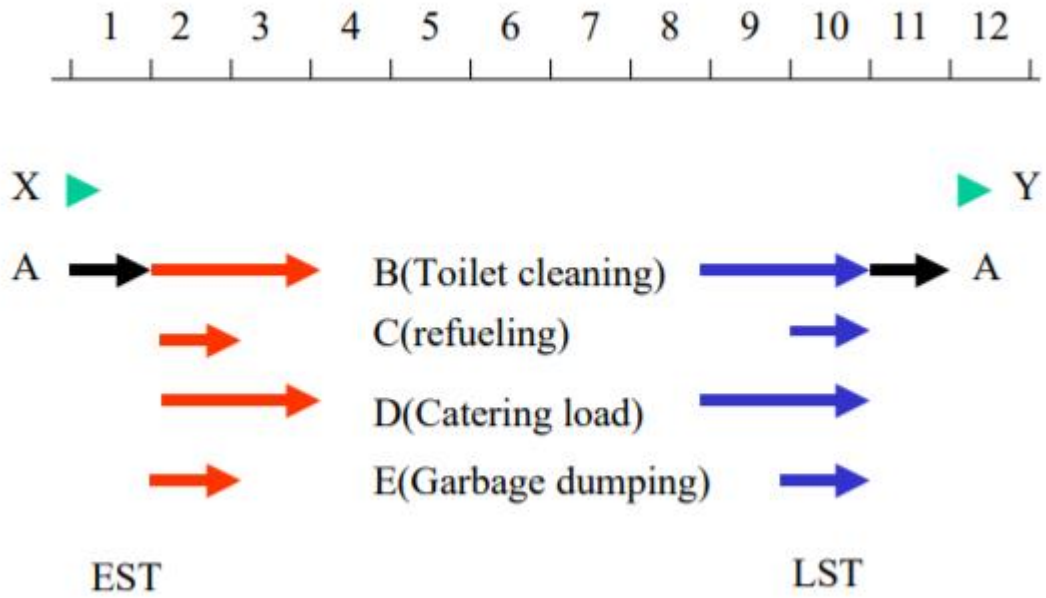


Fig 4.13: Scheduling of Airport Services

As item master files in the manufacturing, we now create a “service master file” shown in Table 4.2.

Table 4.2: Service Master File of Airport Services

Service Number	Service Name	Service Time	Phantom
X	Arrival	0	y
Y	Departure	0	y
A	Marshaling	1	n
B	Toilet cleaning	2	n
C	Refueling	1	n
D	Catering load	2	n
E	Garbage dumping	1	n

The structure of the services is shown in Figure 4.14. Since the service-time of a service means its duration, we have to count the loads of the resources in all time buckets from the start to the end of services. For example, the toilet cleaning service lasts two time units, its service-time is set as 2 in the service master file, and two records are defined in the “bill of service” file with offset-time (OT) 1 and 2. The quantity-per (QP) defined in bill of service file is the load of the service. The quantity-per of the toilet cleaning service is 2, which means two lavatory trucks are needed during the service. The offset-time and the quantity-per determine that two lavatory trucks are required during a period of two consecutive time buckets. Note that the service times in the service master file are used to create the offset-times in the BOM file, and the lead-times used by MRP are all zero.

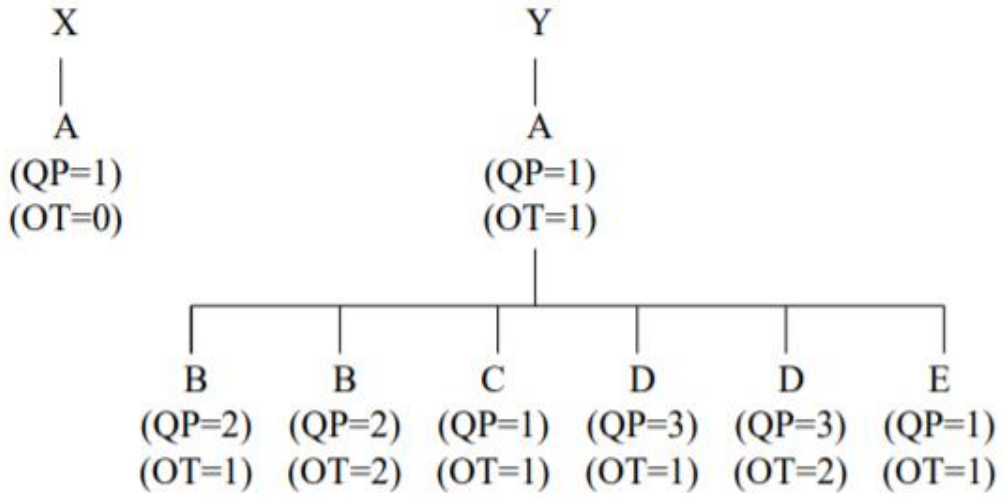


Fig 4.14: Service Structure for Airport Services

The data structure of the bill of service file is shown in Table 4.3.

Table 4.3: Bill of Service File

Parent	Component	Qty-per	Offset-time
X	A	1	0
Y	A	1	1
A	B	2	1
A	B	2	2
A	C	1	1
A	D	3	1
A	D	3	2
A	E	1	1

Suppose a certain aircraft is scheduled to arrive at time 1 and depart at time 12, the schedule is stated similar to MPS in the manufacturing cases, now we name it the master service schedule (MSS), as shown in Table 4.4.

Table 4.4: MSS for aircraft arrival and departure

Time	1	2	3	4	5	6	7	8	9	10	11	12
X	1											
Y												1

Services have neither inventories nor scheduled receipts as in the cases of manufacturing. Services must be provided at the moment when customers use it. In the MRP calculation procedure, gross requirements are the services that customers need. Since there is no on-hand or on-order inventory, the net requirement equals the gross requirement. Only two rows remain in the MRP reports. MRP is now renamed as “service requirement planning”, and the rows are named “required” and “scheduled”. The MRP procedure is described in Table 4.5.

In table 4.5, the scheduled service of A in time 1 required by X should not be exploded further. This can be done with a field of X-A record in the BOM file indicating no further explosion. The above example is for a single aircraft. The system will schedule all the flights in MSS, then use MRP procedure to calculate all the services required. The service requirements are scheduled by MRP at the latest start time. The system also calculates the

EST schedule. Schedules are then adjusted manually or automatically between EST and LST to balance the load and capacity.

Table 4.5: Service Requirement Planning for Airport Services

P_No	time	1	2	3	4	5	6	7	8	9	10	11	12
X	Req	1											
	Schl	1											
Y	Req												1
	Schl												1
A	Req	1											1
	Schl	1										1	
B	Req											4	
	Schl									2	2		
C	Req											1	
	Schl										1		
D	Req											6	
	Schl									3	3		
E	Req											1	
	Schl										1		

This example explains how ERP is used in a service business. Time buckets are sliced as small as the minimal unit a service requires. All service times are multiple of the time bucket length. Lead-times are all set to 0 because the start time of the parent operation is exactly the end time of the child operation, or differs by 1, which can be controlled by offset-time. The service time determines how many time buckets are needed by an operation. An operation repeats, as a child item, the required time buckets times, say n, with offset-time from 1 to n in each BOM record. The service requirement planning uses the same functions of item master, BOM, MPS, and MRP in the ERP system. The idea can also be applied to manufacturing operations.

INDUSTRIAL APPLICATIONS

Applications of Material Requirement Planning

- Purchase orders
- Sales orders
- Shortage of materials
- Expedited orders
- Due dates
- Forecasts
- Marketplace demand
- Material
- Inventory
- Data
- Bill of material

Applications of Enterprise Requirement Planning

- Quotes
- Job costing
- Sales
- Orders
- Controlling stock
- Purchasing
- Manufacturing
- Invoicing

TUTORIAL QUESTIONS

1. What is resource requirement planning and what are the steps involved in resource requirement planning?
2. What is Material requirement planning, its objectives?
3. Explain MRP system
4. What is manufacturing resource planning and explain with a flow chart?
5. Give the definitions of different terms used in MRP system?
6. What are the inputs and outputs of a MRP system?
7. Explain the computational procedure of MRP system with a case study.
8. Explain about Enterprise Resource Planning.
9. What are the benefits and applications of Enterprise Resource planning?
10. Explain ERP with a case study.

QUESTION BANK

1. Briefly explain the steps involved in materials requirement planning.
2. How do you prepare the production plan? Explain with a suitable example.
3. Explain the various stages of manufacturing resource planning with suitable diagram.
4. Discuss the different inputs and outputs of materials planning in an organisation.
5. Explain about Enterprise resource planning scope, benefits and applications.

UNIT – V

STORES MANAGEMENT AND MATERIALS HANDLING

Course Objective: To understand management of stores and material handling in an organization.

Course Outcome: To understand the significance of managing stores and material handling.

NO OF LECTURE HOURS: 10

LECTURE	LECTURE TOPIC	KEY ELEMENTS	LEARNING OBJECTIVES (2 to 3 objectives)
1.	Stores Management – Nature of stores	Responsibilities of stores and objectives of stores management	Understanding of stores management
2.	Store Layout	Layout of a store	Design of floor space of a store
3.	Stock verification and classification	Methods of stock verification and classification of items	Learning of stock verification
4.	Codification	Techniques of inventory control	Familiarize with stock inventory control
5.	Safety stock Inventory control	Inputs and outputs for MRP system	Understanding inputs required and outputs attained from MRP system

6.	Material Handling	Objectives and Principles of Material Handling	Importance of material handling in an organization
7.	Factors effecting selection of material handling equipment, selection and design of material handling system	Selection of material handling equipment	Able to select and design material handling system
8.	Material Handling Equipment's	Types of Material Handling Equipment's	Acquaint with different types of Material Handling Equipment's
9.	Relation between Material handling and plant layout, evaluation of material handling system	Procedure to evaluate material handling system	Understanding of relation between Material handling and plant layout
10.	Safety in material handling	Safety procedures while handling	Understanding of safety procedures in material handling

STORES MANAGEMENT

Nature of Stores

Store is an important component of material management since it is a place that keeps the materials in a way by which the materials are well accounted for, are maintained safe, and are available at the time of requirement. Storage is an essential and most vital part of the economic cycle and store management is a specialized function, which can contribute significantly to the overall efficiency and effectiveness of the materials function. Literally store refers to the place where materials are kept under custody.

A professionally managed Stores has a process and a space within, to receive the incoming materials (Receiving Bay), keep them for as long as they are not required for use (Custody) and then to move them out of stores for use (Issue).

In a manufacturing firm this process forms a cycle to maintain and run the activities of Stores.

The basic responsibilities of stores are to act as custodian and controlling agent for parts, supplies, and materials, and to provide service to users of those goods.

Typically a store has a few processes and a space for storage. The main processes (Fig 5.1) of store are

(i) to receive the incoming materials (receiving),

(ii) (ii) to keep the materials as long as they are required for use (keeping in custody), and

(iii) (iii) to move them out of store for use (issuing). The auxiliary process of store is the stock control also known as inventory control.

In a manufacturing organization, this process of receiving, keeping in custody, and issuing forms a cyclic process which runs on a continuous basis. The organizational set up of the store depends upon the requirements of the organization and is to be tailor made to meet the specific needs of the organization.

Fig 5.1: Main Process of a store

Store is to follow certain activities which are managed through use of various resources. Store management is concerned with ensuring that all the activities involved in storekeeping and stock control are carried out efficiently and economically by the store personnel. In many cases this also encompasses the recruitment, selection, induction and the training of store personnel, and much more.

The basic responsibilities of store are to act as custodian and controlling agent for the materials to be stored, and to provide service to users of these materials. Proper management of store systems provide flexibility to absorb the shock variation in demand, and enable purchasing to plan ahead.
Since the materials have a cost , the organization is to manage the materials in store in such a way so that the total cost of maintaining materials remains optimum.
Store needs a secured space for storage. It needs a proper layout along with handling and material movement facilities such as cranes, forklifts etc, for safe and systematic handling as well as stocking of the materials in the store with an easy traceability and access. It is to maintain all documents of materials that are able to trace an item , show all its details and preserve it up to its shelf life in the manner prescribed or till it is issued for use. Store is to preserve the stored materials and carry out their conservation as needed to prevent deterioration in their qualities. Also store is to ensure the safety of all items and materials whilst in the store which means protecting them from pilferage, theft, damage, deterioration, and fire.

The task of storekeeping relates to safe custody and preservation of the materials stocked, to their receipts, issue and accounting. The objective is to efficiently and economically provide the right materials at the time when it is required and in the condition in which it is required. The basic job of the store is to receive the materials and act as a caretaker of the materials and issue them as and when they are needed for the activity of the organization.
Once the material has been received and cleared through inspection and accepted for use, it needs safe custody of the stores. The role of custody is to receive and preserve the material. A stage comes when the material is needed for use. Store at that time releases the material from its custody to the user department and the process is called ‘issue of goods. It might also happen that after partial use , some materials having useable value in future are returned to the store and thus they also become part of the custody again.
Storekeeping activity does not add any value to the materials. In fact it adds only to the cost. The organization is to spend money on space (expenditure on land, building passage and roads), machinery (store equipment), facilities (e.g. water, electricity, communication etc.), personnel, insurance, maintenance of store equipment, stationary etc. All of these get added to the organizational overheads and finally get reflected in the costing of the finished product. However, it is an essential function in any organization.

Objectives of store management

An efficient stores management has normally the following main objectives.

- To ensure uninterrupted supply of materials without delay to various users of the organization.
- To prevent overstocking and under stocking of the materials
- To ensure safe handling of materials and prevent their damage.
- To protect materials from pilferage, theft, fire and other risks
- To minimize the cost of storage
- To ensure proper and continuous control over the materials.
- To ensure most effective utilization of available storage space
- To optimize the efficiency of the personnel engaged in the store

Stores Layout

Store layout is the design of a store's floor space and the placement of items within that store. It depends on the following factors:

1. Flow of Materials:

According to this factor, materials should move minimum possible distances.

2. Character of Materials:

The materials that are not damaged by weather can be stored outside in shed.

Materials like cement, plaster etc., must be placed in dry place. Tools and machines etc., should also be placed in dry places and coated to prevent rusting.

3. Quantity, Weight etc. of Materials:

It is necessary to find the space required for different purposes.

4. Frequency of Handling:

Handling consists of the following four stages:

(a) Receipts,

(b) Inspection,

(c) Storage and

(d) Issue of materials.

The following are general hints to carry out these stages of handling smoothly and correctly:

1. Layout is such that material may be quickly received in stores.

2. Unloading platforms are built of suitable height.

3. All around the stores there is thorough siding. If trucks are used for transporting the materials, sufficient parking space is provided.

4. For heavy material, suitable equipment for internal transport is provided.

5. It is to be seen that each section of the store has sufficient allotting space. The material is to be arranged in such a way that inward and outward movement of supplies can be carried out smoothly.

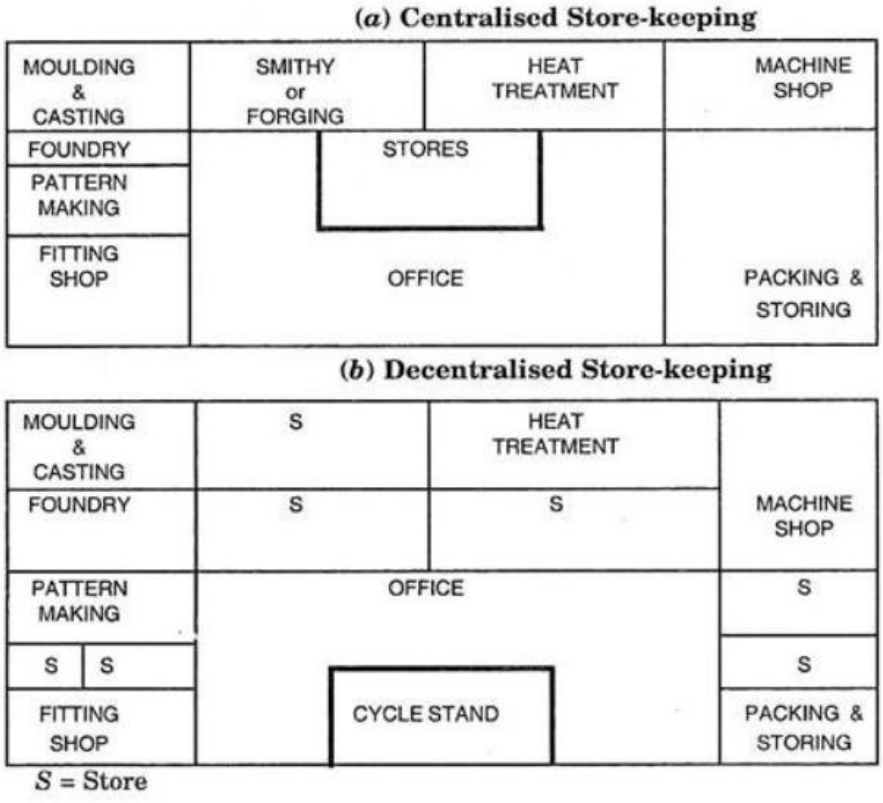


Fig 5.2: Types of store keeping

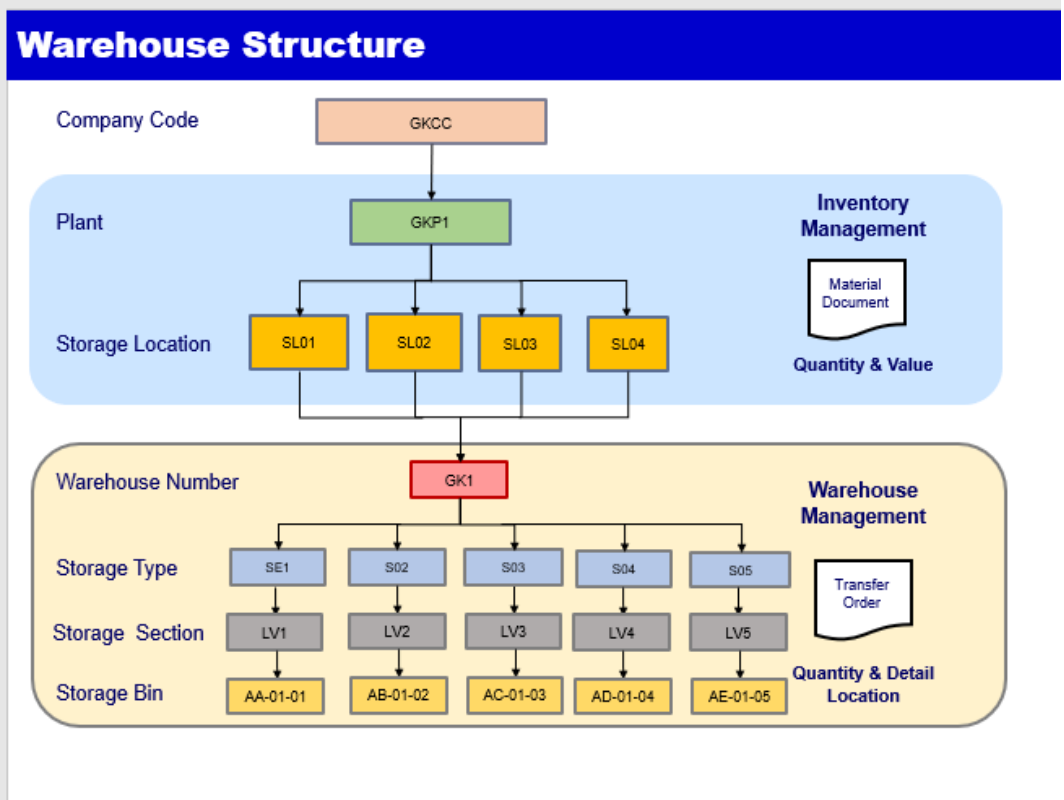


Fig 5.3: Sample warehouse structure

Stock Verification

It is the process of physically counting, measuring or weighting the entire range of items in the stores and recording the results in a systematic manner.

Physical stock verification which involves actual counting, measuring, weighing of all items in stock is necessary for the following four reasons:

(a) To support the value of stock shown in the balance sheet through physical verification;

(b) To verify the accuracy of stock records;

(c) To disclose the possibility of fraud, theft or loss, or deterioration; and

(d) To reveal the weakness of the system, if any (i.e., whether the stock is in safe custody).

Methods of Stock Verification:

There are three methods of stock verification.

These are:

(i) Periodic stock verification

(ii) Perpetual or Continuous stock verification

(iii) Blind stock taking.

(i) Periodic verification:

Under this method the whole of the stock is covered at the same time at the end of a financial year. This can be done only in a small organisation. But this method does not suit big industrial organisations, since complete stoppage of work for several days is not possible just for the purpose of stock taking.

(ii) Perpetual verification:

Under this method physical stock verification is spread throughout the year according to a predetermined programme. And each item is physically examined at least once a year. Four main advantages of perpetual verification are:

- During physical verification neither the stores nor the works are to be closed.
- The normal stores transaction and posting can continue without interrup-tions.
- Surpluses and shortages arising from time to time can be written-off after proper investigation.
- The job of stock verification can be done on time.

(iii) Blind verification:

Under this system the stock verifiers are given the location, but not details about code numbers, description and stock record balances. The underlying logic here is that the verifier will not have his own idea about the stock position and he may just mention the same figures in record without actual verifi-cation of stock.

This method is not very popular. It virtually serves no purpose when the entire operation of stores has to be well-planned. The modern trend is toward the applica-tion of the ABC technique for stock verification.

Classification and Codification

Good store-keeping requires proper classification and codification of various items stored in stock. . Proper classification and codification offer several advantages such as:

1. Systematic grouping of similar items for correct identification of each and every item.
2. The usage of long descriptions is simplified and possible confusion avoided.
3. Avoids duplicate stocks of the same item being held under different names, descriptions, brand names, part number and different stores.
4. Enables reduction in sizes and varieties.
5. Helps in standardization of materials and helps in finding substitutes

6. Can be used as a basic for setting up different stores.

7. To arrange bin cards and records in stores, accounts and inventory control sections in the same uniform manner.

8. Ensures accuracy in correspondence, records and posting of receipts and issues in appropriate records.

Principles of Classification and Codification

The following principles should be observed while establishing an effective classification and codification system:

I. There must be a consistency in the point of view so that, the basis of classification should remain unchanged for all items.

II. The system of classification must cover the entire range of items for which, it is devised and at the same time, allow reasonable scope for extension. This principle is that of comprehensiveness.

III. The third principle is that of mutual exclusiveness which means, that there must be only one code number possible for any item.

IV. The system developed should be simple enough to be understood and easily adopted by the non-specialist personnel. This also means that the codification basis when once understood, the code numbers should be self-explanatory to a certain possible extent.

Methods of Classification and Codification

Stores are generally classified on the basis of their nature or usage, the former being the most common method used. Based on nature, stores are classified into specific groups as shown below:

* Raw materials
* Components
* Consumable stores
* Spare parts
* Tools
* Packing materials
* Work-in-process
* Finished goods
* Hardware.
* Motors
* Gearbox
* CKD Completely knocked down items.

Codification

It is one of the functions of stores management. Codification is a process of representing each item by a number, the digit of which indicates the group, the sub-group, the type and the dimension of the item. Many organizations in the public and private sectors, railways have their own system of codification, varying from eight to thirteen digits. The first two digits represents the major groups, such as raw materials, spare parts, sub-contracted items, hardware items, packing material, tools, oil, stationery etc. The next two digits indicate the sub-groups, such as, ferrous, non-ferrous etc. Dimensional characteristics of length, width, head diameter etc. constitute further three digits and the last digit is reserved for minor variations.

Whatever may be the basis, each code should uniquely represent one item. It should be simple and capable of being understood by all. Codification should be compact, concise, consistent and flexible enough to accommodate new items. The groupings should be logical, holding similar parts near to one another. Each digit must be significant enough to represent some characteristic of the item.

Objectives of Codification

The objectives of a rationalized material coding system are:

1. Bringing all items together.
2. To enable putting up of any future item in its proper place.
3. To classify an item according to its characteristics.
4. To give an unique code number to each item to avoid duplication and ambiguity.
5. To reveal excessive variety and promote standardization and variety reduction.
6. To establish a common language for the identification of an item.
7. To fix essential parameters for specifying an item.
8. To specify item as per national and international standards.
9. To enable data processing and analysis.

Advantages of Codification

As a result of rationalized codification, many firms have reduced the number of items. It enables systematic grouping of similar items and avoids confusion caused by long description of items since standardization of names is achieved through codification, it serves as the starting point of simplification and standardization. It helps in avoiding duplication of items and results in the minimisation of the number of items, leading to accurate record. Codification enables easy recognition of an item in stores, thereby reducing clerical efforts to the minimum. If items are coded according to the sources, it is possible to bulk the items

while ordering. To maximise the aforesaid advantages, it is necessary to develop the codes as concerned, namely, personnel from design, production, engineering, inspection, maintenance and materials.

Safety stock inventory control

Inventory generally refers to the materials in stock. It is also called the idle resource of an enterprise. Inventories represent those items which are either stocked for sale or they are in the process of manufacturing or they are in the form of materials, which are yet to be utilised. The interval between receiving the purchased parts and transforming them into final products varies from industries to industries depending upon the cycle time of manufacture. It is, therefore, necessary to hold inventories of various kinds to act as a buffer between supply and demand for efficient operation of the system. Thus, an effective control on inventory is a must for smooth and efficient running of the production cycle with least interruptions.

Reasons for Keeping Inventories

1. **To stabilise production:** The demand for an item fluctuates because of the number of factors, *e.g.*, seasonality, production schedule etc. The inventories (raw materials and components) should be made available to the production as per the demand failing which results in stock out and the production stoppage takes place for want of materials. Hence, the inventory is kept to take care of this fluctuation so that the production is smooth.
2. **To take advantage of price discounts:** Usually the manufacturers offer discount for bulk buying and to gain this price advantage the materials are bought in bulk even though it is not required immediately. Thus, inventory is maintained to gain economy in purchasing.
3. **To meet the demand during the replenishment period:** The lead time for procurement of materials depends upon many factors like location of the source, demand supply condition, etc. So inventory is maintained to meet the demand during the procurement (replenishment) period.
4. **To prevent loss of orders (sales):** In this competitive scenario, one has to meet the delivery schedules at 100 per cent service level, means they cannot afford to miss the delivery schedule which may result in loss of sales. To avoid the organizations have to maintain inventory.
5. **To keep pace with changing market conditions:** The organizations have to anticipate the changing market sentiments and they have to stock materials in anticipation of non-availability

of materials or sudden increase in prices.

6. Sometimes the organizations have to stock materials due to other reasons like suppliers minimum quantity condition, seasonal availability of materials or sudden increase in prices.

Meaning of Inventory Control

Inventory control is a planned approach of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales. Inventory control basically deals with two problems:

(i) When should an order be placed? (Order level), and (ii) How much should be ordered? (Order quantity).

These questions are answered by the use of inventory models. The scientific inventory control system strikes the balance between the loss due to non-availability of an item and cost of carrying the stock of an item. Scientific inventory control aims at maintaining optimum level of stock of goods required by the company at minimum cost to the company.

Objectives of Inventory Control

1. To ensure adequate supply of products to customer and avoid shortages as far as possible.
2. To make sure that the financial investment in inventories is minimum (i.e., to see that the working capital is blocked to the minimum possible extent).
3. Efficient purchasing, storing, consumption and accounting for materials is an important objective.
4. To maintain timely record of inventories of all the items and to maintain the stock within the desired limits.
5. To ensure timely action for replenishment.
6. To provide a reserve stock for variations in lead times of delivery of materials.
7. To provide a scientific base for both short-term and long-term planning of materials.

Benefits of Inventory Control

It is an established fact that through the practice of scientific inventory control, following are the benefits of inventory control:

1. Improvement in customer’s relationship because of the timely delivery of goods and service.
2. Smooth and uninterrupted production and, hence, no stock out.
3. Efficient utilisation of working capital. Helps in minimising loss due to deterioration, obsolescence damage and pilferage.
4. Economy in purchasing.

5. Eliminates the possibility of duplicate ordering.

Techniques of Inventory Control

In any organization, depending on the type of business, inventory is maintained. When the number of items in inventory is large and then large amount of money is needed to create such inventory, it becomes the concern of the management to have a proper control over its ordering, procurement, maintenance and consumption. The control can be for order quality and order frequency.

The different techniques of inventory control are: (1) ABC analysis, (2) HML analysis, (3) VED analysis, (4) FSN analysis, (5) SDE analysis, (6) GOLF analysis and (7) SOS analysis.

The most widely used method of inventory control is known as ABC analysis. In this technique, the total inventory is categorised into three sub-heads and then proper exercise is exercised for each sub-heads.

1. **ABC analysis:** In this analysis, the classification of existing inventory is based on annual consumption and the annual value of the items. Hence we obtain the quantity of inventory item consumed during the year and multiply it by unit cost to obtain annual usage cost. The items are then arranged in the descending order of such annual usage cost. The analysis is carried out by drawing a graph based on the cumulative number of items and cumulative usage of consumption cost. Classification is done as follows:

Category	*Percentage of items*	*Percentage of annual consumption value*
A	10–20	70–80
B	20–30	10–25
C	60–70	5–15

Fig 5.4: Classification of items

The classification of ABC analysis is shown by the graph as follows:

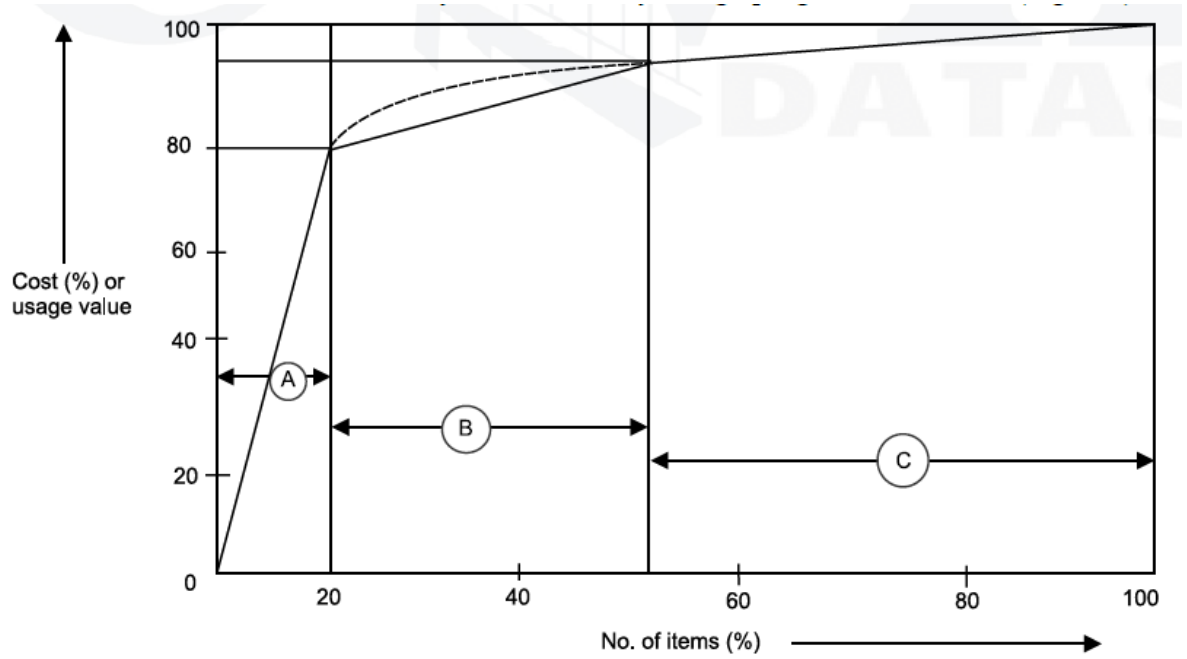


Fig 5.4: ABC Classification

Once ABC classification has been achieved, the policy control can be formulated as follows:

A-Item: Very tight control, the items being of high value. The control need be exercised at higher level of authority.

B-Item: Moderate control, the items being of moderate value. The control need be exercised at middle level of authority.

C-Item: The items being of low value, the control can be exercised at gross root level of authority, *i.e*., by respective user department managers.

2. **HML analysis:** In this analysis, the classification of existing inventory is based on unit price of the items. They are classified as high price, medium price and low cost items.

3. **VED analysis:** In this analysis, the classification of existing inventory is based on criticality of the items. They are classified as vital, essential and desirable items. It is mainly used in spare parts inventory.

4. **FSN analysis:** In this analysis, the classification of existing inventory is based consumption of the items. They are classified as fast moving, slow moving and non-moving items.

5. **SDE analysis:** In this analysis, the classification of existing inventory is based on the items.

6. **GOLF analysis:** In this analysis, the classification of existing inventory is based sources

of the items. They are classified as Government supply, ordinarily available, local availability and foreign source of supply items.

7. **SOS analysis:** In this analysis, the classification of existing inventory is based nature of supply of items. They are classified as seasonal and off-seasonal items.

For effective inventory control, combination of the techniques of ABC with VED or ABC with HML or VED with HML analysis is practically used.

MATERIAL HANDLING

Haynes defines ***"Material handling embraces the basic operations in connection with the movement of bulk, packaged and individual products in a semi-solid or solid state by means of gravity manually or power-actuated equipment and within the limits of individual producing, fabricating, processing or service establishment".***

Material handling does not add any value to the product but adds to the cost of the product and hence it will cost the customer more. So the handling should be kept at minimum. Material handling in Indian industries accounts for nearly 40% of the cost of production. Out of the total time spent for manufacturing a product, 20% of the time is utilised for actual processing on them while the remaining 80% of the time is spent in moving from one place to another, waiting for the processing. Poor material handling may result in delays leading to idling of equipment.

Materials handling can be also defined as ***'the function dealing with the preparation, placing and positioning of materials to facilitate their movement or storage'*.** Material handling is the art and science involving the movement, handling and storage of materials during different stages of manufacturing. Thus the function includes every consideration of the product except the actual processing operation. In many cases, the handling is also included as an integral part of the process. Through scientific material handling considerable reduction in the cost as well as in the production cycle time can be achieved.

Objectives of Material Handling

Following are the objectives of material handling:

1. Minimise cost of material handling.
2. Minimise delays and interruptions by making available the materials at the point of use at right quantity and at right time.

3. Increase the productive capacity of the production facilities by effective utilisation of capacity and enhancing productivity.
4. Safety in material handling through improvement in working condition.
5. Maximum utilisation of material handling equipment.
6. Prevention of damages to materials.
7. Lower investment in process inventory.

Principles of Material Handling

Following are the principles of material handling:

1. **Planning principle:** All handling activities should be planned.
2. **Systems principle:** Plan a system integrating as many handling activities as possible and co-ordinating the full scope of operations (receiving, storage, production, inspection, packing, warehousing, supply and transportation).
3. **Space utilisation principle:** Make optimum use of cubic space.
4. **Unit load principle:** Increase quantity, size, weight of load handled.
5. **Gravity principle:** Utilise gravity to move a material wherever practicable.
6. **Material flow principle:** Plan an operation sequence and equipment arrangement to optimise material flow.
7. **Simplification principle:** Reduce combine or eliminate unnecessary movement and/or equipment.
8. **Safety principle:** Provide for safe handling methods and equipment.
9. **Mechanisation principle:** Use mechanical or automated material handling equipment.
10. **Standardisation principle:** Standardise method, types, size of material handling equipment.
11. **Flexibility principle:** Use methods and equipment that can perform a variety of task and applications.
12. **Equipment selection principle:** Consider all aspect of material, move and method to be utilised.
13. **Dead weight principle:** Reduce the ratio of dead weight to pay load in mobile equipment.
14. **Motion principle:** Equipment designed to transport material should be kept in motion.
15. **Idle time principle:** Reduce idle time/unproductive time of both MH equipment and man power.
16. **Maintenance principle:** Plan for preventive maintenance or scheduled repair of all

handling equipment.

17. **Obsolescence principle:** Replace obsolete handling methods/equipment when more efficient method/equipment will improve operation.

18. **Capacity principle:** Use handling equipment to help achieve its full capacity.

19. **Control principle:** Use material handling equipment to improve production control, inventory control and other handling.

20. **Performance principle:** Determine efficiency of handling performance in terms of cost per unit handled which is the primary criterion.

Factors Affecting Selection of Material Handling Equipment

Selection of Material Handling equipment is an important decision as it affects both cost and efficiency of handling system. The following factors are to be taken into account while selecting material handling equipment.

1. Properties of the material

Whether it is solid, liquid or gas, and in what size, shape and weight it is to be moved, are important considerations and can already lead to a preliminary elimination from the range of available equipment under review. Similarly, if a material is fragile, corrosive or toxic this will imply that certain handling methods and containers will be preferable to others.

2. Layout and characteristics of the building

Another restricting factor is the availability of space for handling. Low-level ceiling may preclude the use of hoists or cranes, and the presence of supporting columns in awkward places can limit the size of the material-handling equipment. If the building is multi-storeyed, chutes or ramps for industrial trucks may be used. Layout itself will indicate the type of production operation (continuous, intermittent, fixed position or group) and can indicate some items of equipment that will be more suitable than others. Floor capacity also helps in selecting the best material handling equipment.

3. Production flow

If the flow is fairly constant between two fixed positions that are not likely to change, fixed equipment such as conveyors or chutes can be successfully used. If, on the other hand, the flow is not constant and the direction changes occasionally from one point to another because several products are being produced simultaneously, moving equipment such as trucks would be preferable.

4. Cost considerations

This is one of the most important considerations. The above factors can help to narrow the range of suitable equipment, while costing can help in taking a final decision. Several cost elements need to be taken into consideration when comparisons are made between various items of equipment that are all capable of handling the same load. Initial investment and operating and maintenance costs are the major cost to be considered. By calculating and comparing the total cost for each of the items of equipment under consideration, a more rational decision can be reached on the most appropriate choice.

5. Nature of operations

Selection of equipment also depends on nature of operations like whether handling is temporary or permanent, whether the flow is continuous or intermittent and material flow pattern-vertical or horizontal.

6. Engineering factors

Selection of equipment also depends on engineering factors like door and ceiling dimensions, floor space, floor conditions and structural strength.

7. Equipment reliability

Reliability of the equipment and supplier reputation and the after sale service also plays an important role in selecting material handling equipments.

Selection and design of handling system

Materials handling systems are expensive to purchase and operate. The expenses are those of initial costs, labor cost for operating the material handling equipments and maintenance and repair costs. The indirect expenses are those resulting from damaged or lost materials, delays in material deliveries and accidents. Since these expenses are quite substantial, greater attention of management is needed to the design and selection of materials handling systems.

Since the pattern of flow of material in a plant definitely affects the materials handling costs, it is vital that the design and layout of buildings must be integrated with the design of the materials-handling system. Hence, the selection and design of the materials handling system should be done along with the development of the layout as each one affects the other.

For example, if overhead cranes are to be used, the structure of the building must be strong enough to support the operation of these services. If heavy loads are to be transported on

trucks, floors must have adequate support to withstand these loads. Aisles or gangways must be wide enough to accommodate fork lift trucks that will travel through the areas carrying the loads. Adequate floor space has to be provided in the layout for fixed position handling devices such as conveyors.

Steps to be followed in the selection and design of materials handling systems are:

1. Identification of the appropriate systems.
2. Review of design criteria and objectives of the handling system.
3. Collection of data regarding flow pattern and flow requirements.
4. Identification of activity relationships between departments.
5. Determination of space requirement and establishment of material flow pattern.
6. Analysis of material and building characteristics.
7. Preliminary selection of basic handling system and generation of alternative systems considering feasibility of mechanization and equipment capabilities.
8. Evaluation of alternatives with respect to optimal material flow, utilizing gravity, minimum cost, flexibility, ease of maintenance and capacity utilization.
9. Selection of the best suitable alternative system and checking it for compatibility with the layout.
10. Specification of the system.
11. Procurement of the equipment and installation of the system.

Material Handing Equipments

Broadly material handling equipment's can be classified into two categories, namely:

(a) Fixed path equipments, and (*b*) Variable path equipments.

(*a*) *Fixed path equipments* which move in a fixed path. Conveyors, monorail devices, chutes and pulley drive equipments belong to this category. A slight variation in this category is provided by the overhead crane, which though restricted, can move materials in any manner within a restricted area by virtue of its design. Overhead cranes have a very good range in terms of hauling tonnage and are used for handling bulky raw materials, stacking and at times palletizing.

(*b*) *Variable path equipments* have no restrictions in the direction of movement although their size is a factor to be given due consideration trucks, forklifts mobile cranes and

industrial tractors belong to this category. Forklifts are available in many ranges, they are manoeuvrable and various attachments are provided to increase their versatility.
Material Handing Equipments may be classified in five major categories.

1. Conveyors

Conveyors are useful for moving material between two fixed workstations, either continuously or intermittently. They are mainly used for continuous or mass production operations—indeed, they are suitable for most operations where the flow is more or less steady. Conveyors may be of various types, with rollers, wheels or belts to help move the material along: these may be power-driven or may roll freely. The decision to provide conveyors must be taken with care, since they are usually costly to install; moreover, they are less flexible and, where two or more converge, it is necessary to coordinate the speeds at which the two conveyors move.

2. Industrial Trucks

Industrial trucks are more flexible in use than conveyors since they can move between various points and are not permanently fixed in one place. They are, therefore, most suitable for intermittent truck petrol-driven, electric, hand-powered, and so on. Their greatest advantage lies in the wide range of attachments available; these increase the trucks ability to handle various types and shapes of material.

3. Cranes and Hoists

The major advantage of cranes and hoists is that they can move heavy materials through overhead space. However, they can usually serve only a limited area. Here again, there are several types of crane and hoist, and within each type there are various loading capacities. Cranes and hoists may be used both for intermittent and for continuous production.

4. Containers

These are either ‘dead’ containers (*e.g*. Cartons, barrels, skids, pallets) which hold the material to be transported but do not move themselves, or ‘live’ containers (*e.g*. wagons, wheelbarrows or computer self-driven containers). Handling equipments of this kind can both contain and move the material, and is usually operated manually.

5. Robots

Many types of robot exist. They vary in size, and in function and manoeuvrability. While many robots are used for handling and transporting material, others are used to perform operations such as welding or spray painting. An advantage of robots is that they can perform

in a hostile environment such as unhealthy conditions or carry on arduous tasks such as the repetitive movement of heavy materials.

The choice of material-handling equipment among the various possibilities that exist is not easy. In several cases the same material may be handled by various types of equipments, and the great diversity of equipment and attachments available does not make the problem any easier.

In several cases, however, the nature of the material to be handled narrows the choice. Some of the material handling equipment are shown in below figs.

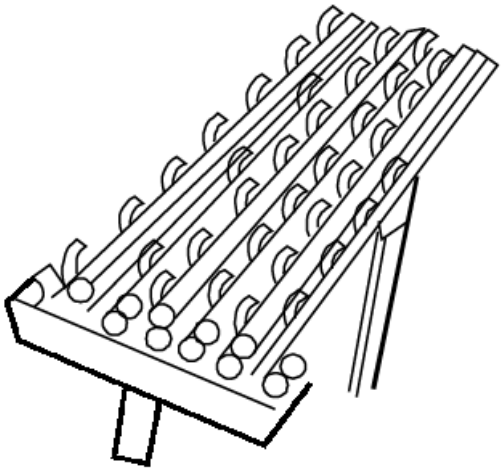


Fig 5.5 Wheel conveyor

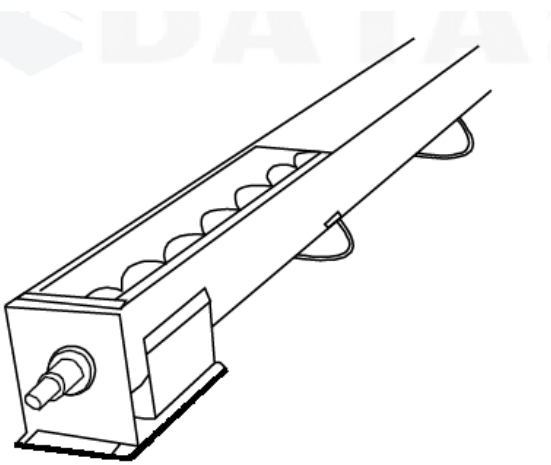


Fig 5.6 Screw conveyor

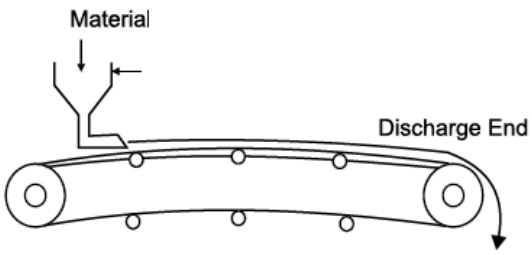


Fig 5.7 Belt conveyor

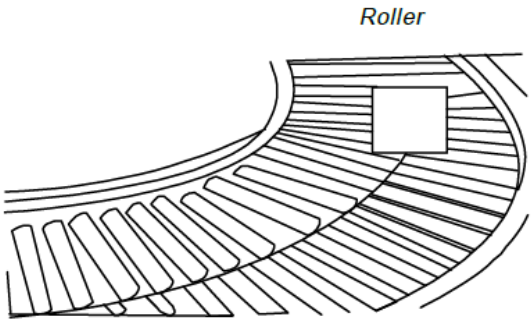


Fig 5.8 Roller conveyor

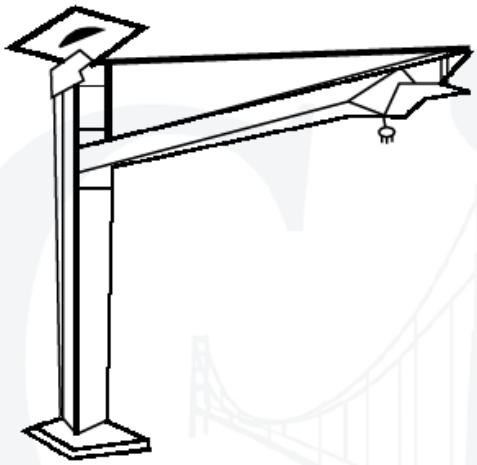


Fig 5.9 Jib Crane

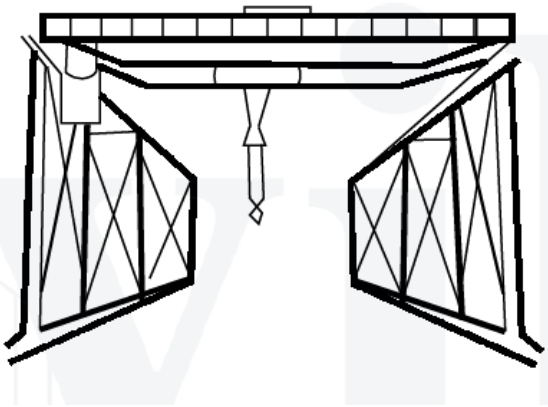


Fig 5.10 Bridge Crane

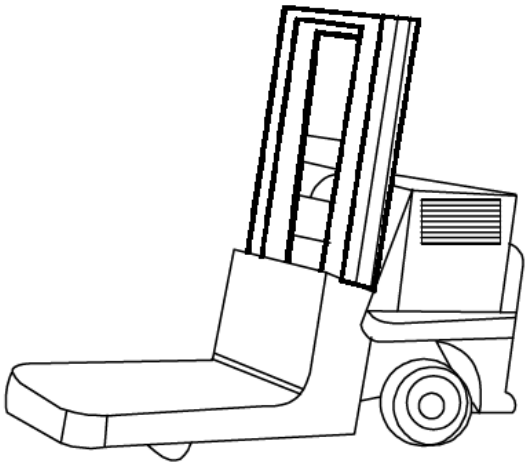


Fig 5.11 Platform Truck

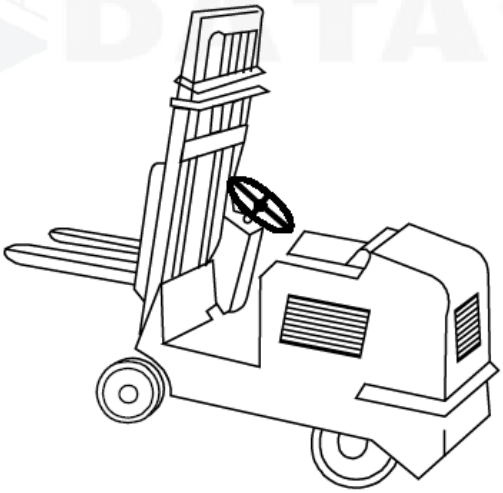


Fig 5.12 Fork Truck

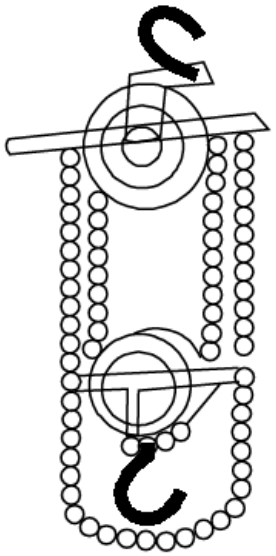


Fig 5.13 Chain Hoist

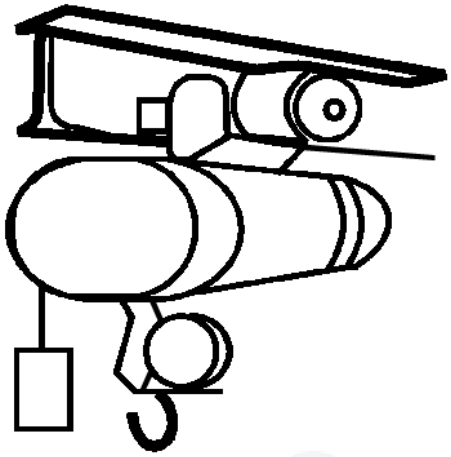


Fig 5.14 Electric Hoist

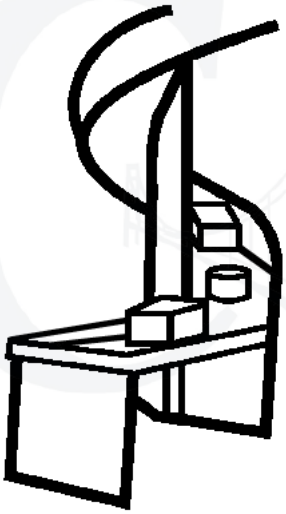


Fig 5.15 Spiral Chute

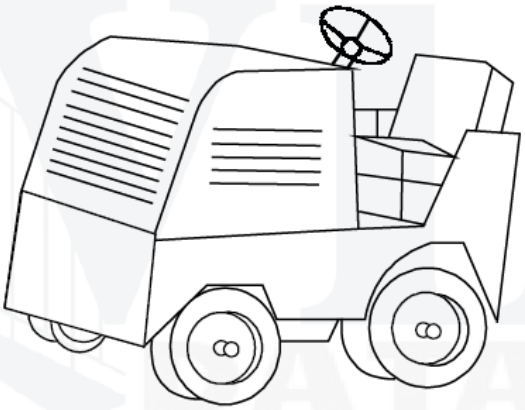


Fig 5.16 Industrial Tractor

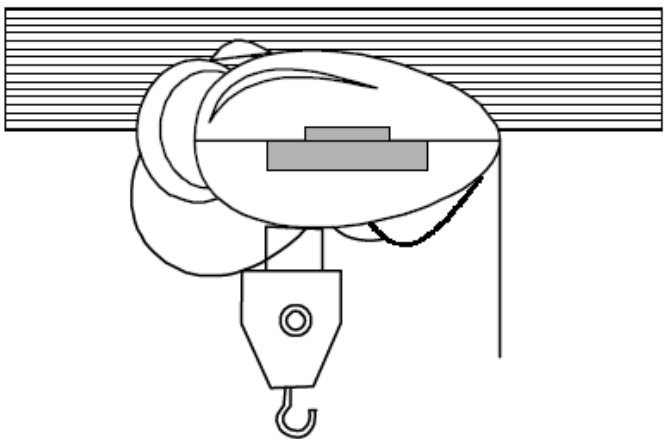


Fig 5.17 Electrical Hoist

Guidelines for effective utilisation of material handling equipments

The following guidelines are invaluable in the design and cost reduction of the materials handling system:

1. As material handling adds no value but increases the production cycle time, eliminate handling wherever possible. Ideally there should not be any handling at all!
2. Sequence the operations in logical manner so that handling is unidirectional and smooth.
3. Use gravity wherever possible as it results in conservation of power and fuel.
4. Standardise the handling equipments to the extent possible as it means interchangeable usage, better utilisation of handling equipments, and lesser spares holding.
5. Install a regular preventive maintenance programme for material handling equipments so that downtime is minimum.
6. In selection of handling equipments, criteria of versatility and adaptability must be the governing factor. This will ensure that investments in special purpose handling equipments are kept at a minimum.
7. Weight of unit load must be maximum so that each 'handling trip' is productive.
8. Work study aspects, such a elimination of unnecessary movements and combination of processes should be considered while installing a material handling system.
9. Non-productive operations in handling, such as slinging, loading, etc., should be kept at a minimum through appropriate design of handling equipment. Magnetic cranes for scrap movement and loading in furnaces combination of excavators and tippers for ores loading and unloading in mines are examples in this respect.
10. Location of stores should be as close as possible to the plant which uses the materials. This avoids handling and minimizing investment in material handling system.
11. Application of OR techniques such as queueing can be very effective in optimal utilisation of materials handling equipments.
12. A very important aspect in the design of a material handling system is the safety aspect. The system designed should be simple and safe to operate.
13. Avoid any wasteful movements-method study can be conducted for this purpose.
14. Ensure proper coordination through judicious selection of equipments and training of workmen.

Relationship between plant layout and material handling

There is a close relationship between plant layout and material handling. A good layout ensures minimum material handling and eliminates rehandling in the following ways:

1. Material movement does not add any value to the product so, the material handling should be kept at minimum though not avoid it. This is possible only through the systematic plant layout. Thus a good layout minimises handling.
2. The productive time of workers will go without production if they are required to travel long distance to get the material tools, etc. Thus a good layout ensures minimum travel for workman thus enhancing the production time and eliminating the hunting time and travelling time.
3. Space is an important criterion. Plant layout integrates all the movements of men, material through a well designed layout with material handling system.
4. Good plant layout helps in building efficient material handling system. It helps to keep material handling shorter, faster and economical. A good layout reduces the material backtracking, unnecessary workmen movement ensuring effectiveness in manufacturing. Thus a good layout always ensures minimum material handling.

Evaluation of material handling system

The cost factors include investment cost, labour cost, and anticipated service hours per year, utilization, and unit load carrying ability, loading and unloading characteristics, operating costs and the size requirements are the factors for evolution of material handling equipment. Other factors to be considered are source of power, conditions where the equipment has to operate and such other technical aspects. Therefore, choices of equipments in organisation will improve the material handling system through work study techniques. They usually result in improving the ratio of operating time to loading time through palletizing, avoiding duplicative movements, etc.

Obsolete handling systems can be replaced with more efficient equipments. The effectiveness of the material handling system can be measured in terms of the ratio of the time spent in the handling to the total time spent in production. This will cover the time element. The cost effectiveness can be measured by the expenses incurred per unit weight handled. It can be safely said that very few organisations try to collate the expenses and time in this manner so as to objectively view the performance and to take remedial measures. Some of the other indices which can be used for evaluating the performance of handling systems are listed below:

Equipment Utilisation Ratio

Equipment utilisation ratio is an important indicator for judging the materials handling system. This ratio can be computed and compared with similar firms or in the same over a period of time.

In order to know the total effort needed for moving materials, it may be necessary to compute **Materials Handling Labour (MHL) ratio**. This ratio is calculated as under:

MHL = Personnel assigned to materials handling / Total operating work force

In order to ascertain whether is the handling system delivers materials work centres with maximum efficiency, it is desirable to compute direct labour handling loss ratio. The ratio is:

DLHL = Materials handling time lost of labour / Total direct labour time

The movement's operations ratio which is calculated after dividing total number of moves by total number of productive operations indicates whether the workers are going through too many motions because of poor routing.

It should, however, be emphasized that the efficiency of materials handling mainly depends on the following factors:

(*i*) efficiency of handling methods employed for handling a unit weight through a unit distance,

(*ii*) efficiency of the layout which determines the distance through which the materials have to be handled,

(*iii*) utilisation of the handling facilities, and

(*iv*) efficiency of the speed of handling.

In conclusion, it can be said that an effective material handling system depends upon tailoring the layout and equipments to suit specific requirements. When a large volume has to be moved from a limited number of sources to a limited number of destinations the fixed path equipments like rollers, belt conveyors, overhead conveyors and gauntry cranes are preferred. For increased flexibility varied path equipments are preferred.

Safety in Material Handling

Materials handling is a form of logistics movement that includes any process that involves the movement between **vehicles, conveyors, store rooms, other forms of logistics support** where employees are involved to some extent.

The extent of employee involvement will vary by operation and may include manual, automated, and semi-automated material handling events. The safety keys outlined below a general guidance that would require tailoring for specific **materials and logistics** support scenarios.

An Effective Materials Handling Safety Policy

The foundation for a safe workplace starts with policies and procedures that senior management must put in place. A **comprehensive health and safety policy** would include the appropriate level of **guidelines on material handling** and the associated employee training program.

A key portion of the policy would be the safety compliance activity that is essential for the business to operate. Most importantly, the policy would inform on the **shared responsibilities** of each employee in keeping the workplace safe.

Safety Training for Materials Handling

There are employee safety risks involved with materials handling in distribution centers, warehouses, shop floors and loading docks. The mitigation of safety risks starts with **proper training** in **awareness**, **procedures** and **safety equipment**.

Safety training should be mandated for any new employees involved with **lifting, carrying, loading or transporting** materials in any form. In addition to new hire training, the safety

risks and potential safety compliance rules may require **re-certification** on an annual or other regular time cycle.

Materials Handling Safety Procedures

The day to day handing of materials continues free of accident or injury when safety procedures are **consistently followed.** Procedures start with awareness of the specific materials handling risks involved and the proper safety equipment for the situation. Procedures would cover the types of material, and the conditions of the work area.

Is the work area free of obstacles? Is there adequate lighting? Other procedures would cover the number of employees involved with specific handing events and the proper safety gear for the task.

Here's a list for **safely lifting and moving materials**:

- Maintain the correct posture: avoid bending over and keep lifts close to the body
- Lift in a careful, deliberate manner and avoid any sudden lift movements
- Never lift materials from a sitting position, or twist to pick up a heavy object
- Use the correct grip on objects; lifts should be shoulder high and with full grasp of the hands
- Get assistance from co-workers to avoid successive lifts of heavy objects
- Always make use of conveyors, slides or other devices, to avoid unnecessary lifting or pushing of objects
- Always go around a blocked pathway, never step over an obstacle while carrying material

- Maintain a clear line of site; objects should not block vision; lift only where there is sufficient lighting
- Whenever possible; reduce load sizes, adjust bulky objects to ease movement
- Regularly stretch back and leg muscles during the day and keep in good physical shape

These are useful if posted and/or included in safety training manuals and modules.

Knowing the Proper Safety Equipment to Use for Materials Handling – And Its Proper Use

Safety for materials handling gear means the proper fit and use of personal protection, to include, eye-protection, steel toed boots, other personal safety equipment.

Materials handling safety equipment included the proper tools should be used in moving material. This would include the proper use of loaders, conveyers, forklifts and other aids to safely move material.

A company's day to day operation and its customers are dependent on **efficient logistics**, and the employees involved must be trained and equipped to consistently work safely in meeting the materials handling requirements of the business.

Knowing the Proper Safety Equipment to Use for Materials Handling – And Its Proper Use

An safety plan for materials handling is part of an overall safety program for any organization that is involved in materials handling.

INDUSTRIAL APPLICATIONS

Applications of Stores Management

- Industrial Enterprises e.g. Mumias Sugar Company Ltd.,
- Trading Enterprises e.g. Uchumi Supermarket
- Service Enterprises e.g. Kenya Airways Ltd., (KQ)
- Multi-Activity Enterprises e.g. Tuskys Supermarket and Equity Bank Ltd – financial Services

Applications of Materials Handling

- Automobile
- 3PL (Third Party Logistics) Industry
- Manufacturing
- Building and Construction
- Healthcare and Pharma

TUTORIAL QUESTIONS

1. What is a store and responsibilities of a store?
2. What are objectives of store management?
3. Explain factors involved in design of store layout.
4. Explain different methods of stock verification?
5. Explain how goods are classified and principles.
6. Explain about codification, its objectives and advantages.
7. What are the reasons for keeping inventories?
8. What is inventory control, its objectives and benefits?
9. Explain different techniques of inventory control.
10. Explain ABC analysis.
11. What is material handling?
12. What are objectives and principles of material handling?
13. What are the Factors Affecting Selection of Material Handling Equipment?
14. How a handling system is selected and designed?
15. How are material handling equipments are classified?
16. Explain different material handling equipments.

17. Explain Guidelines for effective utilisation of material handling equipments.
18. Explain Relationship between plant layout and material handling.
19. How is a material handling system is evaluated and what is equipment utilization ratio?
20. What are the safety measures to be taken in material handling?

QUESTION BANK

1. Explain concept of material handling and Discuss Various material handling Equipments
2. Explain about codification with examples.
3. What are the Factors Affecting Selection of Material Handling Equipment?
4. What are different techniques of inventory control and explain about ABC analysis.
5. Explain Guidelines for effective utilisation of material handling equipments.
6. How is a material handling system is evaluated and what is equipment utilization ratio?