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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SPR1306 – PRODUCTION PLANNING AND CONTROL

COURSE MATERIAL

UNIT – I – SPR1306 - PRINCIPLES OF PPC

Introduction to PPC - Objectives and benefits of PPC - Organization for PPC - Factory planning Production Systems - Job, Batch and Mass production - Elements of Product development and design - Marketing, functional and operational aspects - Durability and dependability - Standardization, specialization and simplification – Break even analysis – Economics of a new design

I. PRINCIPLES OF PPC

PRODUCTION PLANNING AND CONTROL (PPC)

- It may be defined as the **direction and coordination** of the organizations materials and physical facilities towards the attainment of pre-specified goals in the most effective way.
- It is aimed at achieving **the efficient utilization of resources** (material, men, facility, etc.) in the manufacturing organization through planning, coordination and control of production activities that transform the raw material into finished products in a most optimal manner.
- PPC = production planning + production control

OBJECTIVES OF PPC

1. To determine the sequence of operations to continue production.
2. To design a production system to meet due date consistent with **minimum cost and quality** standard.
3. To systematically plan the production activities to achieve the **high production efficiency.**
4. To decide the nature and magnitude of different input factors to produce the output.
5. To ensure **maximum utilization of all resources**
6. To ensure production of **quality product**
7. To **coordinate** the different resources such as labour, machines, equipment etc. effectively and economically.
8. To maintain **optimum inventory levels**
9. To maintain flexibility in manufacturing operations
10. To coordinate production activities of various departments
11. To ensure Effective cost reduction and cost control
12. To plan for plant capacity for future requirements
13. To establish targets and checking them against performance
14. To ensure smooth flow of raw materials eliminating bottlenecks
15. To follow up production schedule to ensure delivery promises
16. To give authority to right person to do right job

BENEFITS OF PPC

- PPC coordinates all the phases of production / Operating system
- An efficient plan results in higher quality, better utilization of resources, reduced inventories, and better customer services.
- An efficient plan enables the firm to improve its sales turnover, market share and profitability.

LIMITATIONS OF PPC

- PPC function is based on certain assumptions or forecasts of customer's demand, Plant capacity, availability of materials etc
- Employee may resist change in production levels set as per production plans.
- This process is time consuming when we need to carry out routing and scheduling function for large products.
- This function becomes difficult when environmental factors changes rapidly.

Factors Determining the Nature of PPC Operations in a Manufacturing System

1. The number of operations, parts and sub-assemblies required to get the final product.
2. The nature and magnitude of variation in the capacity of different kinds of machines and equipment.
3. The size of orders and the production run.
4. The nature of the manufacturing system.

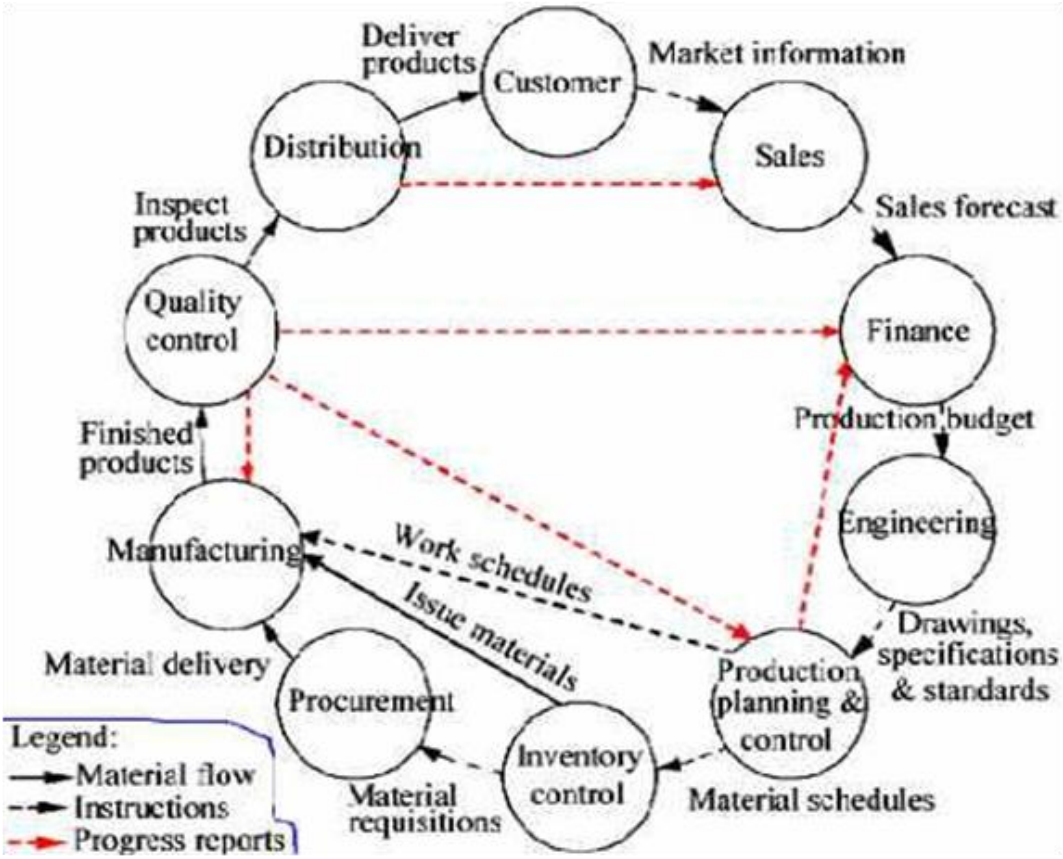

Fig.1.1: PPC Cycle

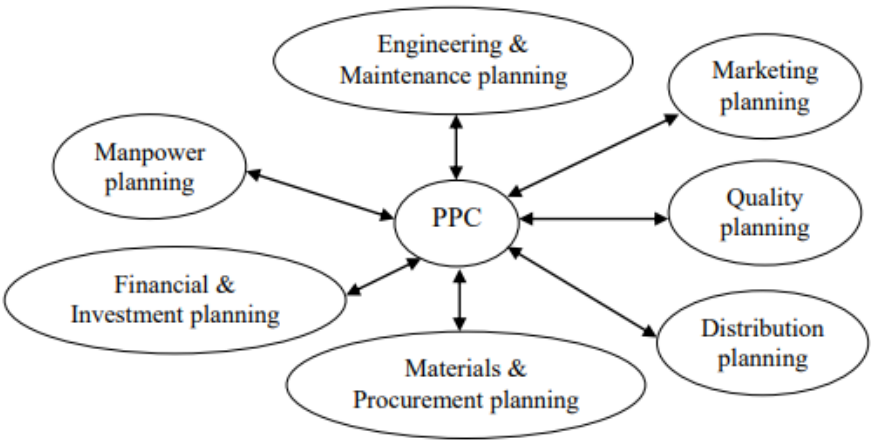

Fig. Relation of PPC with other functional departments

Fig.1.2: Relation of PPC with other departments

THREE PHASES OF PRO DUCTION PLANNING AND CONTROL ARE:

1. **Pre- planning phase**
    a. Product devel pment and design
    b. Process design
    c. Work-station d esign
    d. Sales forecasti ng
    e. Estimation
    f. Factory layout and location
    g. Equipment policy
    h. Pre-planning production
2. **Planning phase:** The choice from several alternatives of the be st utilizing the available resources to achieve th e desired objective
    a. Materials
    b. Methods
    c. Facilities, mac hines and manpower
    d. Routing
    e. Estimating
    f. Scheduling
3. **Control phase:** The monitoring of performance through a fee dback by comparing the results achieved with planned targets so that performance can be im proved
    a. Dispatching
    b. Inspection
    c. Expediting
    d. Evaluation

THE MAIN FUNCTIONS/ACTIVITIES OF PPC:

1. **Material planning:**
   Raw materials, standard parts and semi-finished products and assemblies needed at required time and place. It deals with fixation of material standards, batch quantities, de livery dates, reduction of varieties, procurement of parts and raw materials.

2. **Methods planning:**
   It identifies alternate methods of manufacturing, evaluates them and selects the best method compatible with a given set of circumstances and facilities. It covers the general study and selection of production process which in turn requires a series of decision making encompassing the theoretical feasibility of manufacturing the parts.

3. **Facilities planning:**
   Concerned with procurement of machines and equipment and specification of standard tools, design, and manufacture of special tools.

4. **Process planning (routing):** It is the process of determining sequence of operations to be performed in the production process.
   - What work will be done on a product.
   - Where these operations will be performed
   - In which sequence the job will move in the plant.
   - To fix the path of travel giving due consideration to layout.
   - To break down the operation into elements so as to define each operation in detail
   - To decide the setup time and process time for each operation.

5. **Estimation:**
   The operation time for each operation. Extensive use of operational analysis in conjunction with methods and routing as well as work measurement in order to set up performance standards.

6. **Scheduling:**
   It involves fixing priorities for each job and determining the starting time and finishing time for each operation, the starting dates and finishing dates for each part, sub-assembly and final assembly. It lays down a time table for production, indicating the total time required for the manufacture of a product and also time required for carrying out the operation for each part on each machine or equipment.

   Scheduling devices = Gantt charts, CPM and PERT, the runout approach

7. **Loading (fixing priorities):**
   It is the process of assigning specific jobs to machines, men or work centre's based on relative priorities and capacity utilization. It ensures maximum possible utilization of productive facilities and avoids bottlenecks in production.

8. **Dispatching (release of order) is the execution phase of planning:**
   Setting the production activities in motion through the release of orders and instructions in accordance with the previous planned time schedules and ratings

it authorizes the start of the production operations by releasing materials, components tools, fixtures and instruction sheets to the operator, and ensures that material movement is carried out in accordance to the planned routing sheets and schedules

9. **Expediting (follow up) is a control function that keeps track of the progress of work in accordance with the planned schedule:**
   It maintains the production flow according to plan till job is completed. This follow-up is to done at every stage in production cycle. Controlling variations or deviations from planned performance levels. Following up and monitoring progress of work through all stages of production. Modifying the production plans and preplan if necessary.

10. **Inspection and testing:**
    It ensures that the quality of the product meets the specifications as ordered or decided in the product development and design stage. Limitations are analyzed with a view to improve production methods/facilities.

11. **Evaluation:**
    It serves as a link between control and future planning. Valuable information regarding all the problems faced in realizing the product starting from pre-planning to shipping stages is gathered in this process. The information gathered can be used in preplanning, planning and control stages in future manufacturing activities

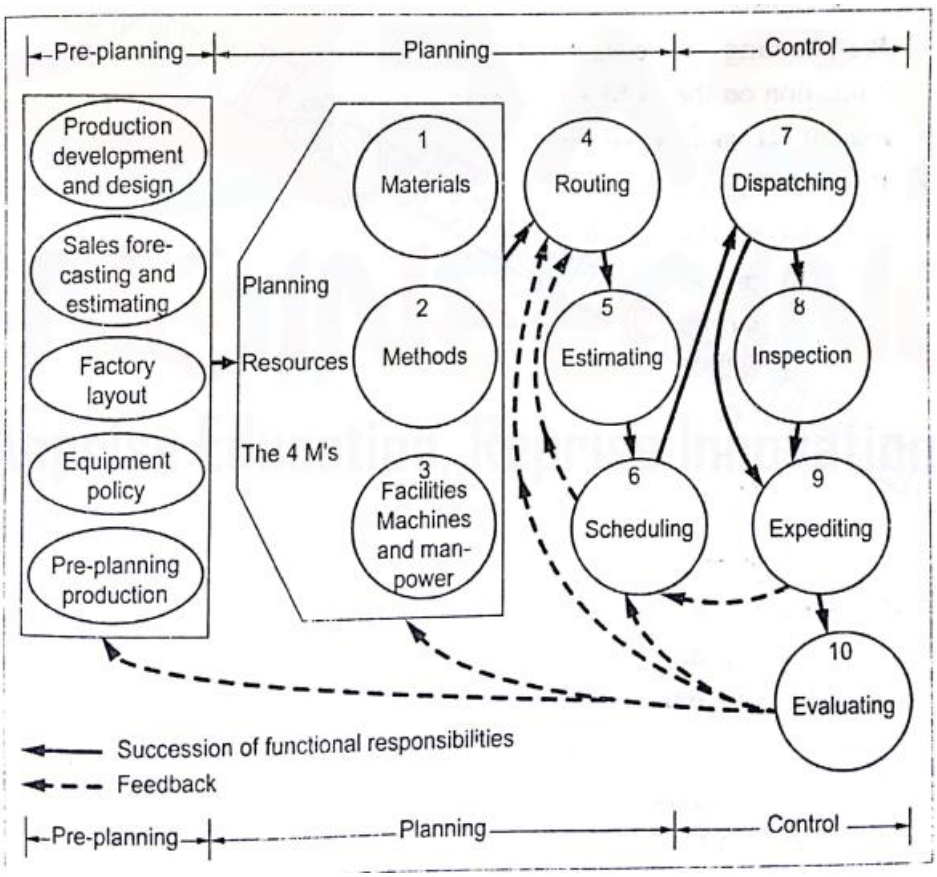

Fig.1.3: Functions of PPC

PRODUCTION PLANNING:

It is defined as the determination, acquisition and arrangement of all facilities necessary for futu re production of products.

- It involves manageme nt decision relating to how much to produce, what materials, part and tools will be required, what steps should be completed and how m uch work is to be done by each work station.
- It is a pre-production a ctivity.
- It is the pre determin ation of manufacturing requirements such as manpower, materials, machines and manufaccturing process.
- According to MikellP.Groover, production planning is concerned w ith.
    - Deciding whic h products to make, how many of each, and when they should be completed.
    - Scheduling the production and delivery of the parts and products
    - Planning the manpower and equipment resources nee ded to accomplish the production plan.

Levels of production planning

1. Factory planning
2. Process planning
3. Operation planning

Factors determining production planning

1. Volume of production
2. Nature of production p rocesses
3. Nature of operations

PRODUCTION CONTROL:

- It reviews the progress of the work and takes corrective steps in order to ensure that programmed productioon takes place.
- It involves implemen tation of production plans by coordinatin g different activities. It ensures that producti on operations and actual performance occur according to planned operations and performmance.

Steps in control process:

1. Initiating the productio n
2. Progressing
3. Corrective action based upon the feedback and reporting back to th e production planning

Objectives of control:

- To implement the production plans into effect by issuing the nec essary orders to the right persons through the proper channels

 To coordinate monitor and feed-back to production managem ent, the results of the production activities, a nalyzing and interpreting their corrective action if necessary.

 To provide for optimum utilization of all resources.

 To achieve the broad o bjectives of low cost production and reliable customer services

Scope of production control:

 Control of planning, materials, tooling, manufacturing, activities, quantity, information and quality.

PRODUCTION SYSTEMS:

Production:

 Is the sequence of operation which transforms the given materials i nto desired products.

 Transformation from one form to another is carried out either b y one form to another is carried out either by o ne or a combination of different manufacturi ng process.

System: A logical arrangement of components designed to achieve particular objectives according to a plan.

Production system:

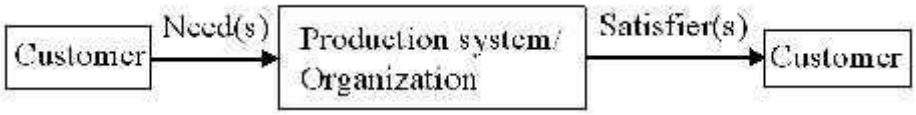

Fig.1.4: Production Systems

 Is the frame work with in which the conversion of input into output occurs.
 At the one end of the p roduction system are the inputs and at the other end outputs
 Inputs and outputs are linked by certain operations or processes.

1. **Job shop production:**

- involves manufacturing of a single complete unit as per customers order
- Each job produced is different from others and no repetition is involved.
- The work is started only when the organisation has orders in hand.

Characteristics:

- ✓ high variety and low volume
- ✓ Flow of material is not continuous.

- ✓ Highly skilled operators and supervisors are required
- ✓ General purpose machines and equipment to perform wider range of operations.
- ✓ Ex: custom-made products.
- ✓ higher cost of production
- ✓ requires the use of specialist labour (compare with the repetitive, low-skilled jobs in mass production)
- ✓ slow compared to other methods (batch production and mass production)
- ✓ The products are made in small batches and in large variety.
- ✓ Each batch contains identical items but every batch is different from others

Characteristics:

- o a large variety of products are manufactured in lots or batches
- o Machines are grouped on functional basis similar to the job shop manufacturing.
- o Both general purpose machines and special purpose machines are used.
- o Labor should be skilled enough to work upon different product batches
- o Flow of material is intermittent
- o Flexible material type.
- o Ex: drugs , cloths ,parts manufactured on lathe, forging machines etc

Disadvantages:

- There are inefficiencies associated with batch production as equipment must be stopped, re-configured, and its output tested before the next batch can be produced.
- Larger stocks of raw materials must be kept.
- In mass production, same type of product is manufactured to meet the continuous demand of the product. Usually demand of the product is very high and market is going to sustain same demand for sufficiently long time
- only one type of product or maximum 2 or 3 types are manufactured in large quantities.
- Standardisation of products, process, materials, machines and uninterrupted flow of materials are basic features.

Characteristics:

- o low variety and high volume
- o flow of material is continuous
- o Material handling is also automatic (such as conveyors).
- o special purpose machines are used
- o the machine capacities are balanced

- degree of automation is high
- it offers lower cost of production
- shorter cycle time
- easier production planning and control.
- Ex: automobiles, bicycles
- As product flows along a pre defined line, planning and control of thesystem is much easier.
- Cost of production is low owing to the high rate of production.
-
- In process inventories are low as production scheduling is simple and can be implemented with ease.

2. Intermittent/Batch Production:

This is concerned with the production of different types of products in small quantities usually termed as batches. A batch contains the similar products but in small quantity. This is used to meet a specific order or to meet a continuous demand. Batch can be manufactured either- only once or repeatedly at irregular time intervals as and when demand arise or repeatedly at regular time intervals to satisfy a continuous demand. Under this system the goods may be produced partly for inventory and partly for customer's orders. For example, components are made for inventory but they are combined differently for different customers. e.g. automobile plants, printing presses, electrical goods plant are examples of this type of manufacturing.

Characteristics of Intermittent/ Batch Production:

a) As final product is somewhat standard and manufactured in batches, economy of scale can be availed to some extent.

b) Machines are grouped on functional basis similar to the job shop manufacturing.

c) Semi-automatic, special purpose automatic machines are generally used to take advantage of the similarity among the products.

d) Labour should be skilled enough to work upon different product batches.

e) In process inventory is usually high owing to the type of layout and material handling policies adopted.

f) Semi-automatic material handling systems are most appropriate in conjunction with the semi-automatic machines.

In addition to the above, a large number of manufacturing plants include both intermittent and continuous processes and are classified as composite or combination operations .Such a plant may have sub assembly departments making parts in a continuous operation, while the

final assembly department works on an intermittent basis.(as in the furniture and custom packaging industries)

3. Continuous/Mass production:

It is used when we need to produce standardized products with a standard set of process and operation sequence in anticipation of demand. This ensures continuous production of output. It is also termed as mass flow production or assembly line production. This system results in less work in process (wip) inventory and high product quality but involves high capital investment in machinery and equipment. This ensures very high rate of production as we need not to intervene once the production has begun. The system is appropriate in plants where large volume of small variety of output is produced. e.g. oil refineries, cement manufacturing and sugar factory etc.

Characteristics of Continuous/Mass production:

a) As same product is manufactured for sufficiently long time, machines can be laid down in order of processing sequence.

b) Standard methods and machines are used during part manufacture.

c) Most of the equipment‘s are semi automatic or automatic in nature.

d) Material handling is also automatic (such as conveyors).

e) Semi-skilled workers are normally employed as most of the facilities are automatic.

f) As product flows along a pre-defined line, planning and control of the system is much easier.

g) Cost of production per unit is very low owing to the high rate of production.

h) In process inventories are low as production scheduling is simple and can be implemented with ease.

PRODUCT DESIGN AND PRODUCT DEVELOPMENT:

PRODUCT DESIGN

- The conversion of knowledge and requirement into a form convenient and suitable for use of manufacturing.
- Designing is very essential before actual transformation of raw material into finished products.
- Deals with shape, appearance and functions of the product.

PRODUCT DEVELOPMENT

- It is a specialised activity which may result in creation of new product or modifications in the production process to produce the same product.
- It is divided into two main categories:
  (1)Introduction of new products (2) Improvement of existing products.

FACTORS INFLUENCING PRODUCT DESIGN:

1. **Marketing aspects**-(determine size, nature of customer, possible trend)
2. **Product characteristics**
   a. Functional aspects (how the product functions)
   b. Operational aspects (easy to handle and simple to operate)
   c. Durability (length of the active lifes) and dependability aspects(reliability)
   d. Aesthetic aspects
3. **Economic analysis**
   a. Profit consideration
   b. Effect of standardization, simplification, and specialization
   c. Break even analysis
4. **Production aspects**

MARKETING ASPECTS:

- A market analysis is done to determine its size, the nature of the customer, and trend.
- Whether the proposed product offers the functions that are desirable and acceptable to the customers?
- Is it within the buying capacity of the customer?
- Does the product already exist?
- What are the factors that influence the demand for this proposed product?
- Is it entirely new product about which the customer is unaware?
- Who are the competitors?
- What is the basis of competition for the product?
- What is the price prevailing in the market?

PRODUCT CHARACTERISTICS:

Functional aspects:

- It reveals the functional scope of the product. How the product functions.
- It influences the design of the machine, its complexity, its appearance and its price.

- Offering functional versatility of the product increases the range of applications of product to the customer.
- Versatility of production machinery may quite often result in substantial savings in floor space and capital expenditure.

Operational aspects:

- The product should also be easy to handle and simple to operate.
- The product is used at different conditions and the customers vary with respect to skill knowledge. These factors in addition with multifunctional features complicate the product designer's problem.

Durability:

- It refers to the length of the active life or endurance of the product under given working condition.
- Another aspect of durability is that of maintenance and repair. The amount of repair and the preventive maintenance required for some products are closely related to quality and design policy.

Dependability aspects:

- It refers to the reliability with which the product serves its intended function
- When a product does not function at the right moment when it is called upon to do the job, then it has very poor or no dependability.

Aesthetic aspects:

- It refers to the final shape and appearance around the basic skeleton which are required for performance of intended functions.
- Aesthetics make the product attractive and induce in the customer a willingness to possess.
- It helps the marketing function of the product by attracting the customers and creating the deep impression about the product.
- Designers use variety of techniques to build aesthetic characteristics into the product.
- Some of the techniques to enhance the aesthetic appeal in product design:
  1. Use of specific material 2.Use of colour, texture as supplement to colour, Packaging.

Economic analysis:

- Profit consideration
- Effect of standardization, simplification, and specialization
- Break even analysis

- Cost-volume-profit analysis.

Production aspects (Design for Manufacture):

- Design of ease of manufacturing of the components of a product.
  - Guidelines for general approach to DFM.

- Design for minimum number of parts.
- Minimize part variations.
- Design parts to be multi- functional.
- Design parts for ease of fabrication

- Guidelines for selection of the manufacturing processes.
- Guidelines for particular processes.
- Guidelines for assembly.

  - Design for assembly(DFA) means the design of the product for ease of assembly

  - Minimize the number of parts
  - Minimize assembly surfaces
  - Design for top- down assembly.
  - Improve assembly access.

PRINCIPLES OF PRODUCT DEVELOPMENT:

There are various methods available to support the product design and development process.

- Standardization
- Simplification
- Specialization

STANDARDIZATION:

It is defined as the process of defining and applying the conditions necessary to ensure that a given range of requirements can normally be met with a minimum variety and in a reproducible and economic manner on the basis of the best current techniques.

- Fixation of appropriate size, shape, quality, manufacturing process, and other characteristics as standards to manufacture a product of desired variety and utility.eg shaving blades, television

- It is applicable to all kind of production.

Objectives: To achieve maximum overall economy in terms of Cost, Human effort and

Conservation of essential materials

- To ensure maximum convenience in use

- To adopt the best possible solutions to recurring problems
- To define requisite levels of quality

- To facilitate national and international exchange of goods and services and to develop mutual cooperation in the sphere of intellectual, scientific, technological and economic activity.

Classification of standardization:

- Basic standardization
- Dimensional standardization
- Material standardization
- Equipment standardization
- Process standardization
- Quantity standardization (EOQ)
- Personal standardization (workers selection-training- operating time-wages rate)
- Administrative standardization

Benefits:

- Reduction of material waste and obsolescence
- Reduced manufacturing cost per unit and Reduced work in process
- Uniform quality of the product
- Reduced maintenance, servicing and replacement of equipment and parts
- Increased customer confidence to buy product.

SIMPLIFICATION:

- Is the process of reducing the variety of products manufactures?
- Elimination of excessive and desirable of product to eliminate waste and to achieve economy
- It is concerned with the reduction of product range: assemblies, parts, materials and design
- It enables the production department to improve planning, achieve higher rates of production and machine utilization, and simplify control procedures.

Benefits:

- It reduces manufacturing operations and risk of obsolescence
- It simplifies production planning and supervision.
- It leads to lower manufacturing cost and higher sales.
- It improves product quality
- Quick delivery and better after sales service

Limitations

- It cannot satisfy a wide range of demands
- It cannot create demand
- It creates constant source of conflict between marketing and production

SPECIALIZATION:

It is a process whereby particular firms concentrate on the manufacture of a limited number of products of types of products.

Advantages:

- Better utilization of equipment
- Higher productivity
- Greater efficiency
- Better quality

- Reduced cost
- Use of standardized methods

Limitations:

- Lesser flexibility in adjustment to change situation
- Monotony in work and loss of initiative

BREAKEVEN ANALYSIS

What is a Break-Even Analysis?

A break-even analysis is a financial tool which helps a company to determine the stage at which the company, or a new service or a product, will be profitable. In other words, it is a financial calculation for determining the number of products or services a company should sell or provide to cover its costs (particularly fixed costs). Break-even is a situation where an organisation is neither making money nor losing money, but all the costs have been covered. Break-even analysis is useful in studying the relation between the variable cost, fixed cost and revenue. Generally, a company with low fixed costs will have a low break-even point of sale. For example, say Happy Ltd has fixed costs of Rs. 10,000 vs Sad Ltd has fixed costs of Rs. 1,00,000 selling similar products, Happy Ltd will be able to break even with the sale of lesser products as compared to Sad Ltd.

Components of Break Even Analysis

Fixed cost

Fixed costs are also called overhead costs. These overhead costs occur after the decision to start an economic activity is taken and these costs are directly related to the level of production, but not the quantity of production. Fixed costs include (but are not limited to) interest, taxes, salaries, rent, depreciation costs, labour costs, energy costs etc. These costs are fixed respective of the production. In case of no production also the costs must be incurred.

Variable costs

Variable costs are costs that will increase or decrease in direct relation to the production volume. These costs include cost of raw material, packaging cost, fuel and other costs that are directly related to the production.

Breakeven analysis is performed to determine the value of a variable of a project that makes two elements equal, e.g. sales volume that will equate revenues and costs.

Single Project

The analysis is based on the relationship:

Profit = revenue – total cost = R – TC

At breakeven, there is no profit or loss, hence,

Revenue = total cost or,

R = TC

Note: It is to be noted that +ve sign is used for both the revenue and the costs. If we are to use –ve sign for costs and +ve sign for revenue, then the above relationships become:

Profit = R + TC and R + TC = 0 at breakeven.

With revenue and costs given in terms of a decision variable, the solution yields the breakeven quantity for the decision variable.

Costs,

which may be linear or non-linear, usually include two components:

Fixed costs (FC) – Includes costs such as buildings, insurance, fixed overhead, equipment capital recovery, etc. These costs are essentially constant for all values of the decision variable.

Variable costs (VC) – Includes costs such as direct labour, materials, contractors, marketing, advertisement, etc. These costs change linearly or non-linearly with the decision variable, e.g. production level, workforce size, etc. For the analysis to be followed here, the variation will generally be assumed to be linear.

Then, total cost,

TC = FC + VC

Revenue also changes with the decision variable. Again, for the analysis, the variation will generally be assumed to be linear. The following diagram illustrates the basics of the breakeven analysis.

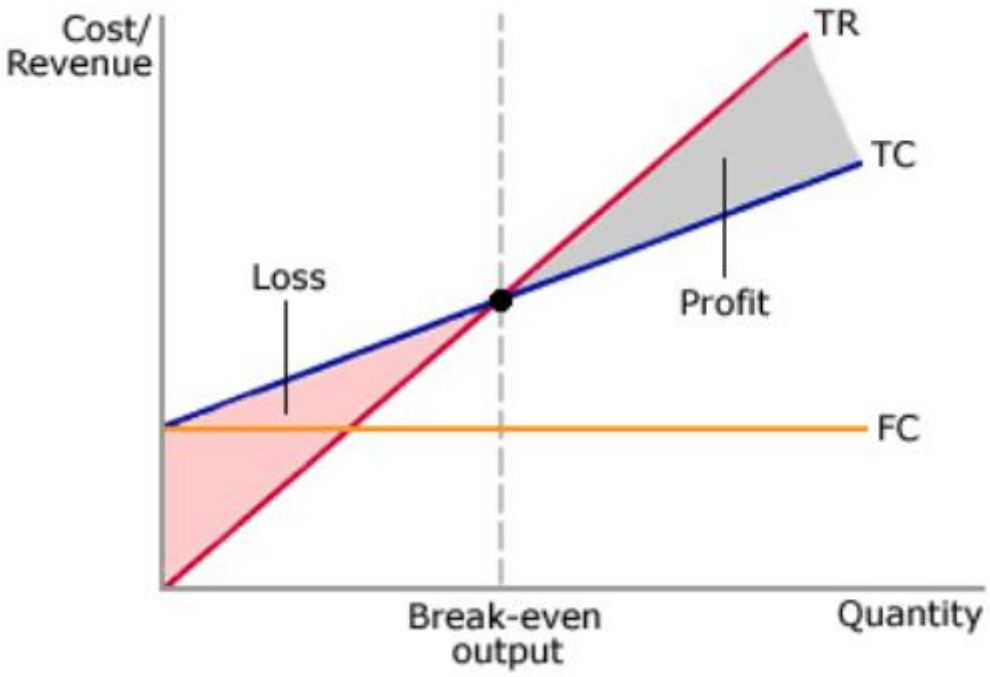

Fig.1.5: Break Even Chart

When is Break even analysis used?

Starting a new business: To start a new business, a break-even analysis is a must. Not only it helps in deciding whether the idea of starting a new business is viable, but it will force the startup to be realistic about the costs, as well as provide a basis for the pricing strategy. Creating a new product: In the case of an existing business, the company should still peform a break-even analysis before launching a new product—particularly if such a product is going to add a significant expenditure.
Changing the business model: If the company is about to the change the business model, like, switching from wholesale business to retail business, then a break-even analysis must be performed. The costs could change considerably and breakeven analysis will help in setting the selling price.

Breakeven analysis is useful for the following reasons:

- It helps to determine remaining/unused capacity of the company once the breakeven is reached. This will help to show the maximum profit on a particular product/service that can be generated.

- It helps to determine the impact on profit on changing to automation from manual (a fixed cost replaces a variable cost).
- It helps to determine the change in profits if the price of a product is altered.
- It helps to determine the amount of losses that could be sustained if there is a sales downturn.

Additionally, break-even analysis is very useful for knowing the overall ability of a business to generate a profit. In the case of a company whose breakeven point is near to the maximum sales level, this signifies that it is nearly impractical for the business to earn a profit even under the best of circumstances.
Therefore, it's the management responsibility to monitor the breakeven point constantly. This monitoring certainly reduces the breakeven point whenever possible.

Ways to monitor Breakeven point

- Pricing analysis: Minimize or eliminate the use of coupons or other price reductions offers, since such promotional strategies increase the breakeven point.
- Technology analysis: Implementing any technology that can enhance the business efficiency, thus increasing capacity with no extra cost.
- Cost analysis: Reviewing all fixed costs constantly to verify if any can be eliminated can surely help. Also, review the total variable costs to see if they can be eliminated. This analysis will increase the margin and reduce the breakeven point.
- Margin analysis: Push sales of the highest-margin (high contribution earning) items and pay close attention to product margins, thus reducing the breakeven point.
- Outsourcing: If an activity consists of a fixed cost, try to outsource such activity (whenever possible), which reduces the breakeven point.

Benefits of Break-even analysis

- **Catch missing expenses:** When you're thinking about a new business, it's very much possible that you may forget about a few expenses. Therefore, a break-even analysis can help you to review all financial commitments to figure out your break-even point. This analysis certainly restricts the number of surprises down the road or atleast prepares a company for them.

- **Set revenue targets:** Once the break-even analysis is complete, you will get to know how much you need to sell to be profitable. This will help you and your sales team to set more concrete sales goals.
- **Make smarter decisions:** Entrepreneurs often take decisions in relation to their business based on emotion. Emotion is important i.e. how you feel, though it's not enough. In order to be a successful entrepreneur, decisions should be based on facts.
- **Fund your business:** This analysis is a key component in any business plan. It's generally a requirement if you want outsiders to fund your business. In order to fund your business, you have to prove that your plan is viable. Furthermore, if the analysis looks good, you will be comfortable enough to take the burden of various ways of financing.
- **Better Pricing:** Finding the break-even point will help in pricing the products better. This tool is highly used for providing the best price of a product that can fetch maximum profit without increasing the existing price.
- **Cover fixed costs:** Doing a break-even analysis helps in covering all fixed cost.

1. The Algebraic Method

(i) Break-even point in terms of Physical Units

Let FC = Fixed cost,

VC = Variable cost per unit,

TVC = Total variable cost,

TC = Total costs,

TR = Total revenue *i.e.*, total income,

Q = Sales volume *i.e.*, quantity sold, and

SP = Selling price per unit.

We know that,

$$\text{Total costs} = \text{Fixed cost} + \text{Variable cost}$$

or $$TC = FC + (VC \times Q)$$

We also know that,

$$\text{Total revenue} = \text{Selling price / unit} \times \text{Quantity sold}$$

or $$TR = SP \times Q$$

At Break-Even Point (BEP),

$$\text{Total costs} = \text{Total revenue}$$

$$TC = TR$$

$$FC + (VC \times Q) = SP \times Q$$

or $$\boxed{Q_{BEP} = \frac{FC}{SP - VC}} \quad \ldots (1\ 1)$$

$$\text{Break-even quantity} = \frac{\text{Fixed costs}}{(\text{Selling price / unit}) - (\text{Variable cost / unit})}$$

(ii) Break-even point in terms of Sales Value

This method is suitable for a multi-product firm.

$$\left.\begin{matrix}\text{Break-even sales} \\ \text{(BEP in rupees)}\end{matrix}\right\} = \frac{\text{Fixed costs}}{1 - \left(\frac{\text{Variable cost / unit}}{\text{Selling price / unit}}\right)}$$

$$\boxed{\text{BEP in rupees} = \frac{FC}{1 - \left(\frac{VC}{SP}\right)}} \quad \ldots (1.2)$$

(iii) Contribution

- ✓ The difference between selling price and variable cost per unit is known as ***contribution or contribution margin.***

$$\text{Contribution} = \text{Selling price} - \text{Variable cost}$$

$$\boxed{C = SP - VC} \quad \ldots (1.3)$$

- ✓ ***Contribution*** is a companion measure of value that tells how much of the revenue from the sale of one unit of a product will contribute to cover fixed costs with the remainder going to profit.

- ✓ Contribution margin divided by selling price is known as ***contribution ratio.***

$$\text{Contribution ratio} = \frac{\text{Contribution}}{\text{Selling price}}$$

or

$$\boxed{\text{Contribution ratio} = \frac{\text{Selling price} - \text{Variable cost}}{\text{Selling price}}} \quad \ldots (1.4)$$

(iv) P/V Ratio (i.e., Profit – Volume Ratio)

$$\boxed{\text{P/V Ratio} = \frac{\text{Contribution}}{\text{Sales}}} \quad \ldots (1.5)$$

2. The Graphical Method (Break-Even Chart)

- ✓ *Break-even chart is a graphical representation of the relationship between costs and revenue at a given time.*
- ✓ It is a graphic device to determine the break-even point and amount of loss or profit under varying conditions of output and costs.
- ✓ A break-even chart is illustrated in Fig.1.8.

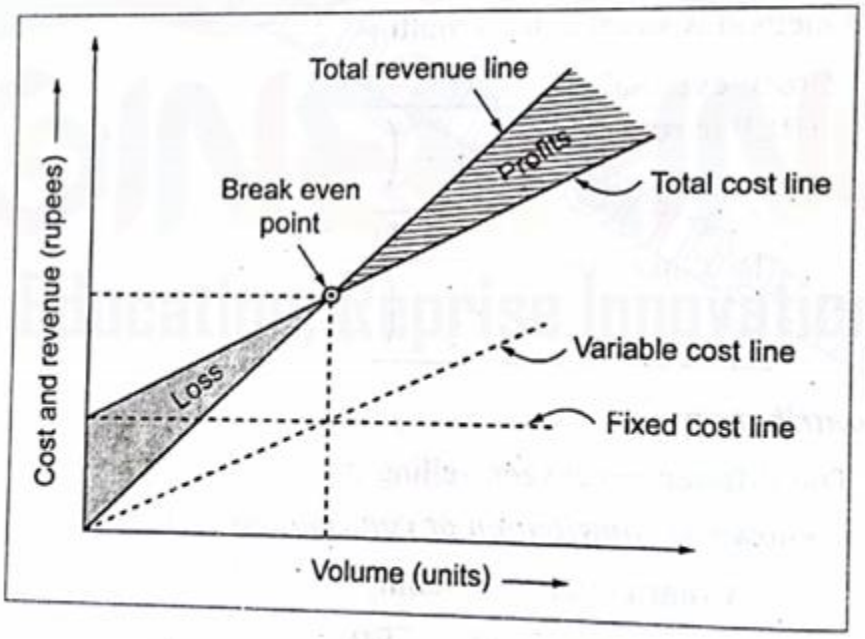

Fig. 1.8. Break-even chart

- ✓ In break-even chart, cost and revenue in rupees is represented on vertical axis, while output in quantity is represented on horizontal axis.
- ✓ In Fig.1.8, the fixed cost line is horizontal and parallel to the X-axis. It indicates that fixed costs remains unchanged for any volume.
- ✓ The variable cost line is superimposed on the fixed cost line to show total costs.
- ✓ The total sales revenue line is drawn as shown in Fig.1.8. This line
- ✓ *The point at which the total revenue line intersects the total cost line is the break-even point.*
- ✓ The shaded area above the BEP marks profit to the firm whereas the shaded area below the BEP represents loss to the concern.

1.13.6. Margin of Safety

✓ ***Margin of safety*** is the difference between the existing level of output and the level of output at BEP.

$$\text{Margin of safety (in \%)} = \frac{\text{Sales} - \text{Sales at BEP}}{\text{Sales}} \times 100 \quad \ldots (1.6)$$

✓ *Greater value of margin of safety means higher profits to the firm.*

✓ If the safety margin is low, then the firm runs the risk of incurring losses.

1.13.7. Angle of Incidence

✓ This is an angle at which sales revenue line cuts the total costs line. (Refer Fig.1.8).

✓ *A large angle of incidence indicates a high profit rate.*

✓ A narrow angle shows that even fixed overheads are absorbed and relatively low rate of return.

1.13.8. Limitations of Break-Even Analysis

Some of the important limitations of break-even analysis are given below:

(i) Break-even analysis is a static picture as it assumes constant relationship of output to costs and revenue.

(ii) Practically, the selling price and variable cost per unit are not constant. So the break-even analysis cannot be more realistic.

(iii) Break-even analysis is based on accounting data which may suffer from several limitations like neglect of imputed costs, arbitrary depreciation estimates, inappropriate allocation of overheads, *etc.*

(iv) The break-even chart is a tool for short run analysis. It cannot be used for long range analysis.

ECONOMICS OF A NEW PRODUCT DESIGN (SAMUEL EILON MODEL)

- ✓ When the launching of a new design or model is contemplated, a careful analysis of the economics of the proposed project has to be undertaken.
- ✓ As discussed already, the purpose of introducing a new model to the market is twofold:
  - (*i*) To increase the profit of the organisation,
  - (*ii*) To avoid decline in sales of an existing model due to stiff competition.
- ✓ Samuel Eilon has proposed a model, which is based on the break-even analysis, to determine whether the additional investment is desirable or not?; whether the new product will be profitable or not?.
- ✓ Let FC = Fixed cost,
  s = Additional investment made,
  P_1, Q_1 = Profit accrued and quantity sold before the additional investment respectively, and
  P_2, Q_2 = Profit accrued and quantity sold after the additional investment respectively.

Now let us compare P_1 and P_2 and justify the new additional investment made.

We know that the slope of the break-even chart (Fig.1.8),

$$\phi = \frac{\text{Profit (P)} + \text{Fixed cost (FC)}}{\text{Quantity sold (Q)}}$$

Therefore, the slope of the break-even chart before the additional investment,

$$\phi_1 = \frac{P_1 + FC}{Q_1} \text{ or } P_1 = \phi_1 Q_1 - FC \quad \ldots (i)$$

and the slope of the break-even chart after the additional investment,

$$\phi_2 = \frac{P_2 + FC + s}{Q_2} \quad \text{or} \quad P_2 = \phi_2 Q_2 - FC - s \qquad \ldots (ii)$$

It is desirable that the new profit will be larger than, or at least equal to, the existing one. *i.e.*, $P_2 \geq P_1$.

$$\therefore \text{ Profit difference } = P_2 - P_1 \geq 0$$

$$\text{or} \qquad = (\phi_2 Q_2 - FC - s) - (\phi_1 Q_1 - FC)$$

$$\text{or} \qquad = \phi_2 Q_2 - \phi_1 Q_1 - s \geq 0$$

This condition tells us how many units of the new design ought to be sold in order to ensure that total profit does not decline.

For $P_2 - P_1 \geq 0$, using equations (*i*) and (*ii*), we get

$$D = \frac{\phi_1}{\phi_2} = \frac{\text{P/V ratio for old design}}{\text{P/V ratio for new design}}$$

$$\therefore \qquad \frac{Q_2}{Q_1} \geq \left[1 + \frac{s}{P_1 + FC}\right] D \qquad \ldots (1.7)$$

In equation (1.7), when $D = 1$, Q_2 must be greater than Q_1 to justify the additional investment (s) on design change.

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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SPR1306 – PRODUCTION PLANNING AND CONTROL

COURSE MATERIAL

UNIT – II – SPR1306 - SALES FORECASTING

Sales forecasting - Needs and benefits - Types of forecasting - Trend analysis - Regression lines and Correlation analysis - Simple problems - Effect of forecasting on production order - Accuracy of forecast- Plant capacity and machine capacity – EOQ.

II. SALES FORECASTING

SALES FORECASTING:

- A prediction, projection, or estimate of some future activity, event, or occurrence
- It is an estimation of the amount of sales for a specified future period under a proposed marketing plan or program.
- It is a process of estimating a future event by casting forward past data. The past data are systematically combined in a predetermined way to obtain the estimate of the future.
- When estimates of future conditions are made on a systematic basis, the process is called forecasting.
- The figure or statement thus obtained is defined as forecast
- Prediction is a process of estimating a future event based on subjective considerations other than just past data; these subjective considerations need not be combined in a predetermined way.
- Forecasts are a basic input in the decision processes of operations management because they provide information on future demand.
- Forecasts are basis for budgeting, planning capacity, sales, production & inventory, personnel, purchasing, etc.
- Forecasts play an important role in the planning process because they enable managers to anticipate the future so they can plan accordingly.
- Forecasts affect decisions and activities throughout an organization, in accounting, finance, human resources, marketing, and management information systems (MIS), as well as in operations and other parts of an organization.

A forecast is an estimate of the level demand to the expected for a production of several products for some period of time in the future.

Forecast is made of sales (in Rs.) or physical units under a proposed marketing or program & under an assumed set of economic & other force outside the unit system).

Forecast should cover a time period at least as long as the period of time required to make the decision & to put that decision into effect.

Applications/uses/purposes:

There are 3 major purposes.

1) To determine necessity for & the size of plant expansion (Facility Forecast)

2) To determine intermediate planning for existing products to be manufactured with existing facilities.
3) To determine Short-time scheduling of existing products to be manufactured on existing equipments (Product Forecast)

NEED AND BENEFITS:

- The near future sales forecast supplies an economic foundation for operation planning, scheduling, production, inventories and logistics, projecting cash generation and operating profits.
- Long run sales forecast supply the frame-work for corporate investment planning, sourcing, capital and expansion capacity, executive development
- There are two uses for forecasts. One is to help managers plan the system, and the other is to help them plan the use of the system.

BENEFITS

- It aid management greatly in implementing the marketing management approach.
- It is a vital tool of marketing planning since adequate planning and effective deployment of marketing resources are based on sales forecasting data.
- Sales forecasting helps to determine various limiting conditions for management decisions.
- It helps to stabilize and regularize outlay and thus cut production costs.
- Seasonal, short term and long term fluctuation can be overcome.
- It furnishes management with information about what market condition will probably be like during future period.
- Accurate sales forecasting lead to lower selling costs by gearing advertising and promotional efforts to future sales rather than to recent sales.
- Sales forecasting provides a firm basis for evaluating the function and productivity of various segments of business activity.
- Basis for maximum business growth, diversification and expansion.
- Helps to integrate the management of controllable & non-controllable factors within which company operates.

USES OF FORECASTS IN BUSINESS ORGANIZATIONS:

- Accounting. New product/process cost estimates, profit projections, cash management.
- Finance. Equipment/equipment replacement needs, timing and amount of funding/
- Borrowing needs.
- Human resources - Hiring activities, including recruitment, interviewing, and training;
- Layoff planning, including outplacement counseling.
- Marketing. Pricing and promotion, e-business strategies, global competition strategies.
- MIS. New/revised information systems, Internet services.
- Operations. Schedules, capacity planning, work assignments and workloads, inventory
- Planning, make-or-buy decisions, outsourcing, project management.
- Product/service design. Revision of current features, design of new products or services.

FEATURES COMMON TO ALL FORECASTS:

- Forecasting techniques generally assume that the same underlying causal system that existed in the past will continue to exist in the future.
- Forecasts are not perfect; actual results usually differ from predicted values; the presence of randomness precludes a perfect forecast. Allowances should be made for forecast errors.
- Forecasts for groups of items tend to be more accurate than forecasts for individual items because forecasting errors among items in a group usually have a canceling effect. Opportunities for grouping may arise if parts or raw materials are used for multiple products or if a product or service is demanded by a number of independent sources.
- Forecast accuracy decreases as the time period covered by the forecast—the time horizon— increases. Generally speaking, short-range forecasts must contend with fewer uncertainties than longer-range forecasts, so they tend to be more accurate.
- The forecast should be timely. Usually, a certain amount of time is needed to respond to the information contained in a forecast. For example, capacity cannot be expanded

overnight, nor can inventory levels be changed immediately. Hence, the forecasting horizon must cover the time necessary to implement possible changes.

- The forecast should be accurate, and the degree of accuracy should be stated. This will enable users to plan for possible errors and will provide a basis for comparing alternative forecasts.
- The forecast should be reliable; it should work consistently. A technique that sometimes provides a good forecast and sometimes a poor one will leave users with the uneasy feeling that they may get burned every time a new forecast is issued
- The forecast should be expressed in meaningful units. Financial planners need to know how many dollars will be needed, production planners need to know how many units will be needed, and schedulers need to know what machines and skills will be required. The choice of units depends on user needs.
- The forecast should be in writing. Although this will not guarantee that all concerned are using the same information, it will at least increase the likelihood of it. In addition, a written forecast will permit an objective basis for evaluating the forecast once actual results are in.
- The forecasting technique should be simple to understand and use. Users often lack confidence in forecasts based on sophisticated techniques; they do not understand either the circumstances in which the techniques are appropriate or the limitations of the techniques. Misuse of techniques is an obvious consequence. Not surprisingly, fairly simple forecasting techniques enjoy widespread popularity because users are more comfortable working with them.
- The forecast should be cost-effective: The benefits should outweigh the costs.

STEPS IN THE FORECASTING PROCESS:

1) **Determine the purpose of the forecast**: How will it be used and when will it be needed? This step will provide an indication of the level of detail required in the forecast, the amount of resources (personnel, computer time, dollars) that can be justified, and the level of accuracy necessary.
2) **Establish a time horizon**. The forecast must indicate a time interval, keeping in mind that accuracy decreases as the time horizon increases:
3) **Obtain, clean, and analyze appropriate data:** Obtaining the data can involve significant effort. Once obtained, the data may need to be "cleaned" to get rid of outliers and obviously incorrect data before analysis.

4) **Select a forecasting technique**

- **Make the forecast**
- **Monitor the forecast**: A forecast has to be monitored to determine whether it is performing in a satisfactory manner. If it is not, reexamine the method, assumptions, validity of data, and so on; modify as needed; and prepare a revised forecast.

TYPES OF FORECASTS:

- Sales Forecasting
- Forecasting the need for raw materials and spare parts
- Forecasting Staffing Needs
- Economic forecasts: Predict a variety of economic indicators, like money supply, inflation rates, interest rates, etc.
- Technological forecasts: Predict rates of technological progress and innovation.
- Demand forecasts: Predict the future demand for a company's products or services.

MAIN TYPES OF FORECASTING METHODS:

1. **Qualitative methods:**

   Qualitative forecasting techniques are subjective, based on the opinion and judgment of consumers and experts; they are appropriate when past data are not available. They are usually applied to intermediate- or long-range decisions. Examples of qualitative forecasting methods are informed opinion and judgment, the Delphi method, market research, and historical life-cycle analogy.

   These types of forecasting methods are based on judgments, opinions, intuition, emotions, or personal experiences and are subjective in nature. They do not rely on any rigorous mathematical computations

2. **Quantitative methods:**

   Quantitative forecasting models are used to forecast future data as a function of past data. They are appropriate to use when past numerical data is available and when it is reasonable to assume that some of the patterns in the data are expected to continue into the future. These methods are usually applied to short- or intermediate-range decisions. Examples of quantitative forecasting methods are[*citation needed*] last period demand, simple and weighted N-Period moving averages, simple exponential

smoothing, poisson process model based forecasting [2] and multiplicative seasonal indexes. Previous research shows that different methods may lead to different level of forecasting accuracy. For example, GMDH neural network was found to have better forecasting performance than the classical forecasting algorithms such as Single Exponential Smooth, Double Exponential Smooth, ARIMA and back-propagation neural network

These types of forecasting methods are based on mathematical (quantitative) models, and are objective in nature. They rely heavily on mathematical computations.

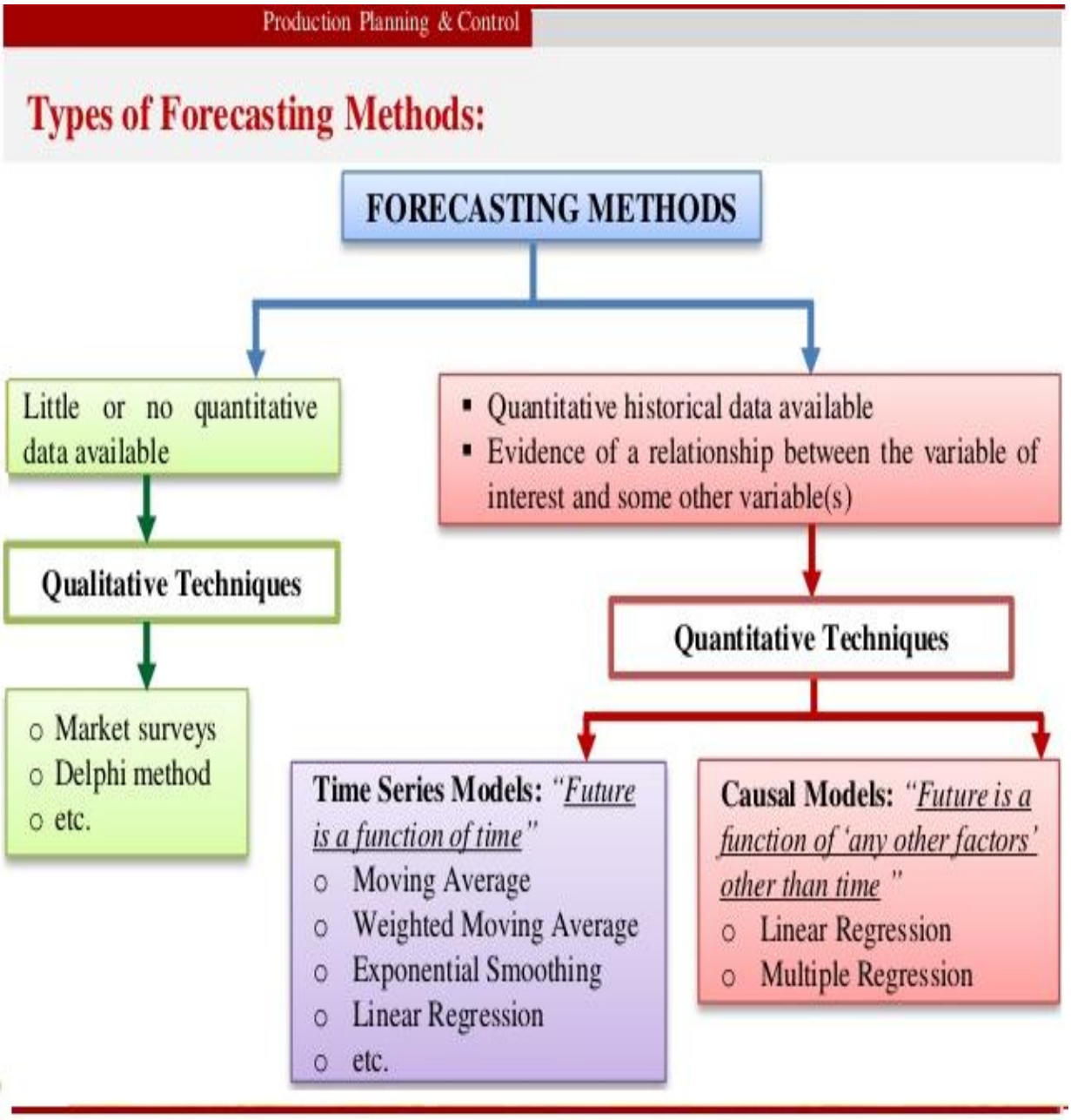


Fig.2.1: Types of forecasting methods

QUALITATIVE FORECASTING METHODS:

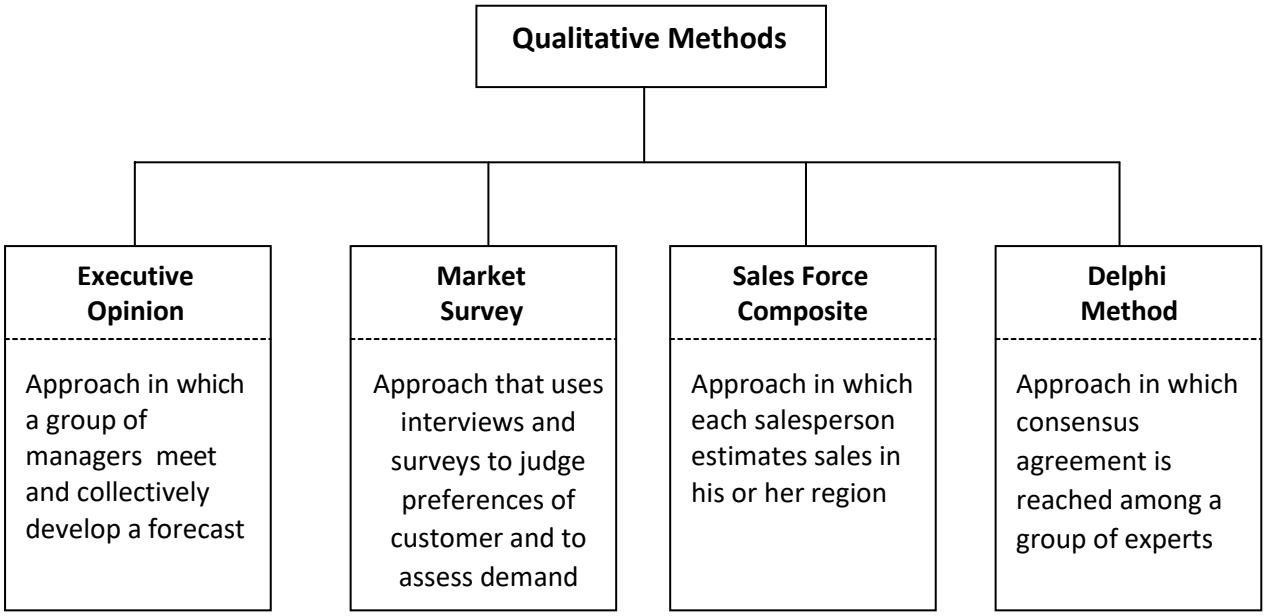


Fig.2.2: Qualitative forecasting methods

1) **Executive Judgment:** Opinion of a group of high level experts or managers is pooled. Forecasts are developed through open meetings with free exchange of ideas form all levels of management and individuals. The difficulty with this open style is that lower employee levels are intimidated by higher levels of management.
2) **Sales Force Composite:** Each regional salesperson provides his/her sales estimates. Those forecasts are then reviewed to make sure they are realistic. All regional forecasts are then pooled at the district and national levels to obtain an overall forecast.
3) **Market Research/Survey:** Solicits input from customers pertaining to their future purchasing plans. It involves the use of questionnaires, consumer panels and tests of new products and services. Market research is used mostly for product research in the sense of looking for new product ideas, likes and dislikes about existing products, which competitive products within a particular class are preferred, and so on. Again, the data collection methods are primarily surveys and interviews.
4) **Delphi Method:** As opposed to regular panels where the individuals involved are in direct communication, this method eliminates the effects of group potential dominance of the most vocal members. The group involves individuals from inside as well as outside the organization.

Typically, the procedure consists of the following steps:

- Each expert in the group makes his/her own forecasts in form of statements.
- The coordinator collects all group statements and summarizes them.
- The coordinator provides this summary and gives another set of questions to each group member including feedback as to the input of other experts.
- The above steps are repeated until a consensus is reached.

5) Brainstorming

Brainstorming technique is used to forecast demand, especially for new products. In this method, many experts sit together and each expert gives his own idea (forecast) and reason for it. One idea leads to many more ideas. The group of experts will develop much more ideas than one person

6) Intuition

Intuitive models rely on the experience of the person making the prediction to accurately forecast future performance or trends, a common approach in business. A final approach calls for a time series or causal analysis, which then leads to adjustment based on intuition.

QUANTITATIVE FORECASTING METHODS:

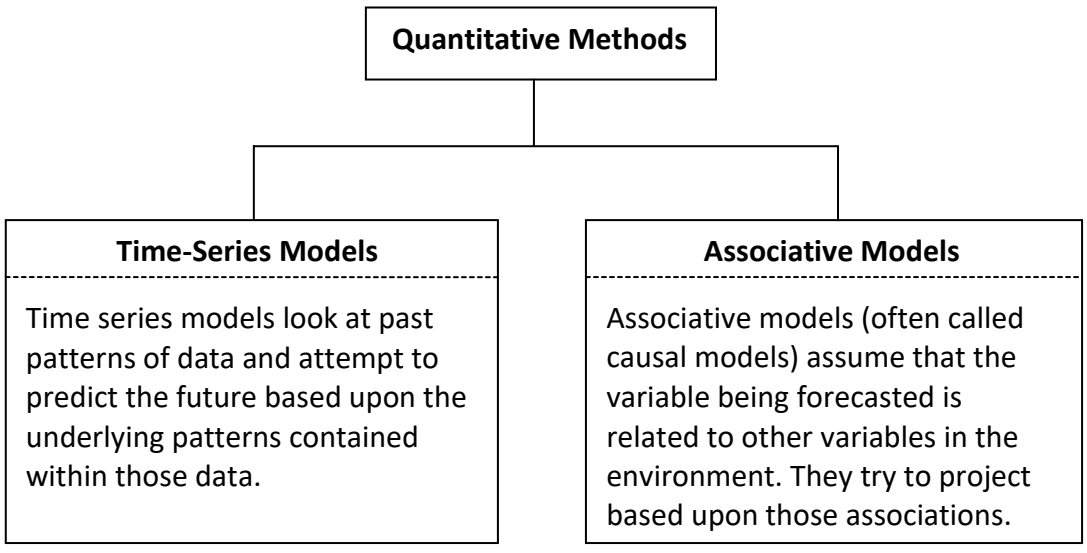


Fig.2.3: Quantitative forecasting methods

TIME SERIES MODELS

Table.2.1: Time series models

Model	Description
Naïve	Uses last period's actual value as a forecast
Simple Mean (Average)	Uses an average of all past data as a forecast
Simple Moving Average	Uses an average of a specified number of the most recent observations, with each observation receiving the same emphasis (weight)
Weighted Moving Average	Uses an average of a specified number of the most recent observations, with each observation receiving a different emphasis (weight)
Exponential Smoothing	A weighted average procedure with weights declining exponentially as data become older
Trend Projection	Technique that uses the least squares method to fit a straight line to the data
Seasonal Indexes	A mechanism for adjusting the forecast to accommodate any seasonal patterns inherent in the data

ILLUSTRATION OF THE NAÏVE METHOD

Naïve method: The forecast for next period (period t+1) will be equal to this period's actual demand (A_t).

In this illustration we assume that each year (beginning with year 2) we made a forecast, then waited to see what demand unfolded during the year. We then made a forecast for the subsequent year, and so on right through to the forecast for year 7.

Table.2.2: Navie method

Year	Actual Demand (A_t)	Forecast (F_t)	Notes

1	310	--	There was no prior demand data on which to base a forecast for period 1
2	365	310	From this point forward, these forecasts were made on a year-by-year basis.
3	395	365	
4	415	395	
5	450	415	
6	465	450	
7		465	

MEAN (SIMPLE AVERAGE) METHOD

Mean (simple average) method: The forecast for next period (period t+1) will be equal to the average of all past historical demands.

In this illustration we assume that a simple average method is being used. We will also assume that, in the absence of data at startup, we made a guess for the year 1 forecast (300). At the end of year 1 we could start using this forecasting method. In this illustration we assume that each year (beginning with year 2) we made a forecast, then waited to see what demand unfolded during the year. We then made a forecast for the subsequent year, and so on right through to the forecast for year 7.

Table.2.3: Moving Average models

Year	Actual Demand (A_t)	Forecast (F_t)	Notes

1	310	300	This forecast was a guess at the beginning.
2	365	310.000	From this point forward, these forecasts were made on a year-by-year basis using a simple average approach.
3	395	337.500	
4	415	356.667	
5	450	371.250	
6	465	387.000	
7		400.000	

SIMPLE MOVING AVERAGE METHOD

Simple moving average method: The forecast for next period (period t+1) will be equal to the average of a specified number of the most recent observations, with each observation receiving the same emphasis (weight).

In this illustration we assume that a 2-year simple moving average is being used. We will also assume that, in the absence of data at startup, we made a guess for the year 1 forecast (300). Then, after year 1 elapsed, we made a forecast for year 2 using a naïve method (310). Beyond that point we had sufficient data to let our 2-year simple moving average forecasts unfold throughout the years.

Table.2.4: Simple Moving Average models

Year	Actual Demand (A_t)	Forecast (F_t)	Notes
1	310	300	This forecast was a guess at the beginning.
2	365	310	This forecast was made using a naïve approach.
3	395	337.500	From this point forward, these forecasts were made on a year-by-year basis using a 2-yr moving average approach.
4	415	380.000	
5	450	405.000	
6	465	432.500	
7		457.500	

ANOTHER SIMPLE MOVING AVERAGE ILLUSTRATION

In this illustration we assume that a 3-year simple moving average is being used. We will also assume that, in the absence of data at startup, we made a guess for the year 1 forecast

(300). Then, after year 1 elapsed, we used a naïve method to make a forecast for year 2 (310) and year 3 (365). Beyond that point we had sufficient data to let our 3-year simple moving average forecasts unfold throughout the years.

Table.2.5: Three Year Moving Average models

Year	Actual Demand (A_t)	Forecast (F_t)	Notes
1	310	300	This forecast was a guess at the beginning.
2	365	310	This forecast was made using a naïve approach.
3	395	365	This forecast was made using a naïve approach.
4	415	356.667	From this point forward, these forecasts were made on a year-by-year basis using a 3-yr moving average approach.
5	450	391.667	
6	465	420.000	
7		433.333	

WEIGHTED MOVING AVERAGE METHOD

Weighted moving average method: The forecast for next period (period t+1) will be equal to a weighted average of a specified number of the most recent observations.

In this illustration we assume that a 3-year weighted moving average is being used. We will also assume that, in the absence of data at startup, we made a guess for the year 1 forecast (300).

Then, after year 1 elapsed, we used a naïve method to make a forecast for year 2 (310) and year 3 (365). Beyond that point we had sufficient data to let our 3-year weighted moving average forecasts unfold throughout the years. The weights that were to be used are as follows: Most recent year, .5; year prior to that, .3; year prior to that, .2

Table.2.6: Weighted Moving Average models

Year	Actual Demand (A_t)	Forecast (F_t)	Notes

1	310	300	This forecast was a guess at the beginning.
2	365	310	This forecast was made using a naïve approach.
3	395	365	This forecast was made using a naïve approach.
4	415	369.000	From this point forward, these forecasts were made on a year-by-year basis using a 3-yr wtd. moving avg. approach.
5	450	399.000	
6	465	428.500	
7		450.500	

EXPONENTIAL SMOOTHING METHOD

Exponential smoothing method: The new forecast for next period (period t) will be calculated as follows:

New forecast = Last period's forecast + □(Last period's actual demand – Last period's forecast)

(***this box contains all you need to know to apply exponential smoothing)***

$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$ (equation 1)

$F_t = \alpha A_{t-1} + (1-\alpha)F_{t-1}$ (alternate equation 1 – a bit more user friendly)

The exponential smoothing method only requires that you dig up two pieces of data to apply it (the most recent actual demand and the most recent forecast).

An attractive feature of this method is that forecasts made with this model will include a portion of every piece of historical demand. Furthermore, there will be different weights placed on these historical demand values, with older data receiving lower weights. At first glance this may not be obvious, however, this property is illustrated on the following page.

DEMONSTRATION: EXPONENTIAL SMOOTHING INCLUDES ALL PAST DATA

Note: the mathematical manipulations in this box are not something you would ever have to do when applying exponential smoothing. All you need to use is equation 1 on the previous page. This demonstration is to convince the skeptics that when using equation 1, all historical data will be included in the forecast, and the older the data, the lower the weight applied to that data.

To make a forecast for next period, we would use the user friendly alternate equation 1: $F_t = \alpha A_{t-1} + (1-\alpha)F_{t-1}$ **(equation 1)**

When we made the forecast for the current period (F_{t-1}), it was made in the

following fashion: $F_{t-1} = \alpha A_{t-2} + (1-\alpha)F_{t-2}$ (equation 2)
If we substitute equation 2 into equation 1 we get the following:
$F_t = \alpha A_{t-1} + (1-\alpha)[\alpha A_{t-2} + (1-\alpha)F_{t-2}]$

Which can be cleaned up to the following:
$F_t = \alpha A_{t-1} + \alpha(1-\alpha)A_{t-2} + (1-\alpha)^2 F_{t-2}$ (equation 3)

We could continue to play that game by recognizing that $F_{t-2} = \alpha A_{t-3} + (1-\alpha)F_{t-3}$ (equation 4) If we substitute equation 4 into equation 3 we get the following:
$F_t = \alpha A_{t-1} + \alpha(1-\alpha)A_{t-2} + (1-\alpha)^2[\alpha A_{t-3} + (1-\alpha)F_{t-3}]$

Which can be cleaned up to the following:
$F_t = \alpha A_{t-1} + \alpha(1-\alpha)A_{t-2} + \alpha(1-\alpha)^2 A_{t-3} + (1-\alpha)^3 F_{t-3}$

EXPONENTIAL SMOOTHING ILLUSTRATION

In this illustration we assume that, in the absence of data at startup, we made a guess for the year 1 forecast (300). Then, for each subsequent year (beginning with year 2) we made a forecast using the exponential smoothing model. After the forecast was made, we waited to see what demand unfolded during the year. We then made a forecast for the subsequent year, and so on right through to the forecast for year 7.

This set of forecasts was made using an α value of .1

Table.2.7: Exponential smoothing model

Year	Actual Demand (A)	Forecast (F)	Notes
1	310	300	This was a guess, since there was no prior demand data.
2	365	301	From this point forward, these forecasts were made on a year-by-year basis using exponential smoothing with α=.1
3	395	307.4	
4	415	316.16	
5	450	326.044	
6	465	338.4396	
7		351.09564	

TREND PROJECTION

Trend projection method: This method is a version of the linear regression technique. It attempts to draw a straight line through the historical data points in a fashion that comes as close to the points as possible. (Technically, the approach attempts to reduce the vertical deviations of the points from the trend line, and does this by minimizing the squared values of the deviations of the points from the line). Ultimately, the statistical formulas compute a

slope for the trend line

(b) and the point where the line crosses the y-axis (a). This results in the straight line equation Y = a + bX

Where X represents the values on the horizontal axis (time), and Y represents the values on the vertical axis (demand).

For the demonstration data, computations for b and a reveal the following ***(NOTE: I will not require you to make the statistical calculations for b and a; these would be given to you.However, you do need to know what to do with these values when given to you.)***

b = 30

a = 295

Y = 295 + 30X

This equation can be used to forecast for any year into the future. For example: Year 7: Forecast = 295 + 30(7) = 505

Year 8: Forecast = 295 + 30(8) = 535

Year 9: Forecast = 295 + 30(9) = 565

Year 10: Forecast = 295 + 30(10) = 595

FORECAST ACCURACY:

- Accuracy and control of forecasts is a vital aspect of forecasting.
- Forecast error is the difference between the value that occurs and the value that was predictedfor a given time period.
- Error = Actual - Forecast
- Absolute Percentage Error = (Error / Actual Observed Value) × 100

$$e_t = A_t - F_t$$

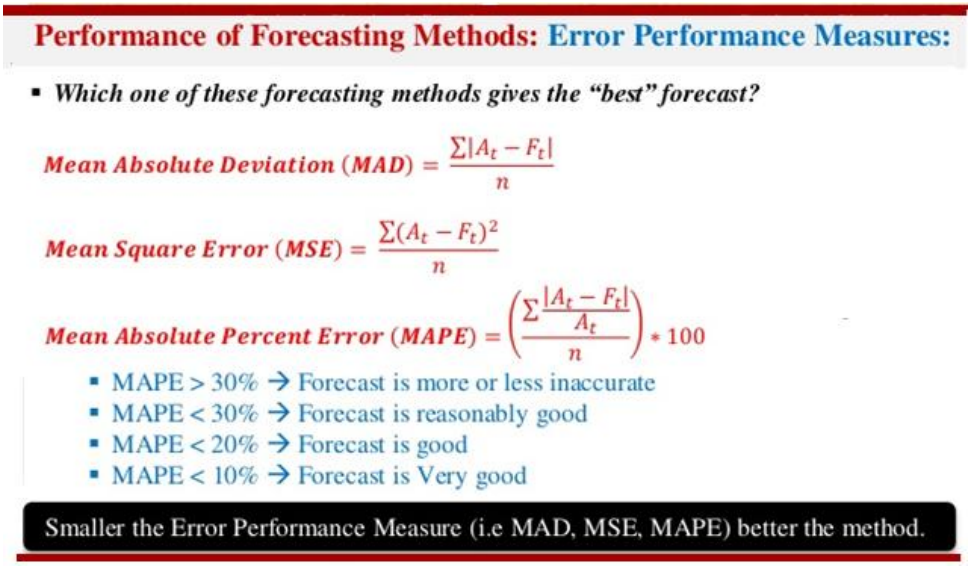
- Positive errors result when the forecast is too low, negative errors when t he forecast is too high. For example, if actual demand for a week is 100 units and forecast demand was 90 units, the forecast was too low; the error is 100 - 90 =10.
- Forecast errors influence decisions in two somewhat different ways. O ne is in making a choice between various forecasting alternatives, and the other is in evaluating the success or failure of a technique in use.

METHODS OF MEASURING ACCURACY OF FORECAST

(1) Mean absolute forecast error or Mean Absolute Deviation (MAD)

(2) Mean absolute percentage error (MAPE) and

(3) Mean square error (MSE)



TREND PROJECTIONS:

- This time-series forecasting method fits a trend line to a series of historical data points and then projects the line into the future for medium- to long range forecasts.
- There are several mathematical trend equations that can be developed viz. linear, exponential, quadratic etc.
- One way to describe the trend component is to fit a line visually to a set of points on a graph. We can also fit a trend line by the method of least squares.
- Reasons for Studying Trends
- The study of secular trends allows us to describe a historical pattern.
  - Studying secular trends permits us to project past patterns, or trends, into the future.

In many situations, studying the secular trend of a time series allows us to eliminate the trend component from the series.

Techniques used:

EFFECT OF FORECASTING ON PRODUCTION ORDER

- More effective production scheduling

- Inventory management and reduction
- Cost reduction
- Optimized transport logistics
- Increased customer satisfaction

CAPACITY PLANNING:

Capacity: Capacity is defined as the ability to achieve, store or produce. For an organization, capacity would be the ability of a given system to produce output within the specific time period. In operations, management capacity is referred as an amount of the input resources available to produce relative output over period of time. In general, terms capacity is referred as maximum production capacity, which can be attained within a normal working schedule.

- Capacity is usually measured in production units (e.g. 1,000 cars per month or 50,000 meals per day).
- Productive capacity can change e.g. when a machine is having maintenance, capacity is reduced
- Capacity is linked to workforce planning: e.g. by working more production shifts, capacity can be increased
- Capacity needs to take account of seasonal or unexpected changes in demand. For example,
- Chocolate factories need capacity to make Easter Eggs in November and December before shipping them to shops after Christmas
- Capacity in a production or process sense (Production Capacity) refers to the maximum amount of output that can be obtained through a certain machine or production line.
- Capacity can also be expressed in terms of an output rate of a certain number of units per unit of time.
    - Capacity can be different when producing different products or it can be flexible and adjusted; this can make stating a certain capacity difficult, because it will ultimately depend on the product mix, which can sometimes follow the Pareto principle, produced and production downtime. Certain machinery and plants can state peak capacity, this is the maximum output amount, but it cannot be sustained for long periods of time or with a greater amount of resources. Thus the best figure to use is the most stable and efficient operating level capacity which delivers the optimum cost

curve for the operation. Capacity is an important input into setting production targets and goals.

Capacity planning forms the second principal step in the production system, the Product and Service design step being the first. The term "Capacity" of a plant is used to denote the maximum rate of production that the plant can achieve under given set of assumed operating conditions, for instance, number of shifts and number of plant operating days etc. Capacity planning is concerned with determining labour and equipment capacity requirements to meet the current master production schedule and long term future needs of the plant.

Capacity planning is essential to be determining optimum utilization of resource and plays an important role decision-making process, for example, extension of existing operations, modification to product lines, starting new products, etc.

Strategic Capacity Planning

A technique used to identify and measure overall capacity of production is referred to as strategic capacity planning. Strategic capacity planning is utilized for capital intensive resource like plant, machinery, labor, etc.

Strategic capacity planning is essential as it helps the organization in meeting the future requirements of the organization. Planning ensures that operating cost are maintained at a minimum possible level without affecting the quality. It ensures the organization remain competitive and can achieve the long-term growth plan.

Capacity Planning Classification

Capacity planning based on the timeline:

Long Term Capacity: Long range capacity of an organization is dependent on various other capacities like design capacity, production capacity, sustainable capacity and effective capacity. Design capacity is the maximum output possible as indicated by equipment manufacturer under ideal working condition. Production capacity is the maximum output possible from equipment under normal working condition or day. Sustainable capacity is the maximum production level achievable in realistic work condition and considering normal machine breakdown, maintenance, etc. Effective capacity is the optimum production level under pre-defined job and work-schedules, normal machine breakdown, maintenance, etc.

Long term capacity planning involves decisions on the following factors (i) Investment in new machines/equipments (ii) New plant construction (iii) Purchase of existing plants (iv) Closing down/selling obsolete facilities.

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

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

Short term capacity planning involves decisions on the following factors: (a) Employment levels (b) Number of work shifts (c) Labour overtime hours (d) Inventory stock piling (e) Order back logs (f) Subcontracting jobs to other plants/shops in busy periods.

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

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

Forecasting v/s Capacity Planning:

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

PLANT CAPACITY:

Plant capacity also referred to as production capacity refers to the volume or number of units that can be manufactured during a given period by using the existing resources. Several factors have a bearing on the capacity decision.

When a plant is first designed capacity planning is one of the first steps in the supply chain design process. The objective of capacity planning is to have enough production ability to meet the market's requirements without excessive lead time delays.

Capacity planning also forms part of the strategic planning process, in deciding the optimum design capacity for upgrades and market timing. When the needs of the market have been evaluated and relevant market studies completed then the next step is to create a capital expenditure request for management to analyse the merits and investment returns of building such production capacity.

The use of capacity is most commonly measured by the capacity utilization rate. This is a good indicator of an excess or deficit of capacity within the business and industry in order to supply current and expected demand. This figure can also vary among inventory/production models, stock building cycles, seasonal demand cycles, and warehousing practices.

The production system design planning considers input requirements, conversion process and output. After considering the forecast and long-term planning organization should undertake capacity planning.

MACHINE CAPACITY

Machine: A machine is a device that performs an intended action either with or without human intervention.

Capacity: Capacity is the maximum amount that something / someone can contain or produce.

Machine Capacity:

It is the maximum measure (Output) that the machine can produce by performing its intended action.

To arrive that maximum measure, there are certain factors to be considered. The major one is to know the rate at which the machine produces and it differs from machine to machine.

Determining Factors:

1.Cycle Time:

For an independent and exclusive CNC machine, the output can be measured through Cycle Time

For example, if the Cycle time of a product to be produced from a machine is 75 secs then,

Output / Hour = (60*60)/75 = 48 Numbers (Nos.)

2.Line Speed:

For a conveyor based machine, the output can be measured through Line speed. It can be metres per minute or metres per sec.

For example, the rate of production from an Extruding machine is defined as 25 mpm.

Output / Hour = 60*25= 1500 Metres

3.Equivalent Cycle Time:

The concepts briefed in 1 & 2 are simple. Now getting to the next level.

There are few process for which the output can be attained through several batches.

For example, A « B « C « D

In the above, first the product A is converted to B then to C and further to D. So D will be the final Product out of the machine. (All the 4 products are produced in the same machine with respect to different specifications at each stage)

So the time taken to produce D from the initiation of A will be the Equivalent cycle time.

4. Flexibility:

As the business of a company expands and grows, it is obvious to have wide variety of products to meet the customer needs, expectations and affordability. Here comes the flexibility. So to cater that demand, shop floor must be flexible enough to accommodate all the varieties in the production.

5.Weighted Average Cycle Time:

Weighted Average is defined as an average resulting from the multiplication of each component by a factor reflecting its importance.

From the above, for easy understanding of Weighted Average cycle time, the component is replaced by the varieties (Stock Keeping Units) of products and the factor is replaced by the production order / plan.

Go through the below example:

6.Weighted Average Line Speed:

You can follow the above example for Weighted Average Line Speed too. Replace cycle time by line speed and Avg. daily demand in Nos. by Metres.

Note:

In many cases, the line speed or cycle time mentioned by the manufacturer of machine varies with the cycle time or line speed for your product specification when fed on machine. So it is always better to get the cycle time or line speed proved with respect to manufacturer specification by producing products with your specification fed in machine. It is advisable to ensure it before series production.

$$CT_{weighted\,average} = \frac{\sum_{\text{each SKU or service offering}} (CT \times demand)}{total\,demand}$$

SKU	CT (seconds)	Avg Daily Demand (ADD)	CT x ADD (seconds)
A	219	23	5,037
B	198	31	6,138
C	203	16	3,248
D	240	13	3,120
E	212	44	9,328
SUM →		127	26,871

$$CT_{weighted\,average} = \frac{26,871 sec}{127}$$

$$CT_{weighted\,average} = 211.6\ sec$$

7.Allowances:

Allowance is defined as the amount of something that is permitted within a set of regulations or for a specified purpose.

When calculating the capacity of a Machine, allowances should be included in it, as every time the machine cannot produce its 100% output.

Example:

Assume 8 hours / shift is available for a factory to manufacture biscuits. Weighted Average cycle time for one biscuit packet to be ready is 211.6 secs. (as mentioned above)

So, the machine capacity for one shift can be arrived as :

Total available time per 8 Hrs shift = 8 x 60 x 60 = 28800 Secs

Cycle time per Biscuit packet = 211.6 Secs

Machine Capacity at 100% = 28800 / 211.6n= 136.106

Meaning 136 biscuit packets can be produced in one shift from that one specified machine. In every shift producing this 136 biscuit packets of Machine's 100% capacity is a tough challenge.

What all will be the factors that might contribute to challenge the 100% capacity?

a. Failure and breakdown : Machine might be stopped because of either mechanical or electrical breakdown. It might take some time to address it and reverting back to its original condition.

b. Setup Change : In order to accommodate different varieties of products in manufacturing (flexibility), set up change is required in the machine. It might be material change or machine setting change or some specification change in the machine. This might also consume some time.

Apart from these 2 major factors, one can also consider other factors with respect to the type of industry that is involved. In general, these factors are bench-marked from the Industry best standards.

Example : Machine Capacity

Table.2.8: Machine Capacity calculations

S.No.	Description	Formula	Units
A	Total Shift Operation		1
B	Housrs per shift		8
C	No. of Machines per shift		1
D	No. of Machine hours per shift	= B x C	
E	Total available mins per shift	= B x 60	480
F	Total available secs per shift	= E x 60	28800
G	Weighted Avg. cycle time (Secs)		211.6
H	Machine Capacity @ 100% (Nos.)	= F / G	136.106
I	Failure & Breakdown %		3.50%
J	Set up Change %		8%
K	Total considered Losses %	=I + J	11.50%
L	Targetted % of Machine capacity	= 100% - K	88.50%
M	Machine Capacity @ 88.5% (Nos.)	= H x L	120.454

ECONOMIC ORDER QUANTITY (EOQ):

Economic order quantity (EOQ) is the ideal order quantity a company should purchase to minimize inventory costs such as holding costs, shortage costs, and order costs. This production-scheduling model was developed in 1913 by Ford W. Harris and has been refined over time. The formula assumes that demand, ordering, and holding costs all remain constant.

- The amount of material procured or quantity produced during one prod uction cycle is known as order quantity or lot size.
- The major costs associated with inventory are ordering cost and inventory carry cost.
- The ordering cost and the carr y cost is mutually exclusive
- When the size of order increases, the ordering cost will decrease wherea s the inventory carry cost will increase.

- When the size of the order d ecreases, the inventory carry cost will decrease whereas the ordering cost will increase.

- The technique of economic ordering quantity strikes a balance between the ordering cost and the carrying cost. EOQ is that siz e of the order which minimize the total costs of carrying and inventory.

Formula and Calculation of Economic Order Quantity (EOQ)

The formula for EOQ is:

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

where:

- Q = EOQ units
- D = Demand in units (typically on an annual basis)
- S = Order cost (per purchase order)
- H = Holding costs (per unit, per year)

The total cost (TC) of stocking inventory is the sum, of the cost of purchase, plus the cost of ordering, plus the cost of carrying.

Total cost= annual ordering cost+ Annual carry cost+ Annual purchase cost

$$TC = \frac{D}{Q}S + \frac{Q}{2}H + DC$$

Annual ordering cost= (annual demand order quantity) * (ordering cost/order)

$$Annual\ ordering\ cost = \frac{D}{Q}S$$

Annual carry cost= (average inventory*inventory carrying cost)

$$Annual\ carrying\ cost = \frac{Q}{2}H$$

Annual purchase cost= (annual demand*cost/unit)

$$Annual\ purchase\ cost = DC$$

The goal of the EOQ formula is to identify the optimal number of product units to order. If achieved, a company can minimize its costs for buying, delivery, and storing units. The EOQ formula can be modified to determine different production levels or order intervals, and

corporations with large supply chains and high variable costs use an algorithm in their computer software to determine EOQ.

EOQ is an important cash flow tool. The formula can help a company control the amount of cash tied up in the inventory balance. For many companies, inventory is its largest asset other than its human resources, and these businesses must carry sufficient inventory to meet the needs of customers. If EOQ can help minimize the level of inventory, the cash savings can be used for some other business purpose or investment.

The EOQ formula determines a company's inventory reorder point. When inventory falls to a certain level, the EOQ formula, if applied to business processes, triggers the need to place an order for more units. By determining a reorder point, the business avoids running out of inventory and can continue to fill customer orders. If the company runs out of inventory, there is a shortage cost, which is the revenue lost because the company has insufficient inventory to fill an order. An inventory shortage may also mean the company loses the customer or the client will order less in the future.

Example of How to Use EOQ

EOQ takes into account the timing of reordering, the cost incurred to place an order, and the cost to store merchandise. If a company is constantly placing small orders to maintain a specific inventory level, the ordering costs are higher, and there is a need for additional storage space.

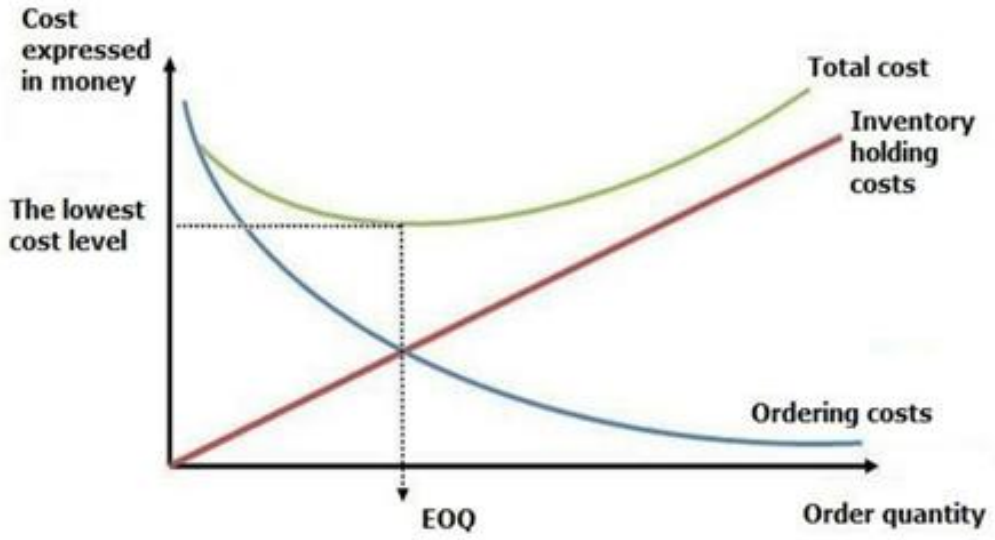
Assume, for example, a retail clothing shop carries a line of men’s jeans, and the shop sells 1,000 pairs of jeans each year. It costs the company $5 per year to hold a pair of jeans in inventory, and the fixed cost to place an order is $2.

The EOQ formula is the square root of (2 x 1,000 pairs x $2 order cost) / ($5 holding cost) or 28.3 with rounding. The ideal order size to minimize costs and meet customer demand is slightly more than 28 pairs of jeans. A more complex portion of the EOQ formula provides the reorder point.

Limitations of Using EOQ

The EOQ formula assumes that consumer demand is constant. The calculation also assumes that both ordering and holding costs remain constant. This fact makes it difficult or

impossible for the formula to account for business events such as changing consumer demand, seasonal changes in inventory costs, lost sales revenue due to inventory shortages, or purchase discounts a company might realize for buying inventory in larger quantities.



PROBLEMS

Problems:1

Simple Average:

A XYZ television supplier found a demand of 200 sets in July, 225 sets in August & 245 sets in September. Find the demand forecast for the month of october using simple average method. The average demand for the month of October is

$$SA = \left(\frac{D1+D2+D3}{3}\right)$$
$$= \left(\frac{200+225+245}{3}\right)$$
$$= 223.33$$
$$\approx 224 \text{ units}$$

Problems:2

Simple Moving Average:

A XYZ refrigerator supplier has experienced the following demand for refrigerator during past five months

Month	Demand
February	20
March	30
April	40
May	60
June	45

Find out the demand forecast for the month of July using five-period moving average & three-period moving average using simple moving average method.

$$MA_n = \frac{\sum_{i=1}^{n} Di}{n}$$

For five period average (i.e. n = 5)

$$MA_5 = \frac{20+30+40+60+45}{5}$$

$$= 29 \text{ units}$$

For three period average (i.e. n = 3)

$$MA_3 = \frac{40+60+45}{3}$$

$$= 48.33$$

$$\approx 49 \text{ units}$$

Problems:3

Weighted Moving Average Method:

The manager of a restaurant wants to m ake decision on inventory and overall cost. He wants to forecast demand for some of the items based on weighte d moving average method. For the past three m onths he experienced a demand for pizzas as follows: Find the demand for the month of January by assuming suitable weights to demand data.

Month	Demand
October	400
November	480
December	550

$$WMA = \sum_{i=1}^{n} CiDi$$

Ci = Weights for Periods

Di = Demand for Periods

Let C1 = 0.25, C2 = 0.3, C3 = 0.5

$\therefore$ WMA = C1D1 + C2D2 + C3D3

$= 0.25 * 400 + 0.3 * 480 + 0.5 * 550$

$= 100 + 144 + 275$

$= 519$ units

Problems:4

Exponential Smoothing:

One of the two wheeler manufacturing company experienced irregular but usually increasing demand for three products. The demand was found to be 420 bikes for June and 440 bikes for July. They use a forecasting method which takes average of past year to for ecast future demand. Using the simple average method demand forecast for June is found as 320 bikes (Use a s moothing coefficient 0.7 to weight the recent d emand most heavily) and find the demand forecast for August

$F_t = \alpha D_{t-1} + (1-\alpha) F_{t-1}$

where α = Smoothig Coefficient

D_{t-1} = Actual Demand for Recent Period

F_{t-1} = Demand Forecast for Recent Period

F_t = Forecast of Next Period Demand

for July:

$= 0.7(420) + (1-0.7)320$

$= 294 + 96$

$= 390$ units

for August:

$= 0.7(440) + (1-0.7)390$

$= 308 + 117$

$= 425$ units

Problems: 5

Regression Analysis:

Farewell Corporation manufactures Integrated Circuit boards (I.C board) for electro nics devices. The planning department knows that the sales of their client goods depends on how much they spend on advertising, on account of which they receive in a dvance of expenditure. The planning department wish to find out the relationship between their clients advertising and sales, so as to find demand for I.C board. The money spends by the client on advertising and sales (in dollar) is given for different periods in followin g table:

Period(t)	Advertising (X_t) $(1,00,000)	Sales (D_t) $(1,000.000)	D_t^2	X_t^2	X_tD_t
1	20	6	36	400	120
2	25	8	64	625	200
3	15	7	49	225	105
4	18	7	49	324	126
5	22	8	64	484	176
6	25	9	81	625	225
7	27	10	100	729	270
8	23	7	49	529	161
9	16	6	36	256	96
10	20	8	64	400	120
$\sum$	211	76	592	4597	1599

$$b=\frac{n(\sum X_tD_t)-(\sum X_t)(\sum D_t)}{n(\sum X_t^2)-(\sum X_t)^2}$$

$$=\frac{10(1599)\ (211)(76)}{10(4597)-(211)^2}$$

$$=\frac{15990-16036}{45970-44521}$$

$$=\frac{-46}{1449}=-0.0317$$

$$a=\sum D_t-b\sum X_t$$

$$=\frac{76-(-0.0317)211}{10}$$

$$=8.268$$

Relationship between future sales F_t and advertising cost X_t is

$$F_t=a+bX_t$$

$$=8.268-0.0317X_t$$

Problem 6:

A comparison of monthly sales of an expensive item, against the total number of visits made l salesman during the previous month, yields the following data. Is the correlation of the two variables goo enough to enable the number of sales visits, to be adopted as an efficient indicator of future sales ?

Sales(x)	1	3	5	7	11
Visits made(y)	2	4	8	9	10

Solution

x	$(x-\bar{x})$	$(x-\bar{x})^2$	y	$(y-\bar{y})$	$(y-\bar{y})^2$	$(x-\bar{x})(y-\bar{y})$
1	−4.4	19.5	2	−4.6	19.5	20.0
3	−2.4	5.8	4	−2.6	6.9	6.25
5	−0.4	1.6	8	+1.4	1.95	0.56
7	+1.6	2.6	9	+2.4	5.8	3.85
11	+5.6	31.5	10	+3.4	11.5	19.6
$\Sigma x=27$		61.0	$\Sigma y=33$		45.45	50.26

$$\bar{x}=\frac{27}{5}=5.4 \qquad \bar{y}=\frac{27}{5}=6.6$$

$$r=\frac{\Sigma(x-\bar{x})(y-\bar{y})}{\Sigma(x-\bar{x})^2\ \Sigma(y-\bar{y})^2}=\frac{50.26}{61.0\times45.5}=0.96$$

The correlation between the number of salesman's visits and the number of sales is 0.96, which sufficient to justify its possible use as a method of short-term sales forecasting.

Problem 7:

Given the data in table below, find the regression line for predicting *growth* and calculate the *growth* for a weight value of 50.

Let growth be variable Y

Let weight be variable X

$\therefore Y = a + bX$

Weight (x)	*Growth* (y)	x^2	xy
12	5.5	144	66
18	5.9	324	106.2
24	6.5	576	156
30	7.4	900	222
36	8.2	1296	295.2
42	8.9	1764	373.8
48	8.6	2304	412.8
$\Sigma x=210$	$\Sigma y=51$	$\Sigma x^2=7308$	$\Sigma xy=1632, n=7$

From equations (*ii*) and (*iii*) above

$$b = \frac{7(1632)-(210)(51)}{7(7308)-(210)^2} = \frac{714}{7056} = 0.10119$$

$$a = \frac{(51)+0.10119(210)}{7} = 10.32$$

Now, $Y = a+bX$; where $X = 50$.

$\therefore Y = 10.32 + (0.10119 \times 50) = 15.379$

The regression line provides only an estimate of the value of Y on X. The uncertainty or accuracy of the estimate can be assessed by calculating the *standard error* of the estimate of Y on X, ($S_{Y.X}$)

$$S_{Y.X} = \sqrt{\frac{\Sigma(y-y_1)^2}{n-2}}$$

where y = actual value

y_1 = value calculated from regression equation.

The standard error of the estimate of X on Y is given similarly by :

$$S_{X.Y} = \sqrt{\frac{\Sigma(x-x_1)^2}{n-2}}$$

$S_{Y.X}$ or $S_{Y.X}$ provides a measure of the *closeness of* the relationship between the two variables. The smaller the figure, the closer are the values to the regression line and hence the more accurate is the regression equation for predictive purposes.

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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SPR1306 – PRODUCTION PLANNING AND CONTROL

COURSE MATERIAL

UNIT – III – SPR1306 - PREPLANNING

Production planning – process planning – economics of new design – value analysis, material layout planning– case studies – elements of MRP and ERP- Inventory Control, EOQ – Selective control systems – ABC, VED, FNS analysis – inventory control parameters

III. PREPLANNING

Production planning: It is defined as the determination, acquisition and arrangement of all facilities necessary for future production of products. Production planning is a managerial function which is mainly concerned with the following important issues:

- What production facilities are required?
- How these production facilities should be laid out in the space available for production?
- How they should be used to produce the desired products at the desired rat e of production?
- t involves management decision relating to how much to produce, what materials, part and tools will be required, what steps should be completed and how much work is to be done by each work station. It is a pre-production activity.
- It is the pre determination of manufacturing requirements such as manpower, materials, machines and manufacturing process.
- Production planning is dynamic in nature and always remains in fluid state as plans may have to be changed according to the changes in circumstances.
- According to Mikell P.Groover, production planning is concerned with.
- Deciding which products to make, how many of each, and when they should be completed.
- Scheduling the production and delivery of the parts and products
- Planning the manpower and equipment resources needed to accomplish the production plan.

Levels of production planning: It can be done at three levels:

1. Factory planning,
2. Process planning,
3. Operation planning

Factors determining production planning:

- Volume of production,
- Nature of production processes,
- Nature of operations

Requirements of production planning:

- It should be based on accurate data.
- It must be flexible, simple and straight forward.
- It must satisfy a set of pre-defined objectives (economy, quality etc.).
- It must have a reporting syste m, so that right information reaches at right place and right time.
- It should not have any week link.

Production system

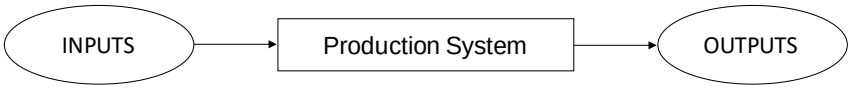

Fig.3.1: Production Systems

Functions of production system

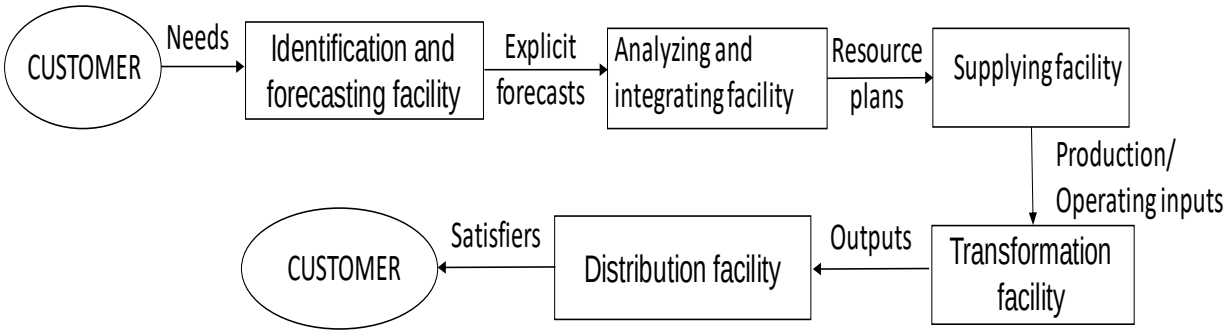

Fig.3.2: Functions of Production Systems

Process planning: Technology selection, process selection, machine selection, tool selection, process parameter selection, operation sequen cing etc.

- Itconsists of preparing set of instruction that describe how to manufacture the product and its parts.
- It is a detailed specification which lists the operation, tools and facilities.
- It is also known as operation planning, is the systematic determination of the engineering processes and systems to manufacture a product competitively and economically.
- Assembly and components drawings and bill of material list.
- Machine and equipment detail
- Various possible operaation that can be performed

- The maximum and minimum dimensions that can be machined on t he machines
- The accuracy of the dimensions that can be obtained
- Available feeds and speeds on the machine

 Standard time for each operat ion and details of setup time for each job

 Availability of machines, equ ipment and tools

Cycle of production functions

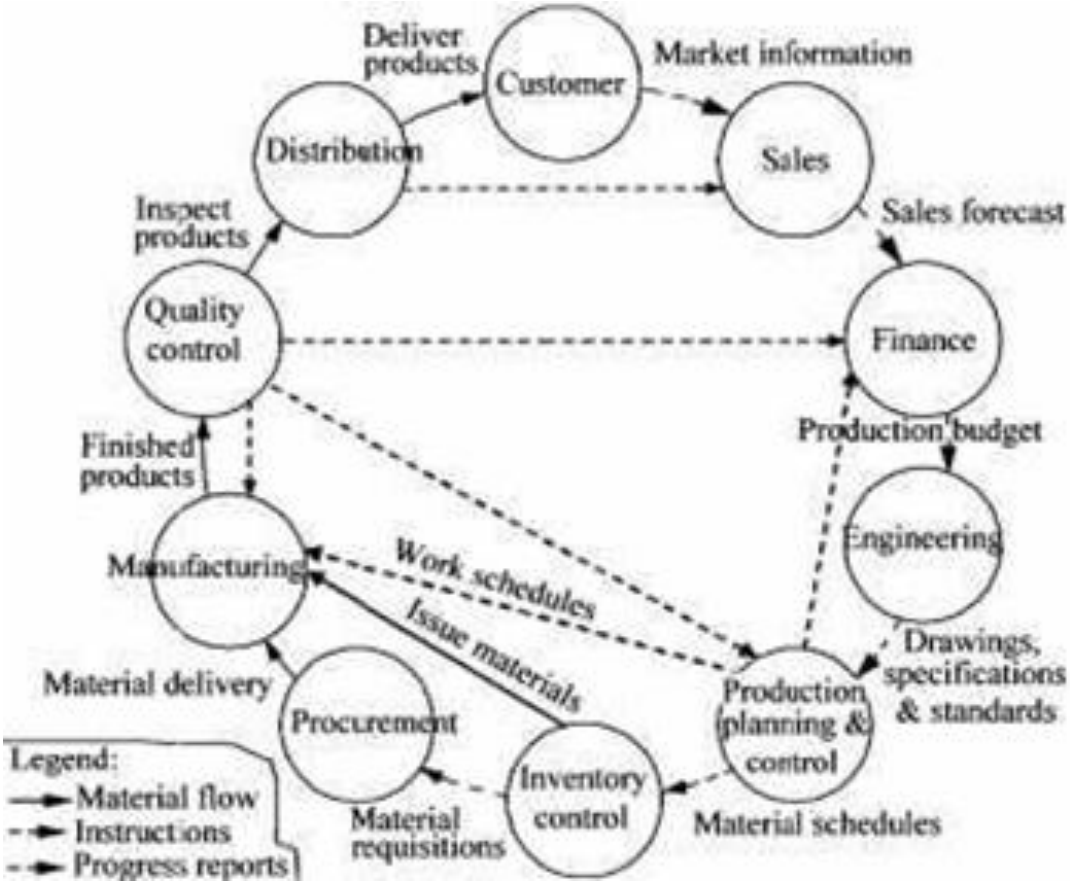

Fig.3.3: Cycle Production functions

Value analysis

Value analysis and Value Engineering:

 Value analysis is a techniqu e applied to identify unnecessary features o r components that can be eliminated in order to reduce the cost, without any reduction in the performance quality of the finished product.

- It focuses the attention of eng ineering, manufacturing, and purchasing on one objective – equivalent performance for lower cost.
- It results in the orderly utiliz ation of low cost alternative materials, low cost alternative processes including new processes, and abilities of specialized suppliers to procure items at lower costs.
- the value analysis is used to id entify efficiently the unnecessary cost,
- Value analysis refers to the analysis of an existing product, service or administrative process while
- Value engineering refers to the same analysis applied to the product, services or administrative processes that are under design and have not been finalized.

Techniques of Value Analysis and Engineering that identifying and removing u nnecessary cost, and thus improving the value, must be done without reducing in the slightest degree quality, safety, life, reliability, Maintainability, and the features and attractiveness that the customer wants.

What is Value?

- Value is the relationship between the defined function the customer requir es and the costs incurred to provide that function.

Types of Economic value:

- Use value: The properties and qualities which accomplish a use, work, or service.

Esteem value: The properties, features, or attractiveness which causes us to want to own it

- Cost value: The sum of labor, material, and various other costs required to produce it.
- Exchange value: Its properties or qualities which enable us to exchange it for something else we ant.

When is VA/VE used?

- Existing part/product cost is high
- Existing technology is complex/old though simpler means are available
- There is a need to release a cheaper product by cutting down some of the existing feature
- The existing customer demands a minimal increment in product features that are in use
- There is a need to cut down the manufacturing cycle time/cost

- To determine the best design alternatives for Projects, Processes, Products, or Services
- To improve quality, increase reliability and availability, and customer satisfaction.

Benefits of Value Engineering:

- Decreasing costs
- Increasing profits
- Improving quality
- Expanding market share
- Saving time
- Using resources more effectively

Six Steps of Value Engineering

Job Plan

Value engineering is often done by systematically following a multi-stage job plan. Miles' original system was a six-step procedure which he called the "value analysis job plan." Depending on the application, there may be four, five, six, or more stages.

Blast: In this stage alternative product, materials, process, or ideas are generated.

- These alternatives should, first of all, qualify for accomplishing some important part of the function in a very economical manner or, at least, serve as an economical base for modifications that are
  likely to accomplish an important part of function.

Create: In create phase, the technique of "Use real creativity" needs to be employed to come out with ways by which the low cost alternatives identified during the blast stage can be modified to accomplish the specified function to a much greater extent with pertinent increase in cost.

Refine: In this step, much more creativity is used and also the techniques "Use industry experts to extend specialized knowledge" and "Utilize and pay for vendors' skills and knowledge" are used to refinethe ideas developed during the create step to come out with a refined alternative that fully accomplishes the specified function at a lower cost. During refine step, some more functionality is added as well as some additional cost.

Phase1. Orientation:(identify the product): Understand the customers' needs and wants.

- Understand the functions performed by the product and the contribution of each part and each feature of the part and the complete product to the functions to be performed by the product.

Phase2. Information: Collection of information on quantities, vendors, drawings, materials, manufacturing methods, and costs.

Phase3. Speculation: Using all the techniques of value analysis to come out with alternative low cost materials and methods to produce components and the product. Creativity is to be employed here. Value engineer has to involve experts from various disciplines to help with ideas.

Phase4. Analysis: Refines and combines ideas, establish costs on all ideas, and ranks the ideas generated in the creativity phase. The two most common Value Method techniques used for ranking are "criteria weighting matrix and evaluation analysis ranking".

Phase5. Program planning: Approach the specialists to further refine the selected alternatives. Inform the specialists the accepted suggestions and give mandate to them to take steps to implement the suggestions

Phase6. Program execution: Pursue regularly the specialists and vendors to get their inputs on various tasks assigned to them. The output of this phase is a detailed design,

Phase7. Status summary and conclusion: The results of the value engineering study are to be presented to decision makers. The reports need to have a summary sheet as well as the full supporting documentation. The value engineering project is concluded when the product is manufactured and distributed at the lowered cost as per the value engineering study.

Materials Resource Planning (MRP):

Material requirement planning is a system based approach, which organizes all necessary production material. Material Requirements Planning, abbreviated as MRP is a straightforward system to calculate arithmetically the requirements of the input materials at different points of time based on actual production plan. Theorists described MRP as a planning and scheduling system to meet time-phased materials requirements for production

operations. It is a set of techniques that calculate the requirement of all items structured in bill of material. The calculated requirements are based on the quantity and timing requirement of end items listed in master production schedule. The item calculation requirement is based on the master production schedule, the bill of material file and the item master file (Toomey, 1996). The main intent of is to meet the delivery schedule of finished products as specified in the master production schedule. MRP is a material planning method that developed in the decade of1970 that utilized computer technology.

Material requirement planning is an information system for production planning based on inventory management. It is stated in management studies that Information Technology has major role in designing and implementing Material Requirements Planning systems and processes as it provides information about manufacturing needs as well as information about inventory levels. MRP techniques focus on optimizing inventory. MRP techniques are used to explode bills of material, to calculate net material requirements and plan future production. The main traits of MRP are the creation of material requirements via exploding the bills of material, and time-phasing of requirements using posted average lead times. MRP II was developed as the second generation of MRP and it features the closed loop system: production planning drives the master schedule which drives the material plan which is the input to the capacity plan. Feedback loops provide input to the upper levels as a reiterative process.

The vital components of material planning include the following:

1. Material planning provides information that all the required raw material and products are available for production.
2. Material planning guarantees that inventory level is maintained at its minimum levels. But also ensures that material and product are available whenever production is scheduled, therefore, helping in matching demand and supply.
3. Material planning provides information of production planning and scheduling but also provides information around dispatch and stocking.

The major objectives of MRP: The goal of the Material Requirements Planning document is to supply information that will facilitate the company to have enough inventory on hand to fulfil demand, available only when needed at a quality level that meets specification, (and at the lowest price. A good Material Requirements Planning program can offer the fundamental

needs of keeping inventory levels low and fulfilling customer expectations for on time delivery. Major objectives are as under:

1. Reduction in Inventory Cost: MRP offers accurate quantity of material at right time to meet master production schedule to avoid the cost of excessive inventory.
2. Meeting Delivery Schedule: By minimizing the delays in materials procurement, production decision making, MRP assists evade delays in production thereby meeting delivery schedules more consistently.
3. Improved Performance: By stream lining the production operations and minimizing the unplanned interruptions, MRP focuses on having all components available at right place in right quantity at right time.

It was discussed in demand forecasting that in the dependent demand situation, if the demand for an item is known, the demand for other related items can be deduced. For example, if the demand of an automobile is known, the demand of its sub-assemblies and sub components can easily be deduced. For dependent demand situations, normal reactive inventory control systems (i.e. EOQ etc.) are not suitable because they result in high inventory costs and unreliable delivery schedules. More recently, managers have realized that inventory planning systems (such as materials requirements planning) are better suited for dependent demand items. MRP is a simple system of calculating arithmetically the requirements of the input materials at different points of time based on actual production plan.

MRP can also be defined as a planning and scheduling system to meet time-phased materials requirements for production operations. MRP always tries to meet

- MRP is a simple system of calculating arithmetically the requirements of the input materials at different points of time based on actual production plan.
- MRP can also be defined as a planning and scheduling system to meet time-phased materials requirements for production operations.
- MRP always tries to meet the delivery schedule of end products as specifie d in the master production schedule.

Elements of MRP: Materials planning: materials specifications, material volumes, economical lot sizing, inventory planning, store planning.

Objectives:

- **Reduction in Inventory Cost**: By providing the right quantity of mate rial at right time to meet master production schedule, MRP tries to avoid the cost of excessive inventory.
- **Meeting Delivery Schedule** : By minimizing the delays in materials procurement, production decision making, MRP helps avoid delays in production thereby meetin g delivery schedules more consistently.
- **Improved Performance**: By stream lining the production operations and minimizing the unplanned interruptions, MRP focuses o n having all components available at right place in right quantity at right time.

Material Requirements Planning System Architecture

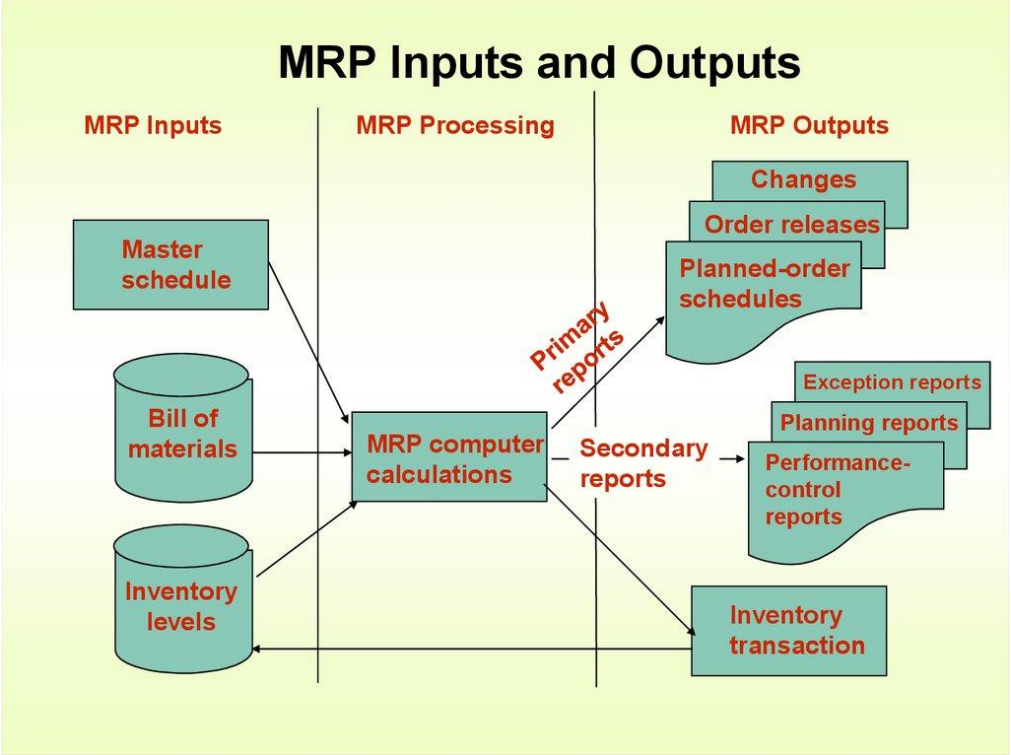

Fig.3.4: Material Requirements Planning

Master Production Schedule (MPS):

MPS is designed to meet the market demand (both the firm orders and forecasted demand) in future in the taken planning horizon. MPS mainly depicts the detailed delivery schedule of the end products. However, orders for replacement components can also be included in it to make it more comprehensive.

Bill of Materials (BOM) File:

BOM represents the product structure. It encompasses information about all sub components needed, their quantity, and their sequence of buildup in the end product. Information about the work centers performing buildup operations is also included in it.

Inventory Status File:

Inventory status file keeps an up-to-date record of each item in the inventory. Information such as, item identification number, quantity on hand, safety stock level, quantity already allocated and the procurement lead time of each item is recorded in this file.

After getting input from these sources, MRP logic processes the available information and gives information about the following:

- **Planned Orders Receipts**: This is the order quantity of an item that is planned to be ordered so that it is received at the beginning of the period under consideration to meet the net requirements of that period. This order has not yet been placed and will be placed in future.
- **Planned Order Release**: This is the order quantity of an item that is planned to be ordered in the planned time period for this order that will ensure that the item is received when needed. Planned order release is determined by offsetting the planned order receipt by procurement lead time of that item.
- **Order Rescheduling**: This highlight the need of any expediting, de-expediting, and cancellation of open orders etc. in case of unexpected situations.

Advantages of MRP: Material requirement planning is framework to give valuable information for decision makers. Main benefits from any MRP system are the capability of the inventory planner to use the information well. The particular benefits of MRP include the following:

1. Increased customer service and satisfaction
2. Improved utilization of facilities and personnel
3. Better inventory planning and scheduling
4. Faster response to market changes and shifts
5. Reduced inventory levels without reduced customer service

Major issues of using procedure of Material requirements planning are that they are not fully perfect. If there is some error in the system, then it is going to throw off all the other numbers

thus making the outputted data inaccurate. The issue with MRP systems is the integrity of the data. If there are any errors in the inventory data, the bill of materials, that are called 'BOM data, or the master production schedule, then the outputted data will also be incorrect. Data integrity is impacted by imprecise cycle count adjustments, mistakes in receiving input and shipping output, scrap not reported, waste, damage, box count errors, supplier container count errors, production reporting errors, and system issues. Many of these types of errors can be minimized by implementing pull systems and using bar code scanning. Most sellers of this type of system recommend at least 99% data integrity for the system to give valuable results. Another problem is that Material requirements planning systems do not necessarily factor in other warehouses in other cities or states. Therefore, the system will explain that company do not need to order anymore parts when in fact those parts are in other factories. Other major factor is that the MRP system can not consider manpower.

To summarize, material requirements planning is a computer-based inventory management system designed to help production managers in scheduling and placing orders for items of dependent demand. Material Requirements Planning is software based production planning, which utilizes an inventory system to systematize various manufacturing processes. Principally when a company is going to produce products to sell, this software organizes all inventories, while making sure that all the products and materials are in place in order for this to be possible.

MANUFACTURING RESOURCES PLANNING (MRP II)

MRP II is essentially an extended form of closed loop MRP that also incorporates strategic planning processes, business planning, and a number of other business functions such as human resources planning, profit calculation and cash flow analysis.

MRP II uses the master production schedule as the basis for scheduling capacity, shipments, tool changes, some design work, and cash flow. It therefore requires several additions to the reference files. One is a bill of resources, which details key resources needed to produce one unit of product. These resources may include labour, machinery, tools, space and materials. The MRP II system can use the bill of resources to project shortages at specific times, giving departments advance notice of required remedial action: for example, of the need to hire or train labour.

MRP II can also project needs for support resources; for example, design engineering support if a customer order entails prior design work. This additional resource is added to the bill of resources. Given still more reference data, MRP II can keep track of tool wear and recommend when to replace or resharpen tooling. It can also keep track of machine loads and project machine capacity shortages, which may signal a need for more machines or a subcontractor.

For financial planning, MRP II treats cash flow almost like materials. The MPS is first exploded into component parts requirements; the system then calculates the cost and payment dates of all planned order releases, effectively creating a cash flow forecast. This includes not just payments to suppliers, but also wages, power and other consumables associated with production. Cash outflows may be projected for a year or more by expense category, work centre or department, making budgeting much simpler than it would be without an MRP II system. The diagram overleaf shows how an MRP II system might operate.

An MRP II system also includes financial information about each operation; as in Fig., in which it calculates profit levels based on financial data from other modules. That's the theory. But when studying real-life MRP II systems, two important factors need bearing in mind. First, MRP II systems can be customized to some extent by adding only the modules an organization needs, and so will often differ from one organization to another. Second, what looks like a 'pure' MRP II system may not have started out as an MRP II system. It may instead have evolved from an existing system until something resembling an MRP II system is being used. What is important is how the system is used to plan and control the business.

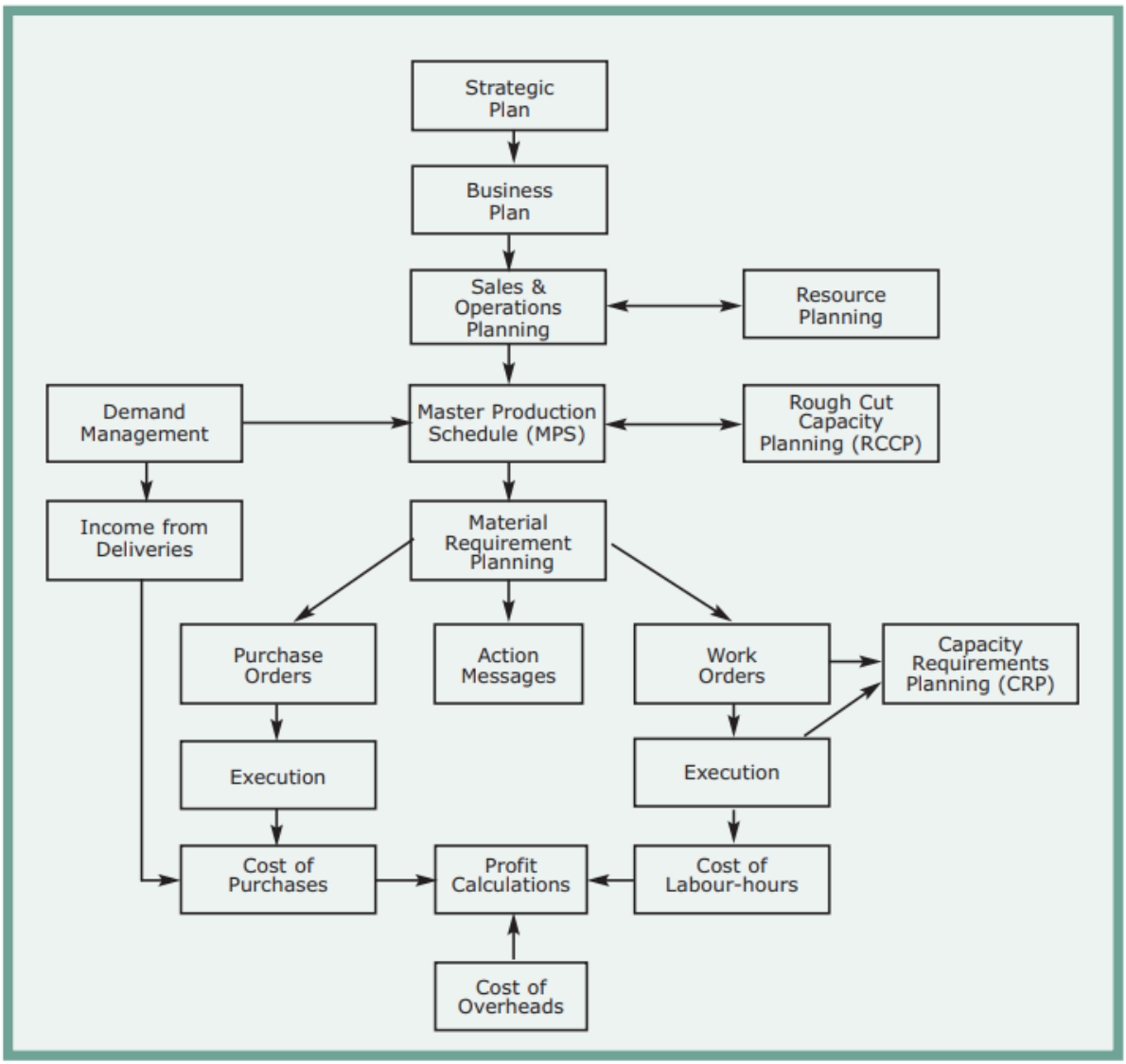

Fig.3.5: Manufacturing Resource Planning

It is also essential to note that MRP II is not a computer-based production planning system. It needs to know the organization's overall business aims and objectives and pulls in many other business functions. These appear as additional functions to material requirements planning and closed loop MRP systems. As these extra modules generate extra feedback loops, it can easily be seen from the next diagram that an MRP II feedback system should significantly improve management's ability to plan and control the organizations activities.

Benefits of MRPII In the narrow sense, the main benefit of MRP II is its ability to generate valid schedules and keep them valid. But valid schedules have broader benefits for the whole organization. These include, more or less in order of importance:

1. Improved on-time completion A typical manufacturing organization using MRP II should be able to achieve on-time completion rates of 95 per cent or more, because completion of a parent item is less likely to be delayed for lack of a component. On-time completion helps improve customer service.

2. Reduced inventories Inventory falls - typically by 20-35 per cent - because parts are not ordered until needed.

3. Capacity requirements planning data Work centre capacity requirements can be planned for many periods into the future.

4. Improved direct labour productivity Fewer shortages means significantly less lost time and overtime, and less disruption to accommodate shortage-list jobs.

5. Improved productivity of support staff MRP II cuts expediting (or 'firefighting') and allows more time for planning. For example, purchasing can start looking for alternative or better suppliers; materials management can plan inventory needs better.

6. Total business planning The ability to use one common set of data to help plan and control the whole business.

Drawbacks of MRPII

There is no getting away from the fact that MRP II is complex. As we'll see shortly in A typical MRP II implementation programme, it takes a lot of time, effort and commitment at all levels of the organization to set up a successful MRP II system. The benefits, however, should very quickly make the exertion worthwhile.

MRPII implementation levels

MRP II systems can be implemented at different levels with varying rates of success. Most MRP II experts use The Oliver Wight ABCD Checklist for Operational Excellence - also known as ABCD classification - to identify these different levels. The ABCD Checklist is a comprehensive list of questions that organizations can use to rate their MRP II capability or potential. According to Oliver Wight, the characteristics that put an organization into category A, B, C or D can be summed up as:

Class A Planning and control processes are effectively used company wide, from top to bottom. Their use generates significant improvements in customer service, productivity, inventory, and costs.

Class B These processes are supported by top management and used by middle management to achieve measurable company improvements.

Class C Planning and control system is operated primarily as a better method for ordering materials; contributing to better inventory management.

Class D Information provided by the planning and control system is inaccurate and poorly understood by users; providing little help in running the business.

(From The Oliver Wight ABCD Checklist for Operational Excellence Oliver Wight Publications Inc, USA - ISBN 0-939246-30-9)

Class A is the level most likely to produce maximum benefits to an organization as a whole. It can be defined as MRP II implemented throughout the organization, generating significantly improved customer service and productivity with lower inventory and costs. At Class A level, the organization is run with one set of figures from top management plans down to shop-floor operating schedules, and managers make extensive use of computer simulation for 'What if?' situation analysis.

Benefits Class A users can expect from an MRP II system include:

- Better customer service: more on-time deliveries etc.
- Shorter manufacturing and administration lead-times, resulting in a more responsive business.
- Less work-in-process as work is not released until demand requires it.
- Steadily diminishing inventory levels and associated costs.
- Better balanced inventory, with less obsolete stock and fewer stock shortages.
- Increased productivity and less waste, as materials and labour are used only to fulfil orders and not on production for stock.
- The ability to simulate 'What if?' situations, especially as a way of keeping production in line with profit targets

MRPII summary

- If an MRP II system is correctly and fully implemented, improvements automatically follow. Significant benefits include better delivery performance, reduced inventory, shorter lead times, lower operating costs and - ultimately - increased profits. MRP II principles can be applied to all forms of manufacturing. Commercial
- MRP II software was originally designed for mass or batch production, but systems are now available for most forms of production.
- However, organizations should not leap straight into MRP II. Senior managers must have a clear and detailed understanding of what MRP II is and how it works, and of its potential benefits, before deciding whether it is right for their organization.
- Let's now look at how an organization might reach a decision to implement (or not!) MRP II, and how an effective implementation programme might be planned and carried out.

Enterprise Resource Planning (ERP)

ERP- DEFINITION 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.

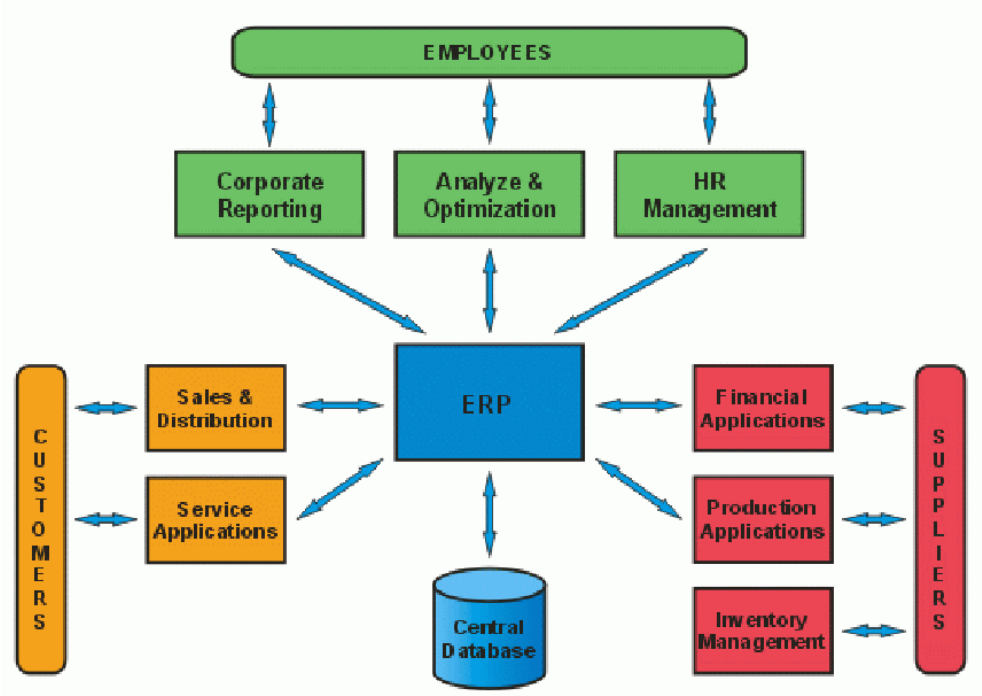

Fig.3.5: Enterprises Resource Planning

Evolution of ERP:

In the ever-growing business environment, the following demands are placed on the industry:

- Aggressive cost control initiatives
- Need to analyse costs/revenues on a product or customer basis
- Flexibility to respond to changing business requirements
- More informed management decision making
- Changes in ways of doing business.

One or more applications and planning systems have been introduced into the business world for crossing Some of hurdles and achieving growth. They are:

- Management Information Systems (MIS)
- Integrated Information Systems (IIS)
- Executive Information Systems (EIS)
- Corporate Information Systems (CIS)
- Enterprise Wide Systems (EWS)
- Material Resource Planning (MRP)

- Manufacturing Resource Planning (MRP II)
- Money Resource Planning (MRP III)

ERP has evolved from the system known as MRPII (Manufacturing Requirement planning) system with the integration of information between Vendor, Customer and Manufacturer using networks such as LAN, WAN and INTERNET etc.

MRPII system again evolved from MRP (Material Requirement Planning) system. MRP is a technique that explodes the end product demands obtained from Master Production Schedule (MPS) for the given product structure which is taken from Bill of Material (BOM) into a schedule of planned orders considering the inventory in hand.

MRPII has a number of drawbacks.

- The main problem is that it has not been able to effectively integrate the different functional areas to share the resources effectively.
- The traditional application systems, which the organizations generally employ, treat each transaction separately
- They are built around the strong boundaries of specific functions that a specific application is meant to cater.

For an ERP, it stops treating these transactions separately as stand-alone activities and considers them to be the part of the inter-linked processes that make up the business.

Enabling Technologies :

- It is not possible to think of an ERP system without sophisticated information technology infrastructure.
- It is said that, the earlier ERP systems were built only to work with huge mainframe computers.
- The new era of PC, advent of client server technology and scalable Relational Database Management Systems (RDBMS)
- Most of the ERP systems exploit the power of Three Tier Client Server Architecture.
- The other important enabling technologies for ERP systems are Workflow, Work group, Group Ware, Electronic Data Interchange (EDI), Internet, Intranet, Data warehousing, etc.

ERP Characteristics: Any system has to possess few key characteristics to qualify for a true ERP solution. These features are:

1. Flexibility : An ERP system should be flexible to respond to the changing needs of an enterprise. The client server technology enables ERP to run across various database back ends through Open Database Connectivity (ODBC).

2. Modular & Open : ERP system has to have open system architecture. This means that any module can be interfaced or detached whenever required without affecting the other modules. It should support multiple hardware platforms for the companies having heterogeneous collection of systems. It must support some third party addons also.

3. Comprehensive : It should be able to support variety of organizational functions and must be suitable for a wide range of business organizations.

4. Beyond The Company : It should not be confined to the organizational boundaries, rather support the on-line connectivity to the other business entities of the organization.

5. Best Business Practices : It must have a collection of the best business processes applicable worldwide. An ERP package imposes its own logic on a company's strategy, culture and organization.

Features of ERP : Some of the major features of ERP and what ERP can do for the business system are :

- ERP provides multi-platform, multi-facility, multi-mode manufacturing, multi-currency, multi-lingual facilities.
- It supports strategic and business planning activities, operational planning and execution activities, creation of Materials and Resources..
- ERP covering all functional areas like manufacturing, selling and distribution, payables, receivables, inventory, accounts, human resources, purchases etc.
- ERP performs core activities and increases customer service, thereby augmenting the corporate image. ERP bridges the information gap across organisations.
- ERP provides complete integration of systems not only across departments but also across companies under the same management.
- ERP is the solution for better project management.

- ERP allows automatic introduction of the latest technologies like Electronic Fund Transfer (EFT), Electronic Data Interchange (EDI), Internet, Intranet, Video conferencing, E-Commerce etc.
- ERP eliminates most business problems like material shortages, productivity enhancements, customer service, cash management, inventory problems, quality problems, prompt delivery etc.
- ERP provides intelligent business tools like decision support system, Executive information system, Data mining and easy working systems to enable better decisions.

Why Companies Undertake ERP

1. Integrate financial information : As the CEO tries to understand the company's overall performance, he may find many different versions of the truth. ERP creates a single version of the truth that cannot be questioned because everyone is using the same system.

2. Integrate customer order information : ERP systems can become the place where the customer order lives from the time a customer service representative receives it until the loading dock ships the merchandise and finance sends an invoice. By having this information in one software system companies can keep track of orders more easily, and coordinate manufacturing, inventory and shipping among many different locations simultaneously.

3. Standardise and speed up manufacturing processes : Manufacturing companies -especially those with an appetite for mergers and acquisitions—often find that multiple business units across the company make the same transaction / recording / report using different methods and computer systems. ERP systems come with standard methods for automating some of the steps of a manufacturing process.

4. Reduce inventory : ERP helps the manufacturing process flow more smoothly, and it improves visibility of the order fulfilment process inside the company. That can lead to reduced inventories of the materials used to make products (work-in-progress inventory), and it can help users better plan deliveries to customers, reducing the finished good inventory at the warehouses and shipping docks.

5. Standardise HR information : Especially in companies with multiple business units, HR may not have a unified, simple method for tracking employees' time and communicating with them about benefits and services. ERP can fix that.

Benefits of ERP : Following are some of the benefits they achieved by implementing the ERP packages :

- Gives Accounts Payable personnel increased control of invoicing and payment processing and thereby boosting their productivity and eliminating their reliance on computer personnel for these operations.
- Reduce paper documents by providing on-line formats for quickly entering and retrieving information.

  Improves timeliness of information by permitting posting daily instead of monthly.
- Greater accuracy of information with detailed content, better presentation, satisfactory for the auditors.
- Improved cost control.
- Faster response and follow-.up on customers.
- More efficient cash collection, say, material reduction in delay in payments by customers.
- Better monitoring and quicker resolution of queries.
- Enables quick response to change in business operations and market conditions.
- Helps to achieve competitive advantage by improving its business process.
- Improves supply-demand linkage with remote locations and branches in different countries.
- Provides a unified customer database usable by all applications.
- Improves International operations by supporting a variety of tax structures, invoicing schemes, multiple currencies, multiple period accounting and languages.
- Improves information access and management throughout the enterprise.
- Provides solution for problems like Y2K and Single Monetary Unit (SMU) or Euro Currency.

Inventory Control & Inventory control parameters

Inventory:

- It is stock of an item or idle resource held for future use.
- It is a stock of physical assets having some economic value, which can be used at a later time to meet expected/unexpected demand.

- The amount of material, a company has in stock at a specific time is known as inventory or in terms of money it can be defined as the total capital investment over all the materials stocked in the company at any specific time
- Items waiting to be purchased or sold are considered to be in inventory.
- The primary factor in the reduction of inventory costs is deciding when to order, how much to order, and if back-ordering is permissible

Types of inventory:

- raw material inventory
- work in process inventory
- finished goods inventory
- spare parts inventory
- office stationary

Need of Inventories:

- To safe guard against the uncertainties in price fluctuations, supply conditions, demand conditions, lead times, transport contingencies etc.
- To reduce machine idle times by providing enough in-process inventories at appropriate locations.
- To take advantages of quantity discounts, economy of scale in transportation etc.
- To decouple operations i.e. to make one operation's supply independent of another's supply. This helps in minimizing the impact of break downs, shortages etc. on the performance of the downstream operations. Moreover operations can be scheduled independent of each other if operations are decoupled.
- To reduce the material handling cost of semi-finished products by moving them in large quantities between operations.
- To reduce clerical cost associated with order preparation, order procurement etc.

Functions of Inventories:

The basic purpose of inventories is to balance supply and demand.

Inventory serves as a link between:

1. Supply and demand
2. Customer demand and finished goods
3. Finished goods and component availability.
4. Requirements for an operation and the output from the preceding operation.
5. Parts and materials to begin production and the suppliers of materials.

Inventory Control

- It may be defined as the scientific method 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 interruption production and sales.
- Inventory control involves decisions by management as to the source from which the inventory is to be procured and as to the quantity to be procured at the time
- According to the Merriam-Webster dictionary, **inventory control** can be defined as the "coordination and supervision of the supply, storage, distribution, and recording of materials to maintain quantities adequate for current customer needs without excessive supply or loss."
- When it comes to wholesalers and distributors of durable goods, inventory control can be further defined as the process employed to maximize a company's use of inventory. The goal of inventory control is to generate the maximum profit from the least amount of inventory investment without hindering customer satisfaction levels or order fill rates.

Objectives of inventory control:

- To ensure continuous supply of materials so that production should not suffer at any time.
- To maintain the overall investment in inventory at the lowest level, consistent with operating requirement
- To minimize the holding, replacement and shortage cost of inventories and maximize the efficiency in production and distribution.
- To keep inactive waste surplus scrap and obsolete items at the minimum level.
- To supply the product raw material to its users as per the requirements at right time and at right price.
- To ensure timely action for replenishment
- To maintain timely record of inventories of all the items and to maintain the stock within the desired limits
- To avoid both over-stocking and under-stocking of inventory.

Definitions of Terms:

- **Procurement quantity**

  Is the order quantity, which in effect determines the frequency of ordering and is related directly to the maximum inventory level

- **Inventory (I):**
  - Stock held for the purpose of meeting a demand either internal or external to the organization.
- **Lead time (L):**
  - The time required to replenish an item of inventory by either purchasing from a vendor or manufacturing the item in-house.
- **Demand (D):**
  - The number of units of an inventory item required per unit of time.
- **Reorder point (r):**
  - The point at which an order must be placed for the procured quantity to arrive at the proper time or, for the manufacturing case, the finished product to begin flowing into inventory at the proper time.
- **Reorder quantity (Q):**
  - The quantity for which an order is placed when the reorder point is reached.
- **Demand during lead time (DL):**
  - This quantity is the product of lead time and demand. It represents the number of units that will be required to fulfill demand during the time that it takes to receive an order that has been placed with a vendor.
- **Replenishment rate (P):**
  - This quantity is the rate at which replenishment occurs when an order has been placed. For a purchase situation it is infinite (when an order arrives, in an instant the stock level rises from 0 to Q). For the manufacturing situation it is finite.
- **Shortage:**
  - The units of unsatisfied demand that occur when there is an out-of-stock situation.

Inventory Costs

In order to control inventories appropriately, one has to consider all cost elements that are associated with the inventories. There are four such cost elements, which do affect cost of inventory.

1. **Unit cost:**

   It is usually the purchase price of the item under consideration. If unit cost is related with the purchase quantity, it is called as discount price.

2. **Procurement costs:**

   This includes the cost of order preparation, tender placement, cost of postages, telephone costs, receiving costs, set up cost etc.

3. **Stock out costs:(Shortage cost):**

   Is the penalty incurred for being unable to meet a demand when it occurs? This cost does not depend on the source chosen to replenish the stock but is a function of the number of units short and the time duration involved

   This represents the cost of loss of demand due to shortage in supplies. This includes cost of loss of profit, loss of customer, loss of goodwill, penalty etc.

4. **Holding costs (Carrying costs):**

   Are incurred as a function of the quantity on hand and the time duration involved. Included in these costs are the real out-of-pocket costs, such as insurance, taxes, obsolescence, and warehouse rental and other space charges, and operating costs, such as light, heat, maintenance, and security. In addition, capital investment in inventories is unavailable for investment elsewhere.

   This represents the cost of maintaining inventories in the plant. It includes the cost of insurance, security, warehouse rent, taxes, interest on capital engaged, spoilage, breakage etc.

5. **Ordering cost**

   Is the cost incurred when an order is placed. It is composed of the cost of time, materials, and any expense of communication in placing an order.

6. **Setup cost:**

Is the cost incurred when a machine's tooling or jigs and fixtures must be changed to accommodate the production of a different part or product.

Total annual inventory cost = Cost of items + Annual procurement cost + Annual carrying cost + Stock out cost

Variables in Inventory Models

D = Total annual demand (in units) Q = Quantity ordered (in units)

Q* = Optimal order quantity (in units) R = Reorder point (in units)

R* = Optimal reorder point (in units) L = Lead time

S = Procurement cost (per order)

C = Cost of the individual item (cost per unit)

I = Carrying cost per unit carried (as a percentage of unit cost C) K = Stock out cost per unit out of stock

P = Production rate or delivery rate

dl = Demand per unit time during lead time

Dl = Total demand during lead time

TC = Total annual inventory costs

TC* = Minimum total annual inventory costs

Number of orders per year = =Annual Demand/Order Quantity=D/Q

Total procurement cost per year = S.D / Q

Total carrying cost per year = Carrying cost per unit * unit cost * average inventory per cycle

Cost of items per year = Annual demand * unit cost = D.C

Total annual inventory cost (TC) = D.C+ S.D/Q+I.C. Q/2

$$\text{Total cost} = \begin{pmatrix}\text{Cost of}\\ \text{items}\end{pmatrix} + \begin{pmatrix}\text{Cost of}\\ \text{ordering}\end{pmatrix} + \begin{pmatrix}\text{Cost of holding}\\ \text{items in stock}\end{pmatrix} + \begin{pmatrix}\text{Cost of}\\ \text{shortage}\end{pmatrix}$$

$$\textbf{Total annual inventory cost (TC)} = D.C + \frac{S.D}{Q} + \frac{I.C.Q}{2}$$

- The objective of inventory management team is to minimize the total annual inventory cost.
- A simplified graphical presentation in which cost of items, procurement cost and carrying cost are depicted is shown in Figure.

- It can be seen that large values of order quantity Q result in large carrying cost.
- Similarly, when order quantity Q is large, fewer orders will be placed and procurement cost will decrease accordingly.
- The total cost curve indicates that the minimum cost point lies at the intersection of carrying cost and procurement cost curves.

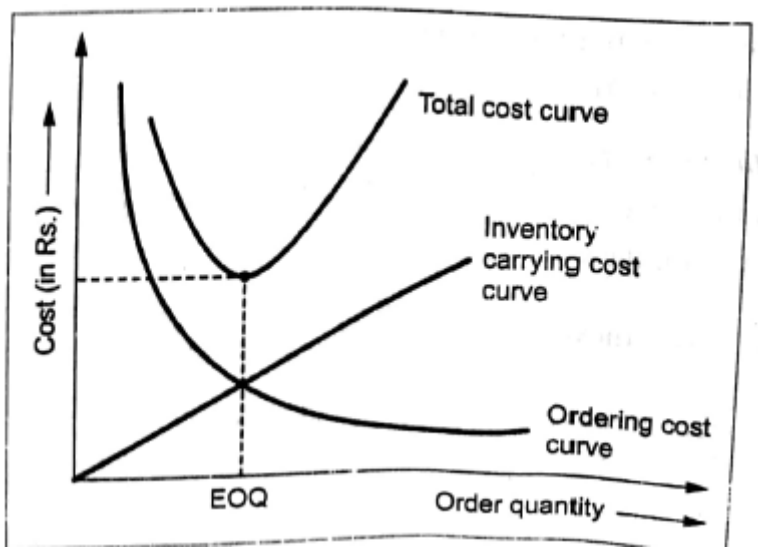

Fig.3.6: Economic Order Quantity

Inventory Operating Doctrine:

When managing inventories, operations manager has to make two important decisions

- When to reorder the stock (i.e. time to reorder or reorder point)
- How much stock to reorder (i. e. order quantity)

Reorder point is usually a predetermined inventory level, which signals the operations manager to start the procurement process for the next order. Order quantity is the order size.

Types of Inventory Models

Deterministic models:

- It assumes that quantities used in the determination of relationships for the model are all known.
- These quantities are such things as demand per unit of time, lead time for product arrival, and costs associated with such occurrences as a product shortage, the cost of holding the product in inventory, and that cost associated with placing an order for product.

Constant demand: Is one case that can be analyzed within the category of deterministic models. It represents very effectively the case for some components or parts in an inventory which are used in multiple parents, these multiple parent components having a composite demand which is fairly constant over time.

Lumpy demand: Is varying demand that occurs at irregular points in time.

- This type of demand is normally a dependent demand that is driven by an irregular production schedule affected by customer requirements.
- Although the same assumptions are made regarding the knowledge of r elated quantities, as in the constant demand case, this type of situation is analyzed separately under the topic of materials requirements planning (MRP). This separation of methodology is due to the different inputs to the modeling process in that the knowledge about demand is approached by different methods in the two cases.

Probabilistic models:

- Consider the same quantities as do the deterministic models but treat the quantities that are not cost related as random variables.
- The demand and lead time have their associated probability distributions. The added complexity of the probabilistic values requires that these models be analyzed by radically different methods.

Inventory Modeling:

This is a quantitative approach for deriving the minimum cost model for the inventory problem in hand.

- This model is applied when objective is to minimize the total annual cost of inventory in the organization.
- Economic order quantity is that size of the order which helps in attaining the above set objective.
- EOQ model is applicable under the following conditions.
    - o Demand per year is deterministic in nature
    - o Planning period is one year
    - o Lead time is zero or constant and deterministic in nature
    - o Replenishment of items is instantaneous

o Demand/consumption rate is uniform and known in advance

o No stock out condition exist in the organization

The total annual cost of the inventory (TC) is given by the following equation in EOQ model

$$TC = CD + S.\frac{D}{Q} + I.C.\frac{Q}{2}$$

By taking the first partial derivative of TC w.r.t Q

$$\frac{\delta(TC)}{\delta Q} = 0 + \left(-SD/Q^2\right) + \left(IC/2\right)$$

Setting the $\frac{\delta(TC)}{\delta Q} = 0$ and solveing for Q

$$Q^* = \sqrt{\frac{2DS}{IC}}$$

where Q* is the optimal order quantity.

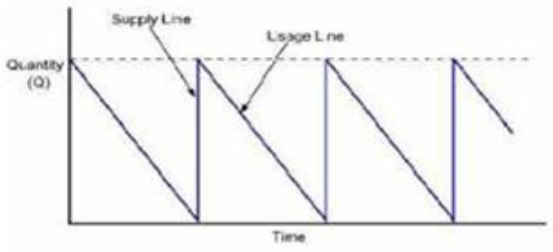

Fig.3.7: Inventory Models

Example: ABC manufacturers produces 1,25,000 oil seals each year to satisfy the requirement of their client. They order the metal for the bushing in lot of 30,000 units. It cost them $40 to place the order. The unit cost of bushing is $0.12 and the estimated carrying cost is 25% unit cost. Find out the economic order quantity? What percentage of increases or decrease in order quantity is required so that the ordered quantity is Economic order quantity?

D = Total Annual Demand
S – Procurement Cost (per order)
I = Carrying Cost per Unit Carried
C = Cost per Unit
Economic order quantity

$$Q^* = \sqrt{\frac{2DS}{IC}}$$

$$= \sqrt{\frac{2(125,000)(40)}{(0.25)(0.12)}}$$

$$= 18,257.4$$

$$\approx 18258$$

Since the order quantity is 30,000 which is more than EOQ; the quantity should be decreased to reach EOQ.
Percentage decrease in order quantity required is

$$= \frac{30,000 - 18,258}{30,000} \times 100\%$$

$$= 39.14\%$$

Techniques of Inventory Control

There are a number of different techniques employed by wholesale distributors to ensure their inventory control is maximizing efficiency and profitability. Below are six key techniques of inventory control for wholesalers and distributors of durable goods:

1) Establishing Annual Stocking Policies

Management must decide the maximum and minimum level of stocks and supplies that need to be kept in the warehouse or across the network of warehouse locations. Management must also set optimized re-order levels, safety stock levels (below which supply must not be allowed to fall) and an average inventory level to ensure costs are contained.

2) Preparation of Inventory Budgets

Many organizations have an annual inventory budget and they are usually prepared well in advance before inventory is procured. Budgets should include the total cost of ownership to keep inventory on hand during that year's account period. This includes materials cost, fixed operational costs, carrying costs, logistics costs, redistribution costs and additional miscellaneous costs that contribute to the total costs of ownership.

3) Maintaining A Perpetual Inventory System

Also known as "the automatic inventory system", this method is designed to keep a constant track of the quantity and value of each stocked item. Many wholesale distributors leverage a combination of an Enterprise Resource Planning (ERP) or Warehouse Management System (WMS) in conjunction with an Inventory Optimization solution, such as EazyStock, to optimize inventory balances. Most ERP and WMS technologies struggle to keep costs low and service rates high, which is why optimization software can be so valuable to operations processes.

4) Inventory Turnover Ratio

This is a calculation used to determine how quickly inventory is used up or "turned over" in a given time period. The higher the ratio the shorter the shelf life of the inventory and typically leads to higher sales volume and profitability for companies with lower profit margins. Inventory turnover should be closely watched for every item in the warehouse. Over the course of the product's life cycle, demand will fluctuate and cause variability in the supply chain. Tracking demand patterns are one way to ensure product replenishment calculations are accurate and optimized.

5) Establishment of Optimized Purchasing Procedures

In order to ensure that inventory is under adequate control, management must adopt purchasing procedures that align with actual sales history and demand pattern data. All inventory items that have not had an inventory turnover or have not been sold within an

accounting period, typically 12 months, should be classified as obsolete stock and should be liquidated from inventory to eliminate unnecessary carrying costs. Any item with a declining customer demand should be flagged in the system and its safety stock level thresholds and re-order point counts should be downwardly adjusted to mitigate risk of obsolescence and cost.

6) ABC Analysis and ABC Classification

The fastest moving products in your inventory should be located closest to the shipping, staging, and receiving area in the lower-right of the diagram below. As the demand for each product decreases over time, products should be migrated backwards to free up space for items with higher inventory turnover or for new product introductions that have high demand. Since the majority of your picking activity is performed in a rather small area, your warehouse layout should be optimized to reduce time spent looking for product in the back of the warehouse.

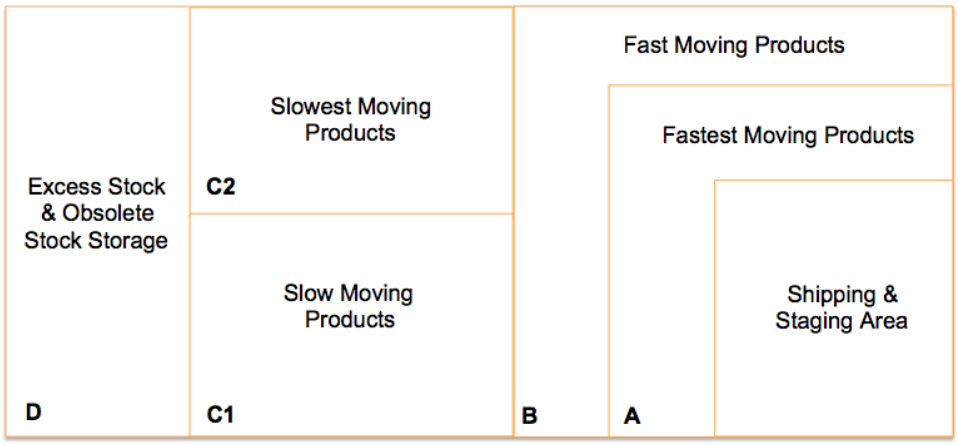

Fig.3.8: Inventory model classification

- **They experience stock outs of other products,** resulting in backorders, lost sales, and dissatisfied customers.
- **They have too much of some products** which leads to excess inventory which ties up working capital and profitability.
- **They have lost track of what is actually in inventory** because their legacy applications cannot effectively keep up with growing demand and the speed of business.

They can't find material in their warehouse, but they know the material is in the warehouse but warehouse management systems says they have product on hand.

With these common challenges come a few industry best practices that can eliminate, or at the very least, reduce the recurrence of these issues. Distributors that have committed to putting into place some of the following best practices on average report 30% reduction in costs associated with managing inventory.

Optimization

Here are 5 inventory optimization best practices to consider that will lead to a more optimized supply chain:

1) Categorize Your Inventory

This is similar to the ABC analysis practice where management categorizes its inventory according to its value and speed of turnover. Sales numbers and profitability margins are some of the ways stocks are valued. Inventory optimization software, such as EazyStock, can help inventory managers track an item's demand and lifecycle across 9 different demand patterns, from new to growing to decline, to ensure replenishment practices and customer demand are never out of step with each other.

2) Automate Demand Forecasting

The company's performance is often dependent on external conditions such as seasonal demand, market trends, economic conditions and other business trends that can cause unpredictable demand variability. Automated demand forecasting can be used to take the guesswork out of how much inventory should be carried for a given period. Automation dynamically calculates an inventory item's based demand according to historical sales data to ensure minimum and maximum order quantities are optimal.

3) Replenishment Automation

A centralized inventory management system coupled with inventory optimization software will enable a company to better track inventory levels and prepare for unexpected events. They can also avoid over stocking and under stocking situations as demand patterns can automatically override the replenishment parameters based on predetermined stocking policies and service level targets.

4) Continuous Process Improvement

Unless companies continuously monitor and analyze operational challenges, they may keep getting the same results, which include high operational costs, poor customer service levels and inefficient operations.

5) Invest into Inventory Optimization Technology

Most wholesalers and distributors rely on antiquated technology platforms such as ERP and WMS to drive their planning, forecasting and replenishment processes. Unfortunately, these

types of systems were not designed to optimize inventory levels. Companies looking to gain a step on the competition need to evaluate add-on systems that can support more lean operations and more efficient operations to save costs and increase service levels.

Selective control systems:

- Selective inventory control refers to the variation in method of control from item to item on some selective basis.

- The principle of selective inventory control recognizes that it is impossible to manage and control every item in inventory holdings, in the same way and still meet the objectives of
  - Bringing down the level of investment inn inventory
  - Avoid stock-out of critical items

- In this system the items are clustered into a few groups depending upon the selected criteria such as value, usage and frequency of consumptions

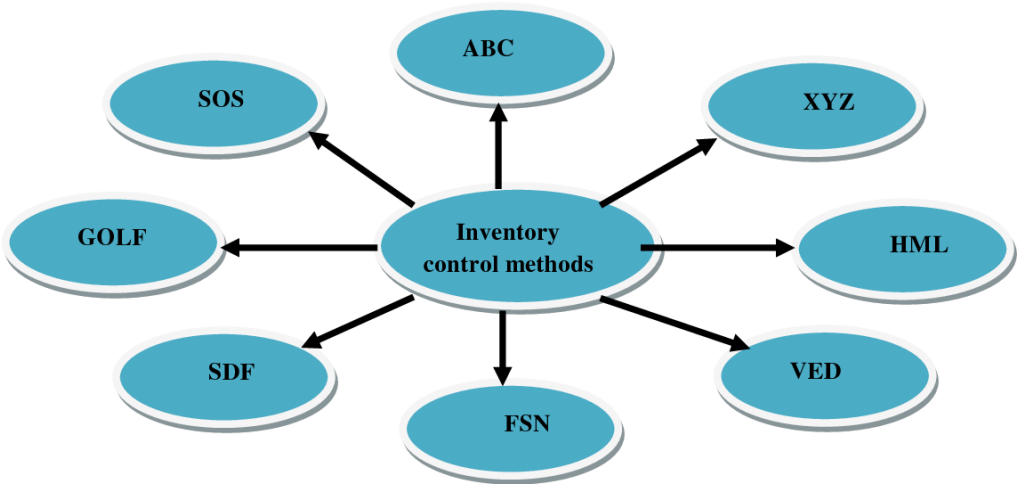

Fig.3.9: Selective Inventory control technique

Table.3.1: Selective Inventory control models

S.No.	Techniques	Meaning	Criteria
1.	ABC analysis	Always, Better, Control analysis	Annual usage value of items
2.	VED analysis	Vital, Essential, Desirable analysis	Material criticality
3.	HML analysis	High, Medium, Low analysis	Unit price of material
4.	FSN analysis	Fast moving, Slow moving, Non-moving analysis	Issues from stores
5.	SDE analysis	Scarce, Difficult, Easy to obtain analysis	Level of difficulty in the procurement of inventory
6.	SOS analysis	Seasonal, Off-Seasonal analysis	Nature of the supplies
7.	GOLF analysis	Government, Ordinary, Local, Foreign analysis	Source of the inventory
8.	XYZ analysis	—	Inventory value of items used
9.	Bar coding analysis	—	Use of bar codes

ABC Analysis:

Inventory is a necessary evil in any organization engaged in production, sale or trading of products. Inventory is held in various forms including Raw Materials, Semi Finished Goods, Finished Goods and Spares. Every unit of inventory has an economic value and is considered an asset of the organization irrespective of where the inventory is located or in which form it is available. Even scrap has residual economic value attached to it.

Depending upon the nature of business, the inventory holding patterns may vary. While in some cases the inventory may be very high in value, in some other cases inventory may be very high in volumes and number of SKU. Inventory may be help physically at the manufacturing locations or in a third party warehouse location.

Inventory Controllers are engaged in managing Inventory. Inventory management involves several critical areas. Primary focus of inventory controllers is to maintain optimum inventory levels and determine order/replenishment schedules and quantities. They try to

balance inventory all the time and maintain optimum levels to avoid excess inventory or lower inventory, which can cause damage to the business.

ABC Classification:

Inventory in any organization can run in thousands of part numbers or classifications and millions of part numbers in quantity. Therefore, inventory is required to be classified with some logic to be able to manage the same.

In most of the organizations inventory is categorized according to ABC Classification Method, which is based on pare to principle. Here the inventory is classified based on the value of the units. The principle applied here is based on 80/20 principles.

Accordingly, the classification can be as under:

- A Category Items Comprise 20% of SKU & Contribute to 80% of money spend. B Category Items Comprise 30% of SKU & Contribute to 15% of money spend. C Category Items Comprise 50% of SKU & Contribute to 5% of money spend.
- It is a widely used method of categorizing inventories to quantity and value.

- It is based on the Pareto principle that a few high usage value items constitute a major part of the capital invested in inventories whereas bulk of inventory item having low usage value constitute insignificant part of the capital.

Procedure for ABC analysis: The following steps may be used to make ABC analysis

- Step 1: Identify all items being used, list them and estimate their
- Step 2: Collect cost date of individual items
- Step 3: Find out annual usage – consumption in rupees for each item.
- Step 4: Start from highest annual usage value, arrange the items in descending order of annual consumption in value
- Step 5: calculate cumulative annual usage and express it in percentage of total annual usage. Also express number of items into cumulative item percentages
- Step 6: plot cumulative usage percentage against cumulative item percentage and segregate into A,B and C category. It will be seen that for certain length the curve has a steep rise after that it flattens off. The two tangential lines where the curve changes its direction will determine the range of A B and C category of items.

- Helps the material manager to exercise selective control and focus his attention only on a few items when he is confronted with many store items
- Implementing ABC analysis results in reduced clerical costs, saves time and effort, resultsin better planning and control, and increased inventory turnover.

Advantages of ABC Classification:

- This kind of categorization of inventory helps one manage the entire volume and assign relative priority to the right category. For Example A Class items are the high value items. Hence one is able to monitor the inventory of this category closely to ensure the inventory level is maintained at optimum levels for any excess inventory can have huge adverse impact in terms of overall value.
- **A Category Items:** Helps one identify these stocks as high value items and ensure tight control in terms of process control, physical security as well as audit frequency.
- It helps the managers and inventory planners to maintain accurate records and draw management's attention to the issue on hand to facilitate instant decision-making.
- **B Category Items:** These can be given second priority with lesser frequency of review and less tightly controls with adequate documentation, audit controls in place.
- **C Category Items:** Can be managed with basic and simple records. Inventory quantities can be larger with very few periodic reviews.

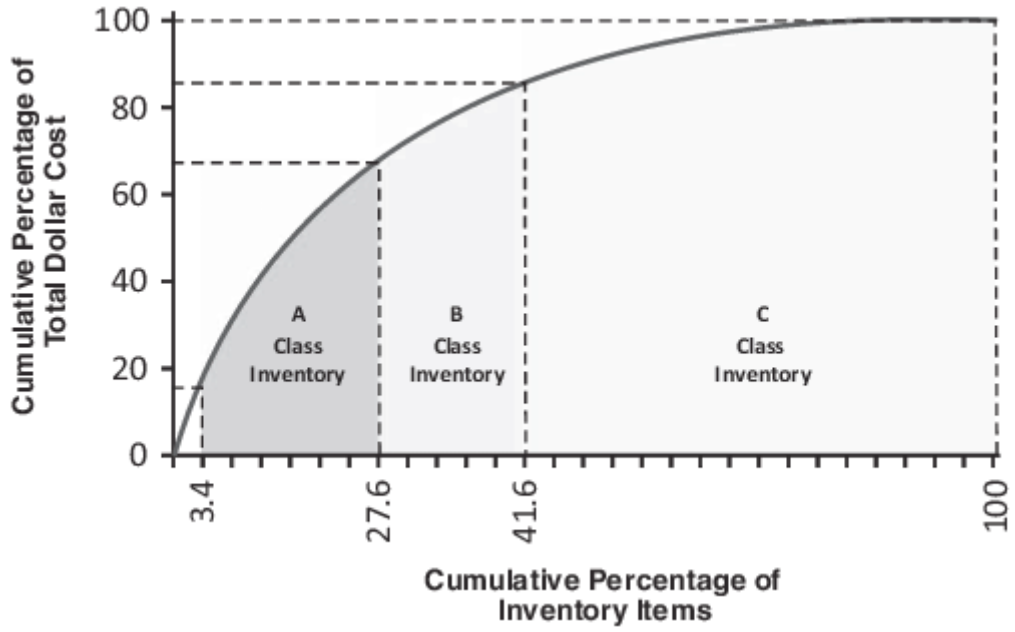

Fig.3.10: ABC Analysis

VED Analysis:

VED stands for vital, essential and desirable. This analysis relates to the classification of maintenance spare parts and denotes the essentiality of stocking spares.

The spares are split into three categories in order of importance. From the view-points of functional utility, the effects of non-availability at the time of requirement or the operation, process, production, plant or equipment and the urgency of replacement in case of breakdown.

Some spares are so important that their non-availability renders the equipment or a number of equipment in a process line completely inoperative, or even causes extreme damage to plant, equipment or human life.

On the other hand some spares are non-functional, serving relatively unimportant purposes and their replacement can be postponed or alternative methods of repair found. All these factors will have direct effects on the stocks of spares to be maintained.

V: Vital

Vital items which render the equipment or the whole line operation in a process totally and immediately inoperative or unsafe; and if these items go out of stock or are not readily available, there is loss of production for the whole period.

E: Essential

Essential items which reduce the equipment's performance but do not render it inoperative or unsafe; non-availability of these items may result in temporary loss of production or dislocation of production work; replacement can be delayed without affecting the equipment's performance seriously; temporary repairs are sometimes possible.

D: Desirable

Desirable items which are mostly non-functional and do not affect the performance of the equipment.

As the common saying goes "Vital Few — trivial many", the number of vital spares in a plant or a particular equipment will only be a few while most of the spares will fall in 'the desirable and essential' category.

However, the decision regarding the stock of spares to be maintained will depend not only on how critical the spares are from the functional point of view (VED analysis) but also on the annual consumption (user) cost of spares (ABC — analysis) and, therefore, for control of spare parts both VED and ABC analyses

FNS ANALYSIS

Based on the consumption pattern to combat obsolete items. Classification depends on the pattern of issues from stores

F – Fast moving

S – Slow moving

N – Non Moving

Date of receipt or last date of issue, whichever is later, is taken to determine the no. of months which have lapsed since the last transaction.

The items are usually grouped in periods of 12 months.

It helps to avoid investments in non moving or slow items. It is also useful in facilitating timely control.

For analysis, the issues of items in past two or three years are considered.

If there are no issues of an item during the period, it is “N” item.

Then up to certain limit, say 10-15 issues in the period, the item is “S” item.

The items exceeding such limit of no. of issues during the period are “F” items.

The period of consideration & the limiting number of issues vary from organization to organization.

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DEPARTMENT OF MECHANICAL ENGINEERING

SPR1306 – PRODUCTION PLANNING AND CONTROL

COURSE MATERIAL

UNIT – IV – SPR1306 - PRODUCTION PLANNING

Aggregate planning – Machine balancing – routing, scheduling and loading - information required and documentation – Process planning layout, route cards - priority scheduling – forward and backward scheduling – master production schedules.

IV. PRODUCTION PLANNING

AGGREGATE PLANNING:

Production planning in the intermediate range of time is termed as Aggregate planning.

It is the process by which a company determines levels of capacity, production, subcontracting, inventory, stock outs, and pricing over a specified time horizon. Goal is to maximize profit.

Aggregate planning is to determine the planned production quantity by period to meet forecast demand over a ***medium-range planning horizon***. The overall objective is to allocate all the resources in an efficient manner while satisfying the forecast demands over the planning horizon.

Aggregate planning is usually performed in broad and general terms at the ***product line (group)*** level. A common unit of measurement (e.g., weight, volume, labor hours) is used to describe the output levels in a production plan.

Aggregate planning is quite complicated with variable demand and/or supply. The demand pattern can be altered to some degree through pricing, promotion, backlogs and reservations, developing alternative products, and turning away customers. On the supply side, the major *variables* associated with aggregate planning include inventory level, work force size (hiring and layoff), extra shift, overtime or under-time, product mix, temporary/part-time employees, and subcontracting.

In aggregate planning, an organization attempts to satisfy demand by manipulation of the ***size*** and ***combination*** of the variables in control. Most organizations do not design aggregate plans that follow very closely the ups and downs of actual demands because it is usually too costly to vary output levels significantly from one period to the next period**.**

INFORMATION NEEDED FOR AN AGGREGATE PLAN:

- Demand forecast in each period
- Production costs, Machine costs, labor costs, regular time ($/hr) and overtime ($/hr), subcontracting costs ($/hr or $/unit)
- Cost of changing capacity: hiring or layoff ($/worker) and cost of adding or reducing machine capacity ($/machine)

- Labor/machine hours required per unit
- Material requirements per unit, material cost and availability
- Inventory holding cost ($/unit/period)
- Stock-out / backlog cost ($/unit/period)
- Constraints: physical or policy limits on overtime, layoffs, capital available, warehousing, stock-outs and backlogs
- Production quantity from regular time, overtime, and subcontracted time: used to determine number of workers and supplier purchase levels
- Inventory held: used to determine how much warehouse space and working capital is needed
- Backlog/stock-out quantity: used to determine what customer service levels can be – (i.e. do we short customers for a certain time- and how much/how long?)
- Machine capacity increase/decrease: used to determine if new production equipment needs to be purchased

An organization can finalize its business plans on the recommendation of demand forecast. Once business plans are ready, an organization can do backward working from the final sales unit to raw materials required. Thus annual and quarterly plans are broken down into labor, raw material, working capital, etc. requirements over a medium-range period (6 months to 18 months). This process of working out production requirements for a medium range is called aggregate planning.

PLANNING HIERARCHY

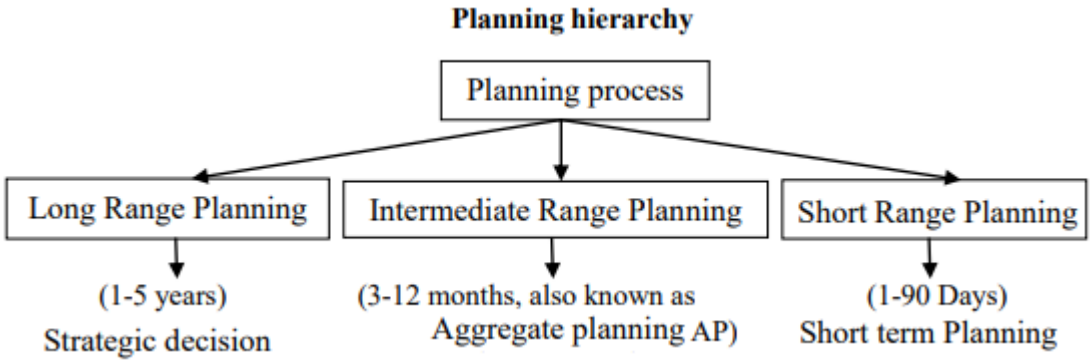


Fig.4.1: Aggregate Planning Hierarchy

FACTORS AFFECTING AGGREGATE PLANNING

Aggregate planning is an operational activity critical to the organization as it looks to balance long-term strategic planning with short term production success. Following factors are critical before an aggregate planning process can actually start;

- A complete information is required about available production facility and raw materials.
- A solid demand forecast covering the medium-range period
- Financial planning surrounding the production cost which includes raw material, labor, inventory planning, etc.
- Organization policy around labor management, quality management, etc.

INPUTS

For aggregate planning to be a success, following inputs are required;

- An aggregate demand forecast for the relevant period
- Evaluation of all the available means to manage capacity planning like sub-contracting, outsourcing, etc.
- Existing operational status of workforce (number, skill set, etc.), inventory level and production efficiency

Aggregate planning will ensure that organization can plan for workforce level, inventory level and production rate in line with its strategic goal and objective.

AGGREGATE PLANNING AS AN OPERATIONAL TOOL

Aggregate planning helps achieve balance between operation goal, financial goal and overall strategic objective of the organization. It serves as a platform to manage capacity and demand planning.

In a scenario where demand is not matching the capacity, an organization can try to balance both by pricing, promotion, order management and new demand creation.

In scenario where capacity is not matching demand, an organization can try to balance the both by various alternatives such as.

- Laying off/hiring excess/inadequate excess/inadequate excess/inadequate workforce until demand decrease/increase.
- Including overtime as part of scheduling there by creating additional capacity.
- Hiring a temporary workforce for a fix period or outsourcing activity to a sub-contractor.

IMPORTANCE OF AGGREGATE PLANNING

Aggregate planning plays an important part in achieving long-term objectives of the organization. Aggregate planning helps in:

- Achieving financial goals by reducing overall variable cost and improving the bottom line
- Maximum utilization of the available production facility
- Provide customer delight by matching demand and reducing wait time for customers
- Reduce investment in inventory stocking
- Able to meet scheduling goals there by creating a happy and satisfied work force

AGGREGATE PLANNING PROCEDURE

1. Develop organizational policies regarding the use of aggregate planning

variables.

2. Establish the forecasting time period and the horizon of the aggregate plan.

3. Develop the demand forecasting system.

4. Select an appropriate unit of aggregate capacity.

5. Determine the relevant cost structures.

6. Develop an aggregate planning model.

7. Develop alternative aggregate plans and select the best plan.

AGGREGATE PLANNING STRATEGIES

There are three types of aggregate planning strategies available for organization to choose from. They are as follows.

1. Pure chase strategy – match demand period by period

2. Pure level strategy – maintain a level workforce or a steady output rate

3. Hybrid (mixed) strategy – use a combination of decision variables

1. **Level Strategy**

   As the name suggests, level strategy looks to maintain a steady production rate and workforce level. In this strategy, organization requires a robust forecast demand as to increase or decrease production in anticipation of lower or higher customer demand. Advantage of level strategy is steady workforce. Disadvantage of level strategy is high inventory and increase back logs.

2. **Chase Strategy**

   As the name suggests, chase strategy looks to dynamically match demand with production. Advantage of chase strategy is lower inventory levels and back logs. Disadvantage is lower productivity, quality and depressed work force.

3. **Hybrid Strategy**

   As the name suggests, hybrid strategy looks to balance between level strategy and chase strategy. If the demand and supply is regulated by mixture of the strategies as mentioned, it is called hybrid strategy

AGGREGATE PLANNING METHODS

1. Trial-and-error method

2. Mathematical methods

PROCESS PLANNING

Process planning is a preparatory step before manufacturing, which determines the sequence of operations or **processes** needed to produce a part or an assembly. This step is more important in job shops, where one-of-a-kind products are made or the same product is made infrequently

The outputs of this step are: route sheet and operations sheet. A route sheet is a document which lists the exact sequence of operations needed to complete the job. The route sheet is intended to accompany parts moving individually or in batches. Route sheets provide the

information to the material handlers to help them move materials or partly completed items from one work center to another, until the finished part or assembly reaches the shipping department. Route sheets are useful for Production planning. An example of a route sheet is in Table 4.1

Table.4.1: Route Sheet

ABC Company

Routing Sheet

(sample, incomplete)

Name of Part:	Turned rod
Part Number	B324
Quantity to be produced:	102
Material Used:	SAE 1040

Operations Number	Description of Operation	Equipment	Tooling
1	Turn ¾"	Turret Lathe	#24
2	Cut off 1 ½"	Turret Lathe	#2
3	Degrease	Degreaser	
4.	…	…	…

PLANNING

- Production plans determine what will be produced and where, at what type, by whom, and how. For detailed planning of operations, the relevant information may be obtained from several sources in the enterprise. Information about quantity and quality of products to be manufactured may be obtained from customers' orders and the sales budget, and information about production facilities may be obtained from the management and the engineering department.
- The planning function formulates production plans, and translates them into requirements for men, machinery and materials.
- Production Planning helps in avoiding randomness in production, providing regular and steady flow of production activities, utilizing production facilities to its maximum for minimizing operating costs and meeting delivery schedules; coordinating various departments of the enterprise for maintaining proper balance of activities, and above all, providing the basis for control in the enterprise.

ROUTING:

Routing is the first step in production planning and control.

Routing can be defined as the process of deciding the path (route) of work and the sequence of operations. Routing fixes in advance:

1. The quantity and quality of the product.
2. The men, machines, materials, etc. to be used.
3. The type, number and sequence of manufacturing operations, and
4. The place of production.

In short, routing determines 'What', 'How much', 'With which', 'How' and 'Where' to produce.

Routing may be defined as the selection of path which each part of the product will follow while being transformed from raw materials to finished products. Path of the product will also give sequence of operation to be adopted while being manufactured.

In other way, routing means determination of most advantageous path to be followed from department to department and machine to machine till raw material gets its final shape, which involves the following steps:

Type of work to be done on product or its parts, Operation required to do the work, Sequence of operation required, where the work will be done, a proper classification about the personnel required and the machine for doing the work.

For effective production control of a well-managed industry with standard conditions, the routing plays an important role, i.e., to have the best results obtained from available plant capacity. Thus routing provides the basis for scheduling, dispatching and follow-up.

- Routing involves the determination of the path (i.e. route) of movement of raw materials through various machines and operations in the factory.
- "Routing includes the planning of where and by whom work shall be done, the determination of the path that work shall follow, and the necessary sequence of operations".
- To find this path, emphasis is placed on determining operating data, which usually includes planning of 'where' and 'by whom' work should be done, the determinations of the path that work shall follow, and the necessary sequence of operations.
- The most efficient routing may have to be compromised with the availability of the machines at a particular time.
- Routing establishes the operations, their path and sequence, and the proper class of machines and personnel required for these operations.

Techniques of Routing:

While converting raw material into required goods different operations are to be performed and the selection of a particular path of operations for each piece is termed as 'Routing'. This selection of a particular path, i.e. sequence of operations must be the best and cheapest to have the lowest cost of the final product. The various routing techniques are:

Route card:

This card always accompanies with the job throughout all operations. This indicates the material used during manufacturing and their progress from one operation to another. In addition to this the details of scrap and good work produced are also recorded

Worksheet: It contains Specifications to be followed while manufacturing. Instructions regarding routing of every part with identification number of machines and This sheet is made for manufacturing as well as for maintenance.

Route sheet: It deals with specific production order. Generally made from operation sheets. One sheet is required for each part or component of the order. This includes the following: Number and other identification of order. Symbol and identification of part, Number of pieces to be made, Number of pieces in each lot if put through in lots. Operation data which includes: List of operation on the part. Department in which operations are to be performed, Machine to be used for each operation. Fixed sequence of operation, if any

Move order: Though this is document needed for production control, it is never used for routing system. Move order is prepared for each operation as per operation sheet. On this the quantity passed forward, scrapped and to be rectified are recorded. It is returned to planning office when the operation is completed.

Routing Procedure:

1. Product analysis

Product analysis is the first step in the routing procedure. This is done to find out what parts (goods) should be manufactured and what parts should be purchased. This depends mainly on the relative cost. It also depends on other factors such as technical consideration, purchase policies, availability of personnel, availability of equipment, etc. Generally, during less-busy periods; most of the parts are manufactured in the factory. However, during the busy period, many parts are purchased from outside.

2. Determine required materials

Product-analysis is done again to find out what materials are required for production and their quantity and quality.

3. Fix manufacturing operations

The next step in the routing procedure is to fix (decide) the manufacturing operations and their sequences. The detailed production procedure is then scheduled (planned). Information required for this is derived from technical experience and by analyzing the machine capacity.

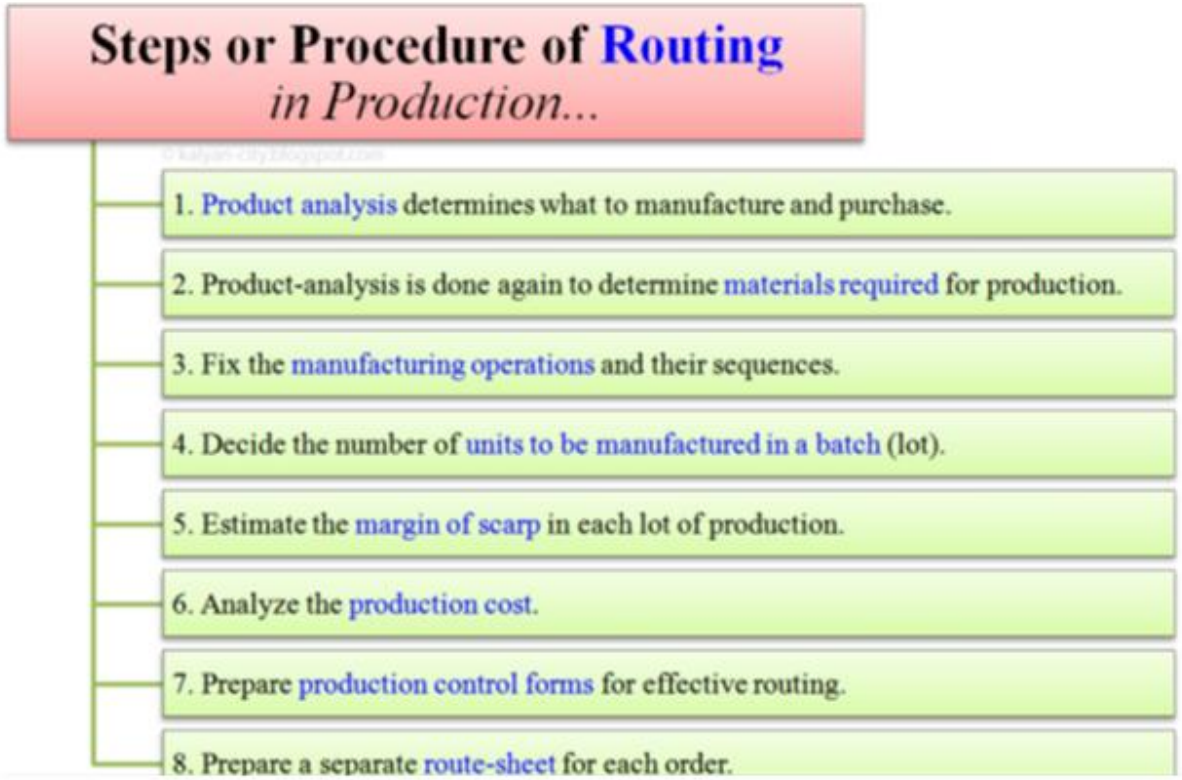


Fig.4.2: Routing Procedure

4. Determine size of batch

The number of units to be manufactured in any one lot (group or batch) should be decided. This is done concerning customers' orders. Necessary provision should also be made for rejections during the production process

5. Estimate margin of scrap

The amount of scrap in each lot, should be estimated. Generally, a scrap margin is between 2% to 5% of production.

6. Analyze the production cost

Estimating the cost of manufactured goods is actually the function of costing department. However, the routing section provides necessary data to the costing department that enables it to analyze the production cost.

7. Prepare production control forms

Production Control forms such as Job Cards, Inspection Cards, Tool Tickets, etc. should be prepared. These forms should contain complete information for effective routing.

8. Prepare route sheet

Route sheet is prepared on a production control form. It shows the part number, description of the part and the materials required. It is prepared by a route clerk. Separate route-sheet is required for each part of a customer's order.

BILL of material:

The bill-of-material BOM in the machine tool industry takes two different forms in design and manufacturing functions:

Engineering BOM

E BOM, which is used by the design engineer to represent designed product structure; and Manufacturing BOM

M BOM, which is used by MRPII system for MRP explosion.

The designer constructs the E BOM after the product has been designed. Next, the E BOM is transformed into the M BOM by considering assembly sequence and constraints. Constructing a M BOM simply involves compressing the E BOM into a three-level M BOM. Planning of a M BOM still depends primarily on the experience input of a manufacturing engineer and is performed manually. This trial and error and time consuming approach creates an inconsistent method for planning the M BOM. Therefore, in this study, a three-stage M BOM planning method is developed. Stage one plans the initial M BOM, stage two improves the M BOM and stage three tunes the M BOM. Concepts and algorithms of each stage are highlighted in this study. Moreover, an illustration is presented to demonstrate the feasibility of M BOM planning

A bill of materials or product structure (sometimes bill of material, BOM or associated list) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture an end product. A BOM may be used for communication between manufacturing partners, or confined to a single manufacturing plant. A bill of materials is often tied to a production order whose issuance may generate reservations for components in the bill of materials that are in stock and requisitions for components that are not in stock.

Introduction of Product planning

Production planning and control is a tool available to the management to achieve the stated objectives. Thus, a production system is encompassed by the four factors. i.e., quantity, quality, cost and time. Production planning starts with the analysis of the given data, i.e. demand for products, delivery schedule etc., and on the basis of the information available, a

scheme of utilization of firms resources like machines, materials and men are worked out to obtain the target in the most economical way.

Once the plan is prepared, then execution of plan is performed in line with the details given in the plan. Production control comes into action if there is any deviation between the actual And planned. The corrective action is taken so as to achieve the targets set as per plan by using control techniques.

Thus production planning and control can be defined as the "direction and coordination of firms' resources towards attaining the prefixed goals." Production planning and control helps to achieve uninterrupted flow of materials through production line by making available the materials at right time and required quantity.

Thus, product planning is required for the following reasons:

(i) To replace obsolete products

(ii) To maintain and increase the growth rate/sales revenue of the firm

(iii)To utilize spare capacity

(iv) To employ surplus funds or borrowing capacity

(v) To diversify risks and face competition

Product planning - Extending the original product information

Product planning

Product planning is the process of creating a product idea and following through on it until the product is introduced to the market. Additionally, a small company must have an exit strategy for its product in case the product does not sell. Product planning entails managing the product throughout its life using various marketing strategies, including product extensions or improvements, increased distribution, price changes and promotions.

Extending the original product information is

Product Design

A product is designed to meet certain functional requirements, and to satisfy the customers' needs. At the same time product must be aesthetically appealing to the customer or user. New technology and new materials currently available will also be explored during the product design stage. A product consists of assemblies, subassemblies and component parts. If the product is to be manufactured to customer specifications, the design is provided by the customer. The manufacturer's product design department will not be involved.

If the product is proprietary, the manufacturing firm is responsible for the design and development of the product. The cycle of events that initiates a new product design often

originates from the sales and marketing department. The departments of the firm that are organized to perform the product design function might include, Research and Development, Design engineering, Drafting, and perhaps a Prototype shop.

The product design is documented by means of component drawings, specifications, and a bill of materials that defines how many of each component go into the product. A prototype is often built for testing and demonstration purposes. The manufacturing engineering department is sometimes consulted for advice on matters of produce ability or manufacturability. Questions like "What changes in design could be made to reduce production costs without sacrificing function" ? are raised and answers sought. Cost estimates are prepared to establish an anticipated price for the product.

Upon completion of the design and fabrication of the prototype, the top company management officials are invited for a presentation and discussion held. The design engineer gives a presentation and demonstration of the product so that management can decide whether to manufacture the item. The decision is often a two-step process. The first is a decision by engineering management that the design is approved. The second step is a decision by top corporate management as to the general suitability of the product. This second decision represents an authorization to produce the item.

Manufacturing Planning

The information and documentation that constitute the design of the product are considered in the manufacturing planning. The Departments in the organization that perform manufacturing planning include manufacturing engineering, industrial engineering, and production planning and process planning.

Process Design

Industry employs a set of procedures in the design of manufacturing processes. Generally speaking this activity starts with the receipt of the product specifications and ends with the final plans for the manufacture of the product. In a broad sense this pattern of activity is uniform, regardless of the kind of product or the type of manufacturing involved.

The steps involved in process design are as follows.

(i) A careful review of the product design and specifications to make sure that economical manufacture is feasible.

(ii) Determination of the methods of manufacture that will result in the optimum manufacturing cost.

(iii) Selection or development and procurement of all machines, tools, and other equipment required for the manufacture of the product at the required quality and rate of production.

(iv) Layout of the production area and auxiliary spaces, and installation of the manufacturing facilities.

(v) Planning for and establishing the necessary control of materials, machines, and manpower to ensure the effective utilization of the manufacturing facility for the economical production of the product.

The above steps may be identified as functions of various activities, such as manufacturing engineering, process engineering, process planning methods engineering, or tool engineering. The scope of process-design activity can be identified as all work that is necessary to arrange for the manufacture of the product by the most economical means.

Master Production Schedule (MPS):

It is a detailed plan that states how many end items will be available for sale or distribution during specified periods.

- MPS is designed to meet the market demand (both the firm orders and forecasted demand) in future in the taken planning horizon.
- MPS mainly depicts the detailed delivery schedule of the end products.
- However, orders for replacement components can also be included in it to make it more comprehensive.

 Purpose of MPS:
    - To set due date for the availability of end items
    - To provide information regarding resources and materials required to support the aggregate plan
    - As an input to MRP, which will set specific production schedules for part and components used in end items

 Input to MPS
    - Market requirements
    - Production plan from aggregate planning
    - Resource available

 MPS output: The output of MPS is the list of end items available every period that is feasible with respect to demand and delivery

 Bill of Materials (BOM) File:

- Designates what items and how many of each are used to make up a specified final product.
- **o** It is used to compute the raw material and components requirements for end products listed in the master schedule.

Scheduling

Scheduling can be defined as "prescribing of when and where each operation necessary to manufacture the product is to be performed." It is also defined as "establishing of times at which to begin and complete each event or operation comprising a procedure".

The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date.

Scheduling is the process of arranging, controlling and optimizing work and workloads in a production process or manufacturing process. Scheduling is used to allocate plant and machinery resources, plan human resources, plan production processes and purchase materials.

Scheduling is planning the time element of production – i.e. prior determination of "when work is to be done".

It consists of the starting and completion times for the various operations to be performed.

Scheduling function determines when an operation is to be performed, or when work is to be completed, the difference lies in the details of the scheduling procedure.

To work out effectively, the scheduling, as a part of production control function, determines the time when each operation called for on the route sheet is to be done on the specified machine in order to meet the desired delivery dates.

- Good control function directs not only the time that each particular operation should start but also indicates the progress of each manufacturing part, the amount of work ahead of each machine, and the availability of each machine for the assignment of new work.Schedules are of two types:
- Master schedule and Detailed schedule. Activities, if recorded on plant-wise basis, would be preparing master schedule, while mere detailed schedules are employed to plan the manufacturing and assembly operations required for each product

The benefits of production scheduling include:

- ✓ Process change-over reduction
- ✓ Inventory reduction, leveling
- ✓ Reduced scheduling effort
- ✓ Increased production efficiency
- ✓ Labor load leveling
- ✓ Accurate delivery date quotes
- ✓ Real time information

Principles of Scheduling:

The principle of optimum task size: Scheduling tends to achieve maximum efficiency when the task sizes are small, and all tasks of same order of magnitude.

Principle of optimum production plan: The planning should be such that it imposes an equal load on all plants.

Principle of optimum sequence: Scheduling tends to achieve the maximum efficiency when the work is planned so that work hours are normally used in the same sequence.

Inputs to Scheduling

Performance standards: The information regarding the performance standards (standard times for operations) helps to know the capacity in order to assign required machine hours to the facility. Units in which loading and scheduling is to be expressed. Effective capacity of the work centre. Demand pattern and extent of flexibility to be provided for rush orders. Overlapping of operations. Individual job schedules.

Scheduling Strategies Scheduling strategies vary widely among firms and range from 'no scheduling' to very sophisticated approaches. These strategies are grouped into four classes:

Detailed scheduling: Detailed scheduling for specific jobs that are arrived from customers is impracticable in actual manufacturing situation. Changes in orders, equipment breakdown, and unforeseen events deviate the plans.

Cumulative scheduling: Cumulative scheduling of total work load is useful especially for long range planning of capacity needs. This may load the current period excessively and under load future periods. It has some means to control the jobs.

Cumulative detailed: Cumulative detailed combination is both feasible and practical approach. If master schedule has fixed and flexible portions.

Priority decision rules: Priority decision rules are scheduling guides that are used independently and in conjunction with one of the above strategies, i.e., first come first serve. These are useful in reducing Work-In-Process (WIP) inventory.

Forward scheduling:

Forward scheduling is planning the tasks from the date resources become available to determine the shipping date or the due date.

It is commonly used in job shops where customers place their orders on "needed as soon as possible" basis. Forward scheduling determines start and finish times of next priority job by assigning it the earliest available time slot and from that time, determines when the job will be finished in that work centre. Since the job and its components start as early as possible, they will typically be completed before they are due at the subsequent work centers in the routing. The forward method generates in the process inventory that are needed at subsequent work centers and higher inventory cost. Forward scheduling is simple to use and it gets jobs done in shorter lead times, compared to backward scheduling.

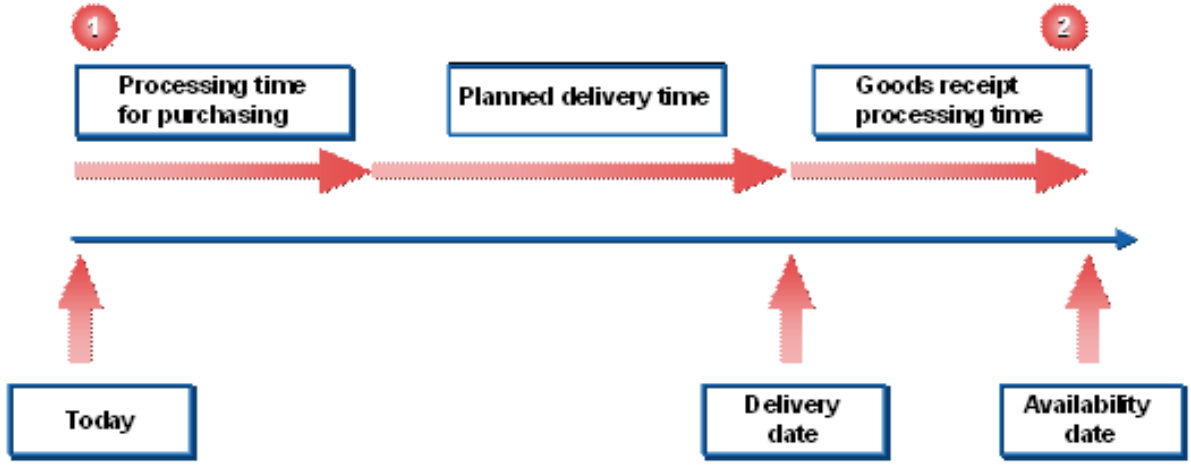


Fig.4.3: Forward Scheduling

Backward scheduling:

Backward scheduling is planning the tasks from the due date or required-by date to determine the start date and/or any changes in capacity required.

It is often used in assembly type industries and commit in advance to specific delivery dates. Backward scheduling determines the start and finish times for waiting jobs by assigning them to the latest available time slot that will enable each job to be completed just when it is due, but done before. By assigning jobs as late as possible, backward scheduling minimizes inventories since a job is not completed until it must go directly to the next work centre on its routing.

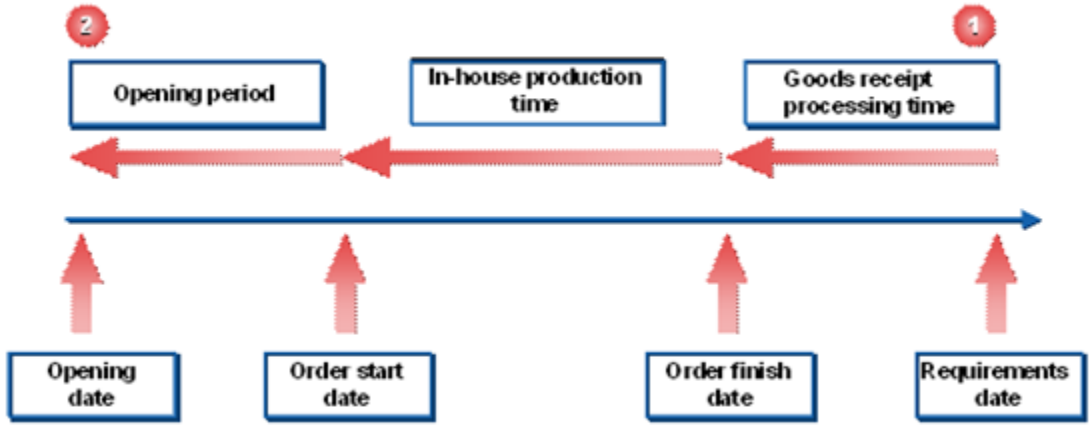


Fig.4.4: Backward Scheduling

BACKWARD SHEDULING:

- Backward scheduling is the calculation of deadline dates: the arrival time at the customer site is calculated as the earliest possible goods receipt time at the customers unloading point on the requested delivery date.
    - All four of the delivery and transportation scheduling lead times are subtracted from the customer's requested delivery date to determine if this date can be met.
- The transit time, loading time, and pick/pack time are subtracted from the customer 2019s requested delivery date to calculate the required material availability date.

The system calculates backward scheduling as follows:

- Requested delivery date minus transit time = Goods issue date
- Goods issue date minus loading time = Loading date
- Loading date minus transportation lead time = Transportation scheduling date

- Loading date minus pick/pack time = Material availability date

By default, the system will calculate delivery dates the closest day, taking into consideration the working days of the shipping point and a rounding profile. In this case the system assumes a 24 hour work day and lead times can be entered in days up to 2 decimal points. This is referred to as daily scheduling.

Precise scheduling calculated down to the day, hour and minute is supported. This allows the scheduling of a delivery within a single day. It is activated by maintaining the working hours for a particular shipping point.

- Backward scheduling is always carried out first. If the material availability date or transportation scheduling date is calculated to be in the past, the system must then use forward scheduling.
- Backward scheduling is the calculation of deadline dates: the arrival time at the customer site is calculated as the earliest possible goods receipt time at the customers unloading point on the requested delivery date. All four of the delivery and transportation scheduling lead times are subtracted from the customer's requested delivery date to determine if this date can be met.

FORWARD SHEDULING:

- Forward scheduling is also done if no product is available on the material availability date calculated by backward scheduling. The system does an availability check to determine the first possible date when product will be available. This new material availability date forms the starting point for scheduling the remaining activities. The loading time, pick/pack time, transit time, and transportation lead time are added to the new material availability date to calculate the confirmed delivery date.
- Forward scheduling - With this scheduling type the system schedules forwards starting from the basic start date or the scheduled start date of the order.
- Backward scheduling - With this scheduling type the system schedules backwards starting from the basic finish date or scheduled finish of the order
- Forward scheduling is also done if no product is available on the material availability date calculated by backward scheduling. The system does an availability check to determine the first possible date when product will be available. This new material availability date forms the starting point for scheduling the remaining activities. The

loading time, pick/pack time, transit time, and transportation lead time are added to the new material availability date to calculate the confirmed delivery date.

MASTER PRODUCTION SCHEDULE (MPS)

A **master production schedule** (MPS) is a plan for individual commodities to produce in each time period such as production, staffing, inventory, etc.

It is usually linked to manufacturing where the plan indicates when and how much of each product will be demanded.

This plan quantifies significant processes, parts, and other resources in order to optimize production, to identify bottlenecks, and to anticipate needs and completed goods. Since an MPS drives much factory activity, its accuracy and viability dramatically affect profitability.

The MPS is a statement of what the company expects to produce and purchase (i.e. quantity to be produced, staffing levels, dates, available to promise, projected balance).

The MPS translates the business plan, including forecast demand, into a production plan using planned orders in a true multi-level optional component scheduling environment. Using MPS helps avoid shortages, costly expediting, last minute scheduling, and inefficient allocation of resources.

Working with MPS allows businesses to consolidate planned parts, produce master schedules and forecasts for any level of the Bill of Material (BOM) for any type of part.

By using many variables as inputs the MPS will generate a set of outputs used for decision making.

Inputs may include forecast demand, production costs, inventory money, customer needs, inventory progress, supply, lot size, production lead time, and capacity. Inputs may be automatically generated by an ERP system that links a sales department with a production department. For instance, when the sales department records a sale, the forecast demand may be automatically shifted to meet the new demand. Inputs may also be inputted manually from forecasts that have also been calculated manually.

Outputs may include amounts to be produced, staffing levels, quantity available to promise, and projected available balance. Outputs may be used to create a Material Requirements Planning (MRP) schedule.

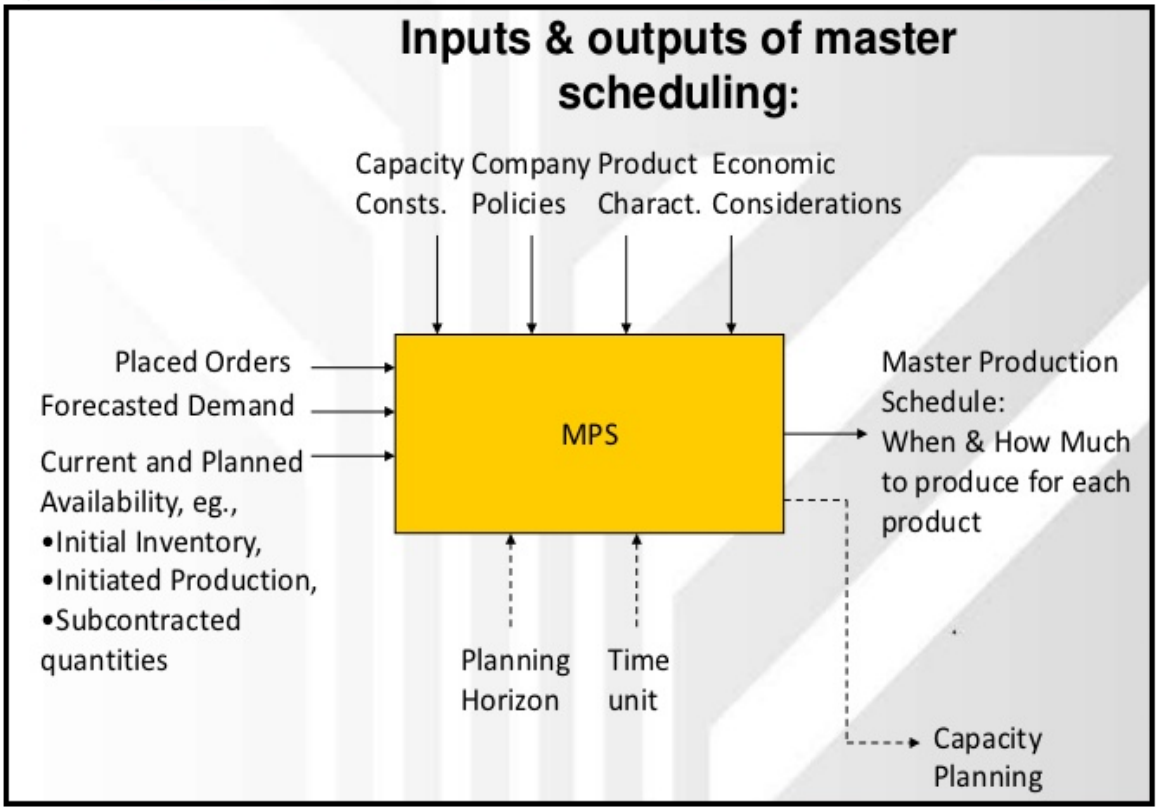


Fig.4.5: Master Production Scheduling

An effective MPS provides

- Basis for making customer delivery promises
- Utilizing plant capacity effectively
- Attaining the firm's strategic objectives as reflected in the production plan and
- Resolving trade-off between manufacturing and marketing
- Give production, planning, purchasing, and management the information to plan and control manufacturing
- Tie 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

Standard scheduling Methods

The scheduling methodology depends upon the type of industry, organization, product, and level of sophistication required. They are:

Charts and boards, Priority decision rules, and Mathematical programming methods,

Gantt Charts and Boards Gantt charts and associated scheduling boards have been extensively used scheduling devices in the past, although many of the charts are now drawn by computer. Gantt charts

are extremely easy to understand and can quickly reveal the current or planned situation to all concerned. They are used in several forms, namely, Scheduling or progress charts, which depicts the sequential schedule; Load charts, which show the work assigned to a group of workers or machines; and Record a chart, which are used to record the actual operating times and delays of workers and machines.

Priority Decision Rules Priority decision rules are simplified guidelines for determining the sequence in which jobs will be done. In some firms these rules take the place of priority planning

systems such as MRP systems. Following are some of the priority rules followed.

Mathematical Programming Methods: Scheduling is a complex resource allocation problem. Firms process capacity, labor skills, materials and they seek to allocate their use so as to maximize a profit or service objective, or perhaps meet a demand while minimizing costs. The following are some of the models used in scheduling and production control.

Linear programming model: Here all the constraints and objective functions are formulated as a linear equation and then problem is solved for optimality. Simplex method, transportation methods and assignment method are major methods used here.

PERT/CPM network model: PERT/CPM network is the network showing the sequence of operations for a project and the precedence relation between the activities to be completed.

Note: Scheduling is done in all the activities of an organization i.e., production, maintenance etc. Therefore, all the methods and techniques of scheduling are used for maintenance management.

Process planning layout

Layout Planning

- Layout planning is planning that involves decisions about the physical arrangement of economic activity centers needed by a facility's various processes.

- Layout plans translate the broader decisions about the competitive priorities, process strategy, quality, and capacity of its processes into actual physical arrangements

Layout Planning Questions

Before a manager can make decisions regarding physical arrangement, four questions must be addressed.

1. What centers should the layout include?
2. How much space and capacity does each center need?
3. How should each center's space be configured?
4. Where should each center be located?

Location Dimensions

The location of a center has two dimensions:

1. Relative location: The placement of a center relative to other centers.
2. Absolute location: The particular space that the center occupies within the facility.

- Layout choices can help communicate an organization's product plans and competitive priorities.
- Altering a layout can affect an organization and how well it meets its competitive priorities in the following ways:
  - Increasing customer satisfaction and sales at a retail store.
  - Facilitating the flow of materials and information.
  - Increasing the efficient utilization of labor and equipment.
  - Reducing hazards to workers.
  - Improving employee morale.
  - Improving communication.

Performance Criteria

- Customer satisfaction
- Level of capital investment
- Requirements for materials handling
- Ease of stockpicking
- Work environment and "atmosphere"
- Ease of equipment maintenance

- Employee and internal customer attitudes
- Amount of flexibility needed
- Customer convenience and levels of sales

Types of Layouts

- Flexible-flow layout: A layout that organizes resources (employees) and equipment by function rather than by service or product.
- Line-flow layout: A layout in which workstations or departments are arranged in a linear path.
- Hybrid layout: An arrangement in which some portions of the facility have a flexible-flow and others have a line-flow layout.
- Fixed-position layout: An arrangement in which service or manufacturing site is fixed in place; employees along with their equipment, come to the site to do their work.

SCHEDULING, SEQUENCING AND DISPATCHING

SCHEDULING

Scheduling can be defined as "prescribing of when and where each operation necessary to manufacture the product is to be performed". It is also defined as "establishing of times at which to begin and complete each event or operation comprising a procedure". The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date.

Principles of Scheduling

1. ***The principle of optimum task size:*** Scheduling tends to achieve maximum efficiency when the task sizes are small, and all tasks of same order of magnitude.

2. ***Principle of optimum production plan:*** The planning should be such that it imposes an equal load on all plants.

3. ***Principle of optimum sequence:*** Scheduling tends to achieve the maximum efficiency when the work is planned so that work hours are normally used in the same sequence.

Inputs to Scheduling

1. **Performance standards:** The information regarding the performance standards (standard times for operations) helps to know the capacity in order to assign required machine hours to the facility.

2. **Units** in which loading and scheduling is to be expressed.

3. **Effective capacity** of the work centre.

4. **Demand pattern** and extent of flexibility to be provided for rush orders.

5. **Overlapping** of operations.

6. **Individual job** schedules.

Techniques of Scheduling

(a) Master Scheduling (MS): It shows the dates on which important production items are to be completed. It's a weekly or monthly break-up of the production requirements for each product. Whenever any order is received, it is accommodated first in the MS considering the availability of the machine and labor. It helps production manager for advance planning & to have check over the production rate and efficiency. See table 3-1.

Table.4.2: Aggregate plan and master schedule for electric motors

Aggregate Plan

Month	J	F	M	A	M	J	J	A	S
Number of motors	40	25	55	30	30	50	30	60	40

Master Schedule

Month	J	F	M	A	M	J	J	A	S
AC motors									
5hp	15	–	30	–	–	30	–	–	10
25hp	20	25	25	15	15	15	20	30	20
DC motors									
20hp	–	–	–	–	–	–	10	10	–
WR motors									
10hp	5	–	–	15	15	5	–	20	10

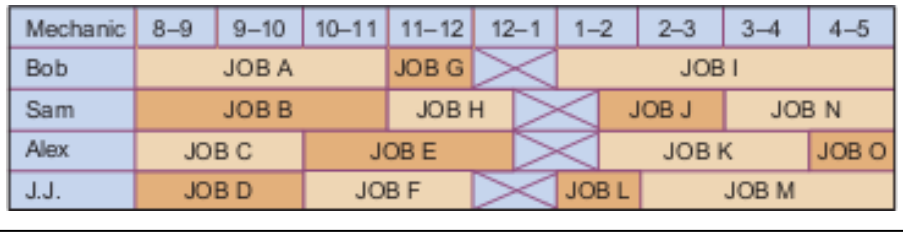
(b) Shop Manufacturing Schedule: After preparing the MS, shops schedules (SS) are prepared. It assigns a definite period of time to a particular shop for manufacturing products in required quantity. It shows how many products are to be made, and on what day or week.

(c) Backward or Reverse Scheduling: External due date considerations will directly influence activity scheduling in certain structures. The approach adopted in scheduling activities in such cases will often involve a form of reverse scheduling with the use of ***bar or Gantt charts***. *A major problem with such reverse or 'due date' scheduling is in estimating the total time to be allowed for each operation,* in particular the time to be allowed for waiting or queuing at facilities. Some queuing of jobs (whether items or customers) before facilities is often desirable since, where processing times on facilities are uncertain, high utilization is achieved only by the provision of such queues.

Operation times are often available, but ***queuing times*** are rarely known initially, the only realistic way in which queuing allowances can be obtained is by experience. Experienced planners will schedule operations, making allowances which they know from past performances to be correct. Such *allowances may vary from 50 per cent to 2000 per cent of operation times and can be obtained empirically or by analysis of the progress of previous jobs.* It is normally sufficient to obtain and use allowances for groups of similar facilities or for particular departments, since delays depend not so much on the nature of the job, as on the amount of work passing through the departments and the nature of the facilities.

Operations schedules of this type are usually depicted on ***Gantt or bar charts***, see Fig.(3-1). The advantage of this type of presentation is that ***the load on any facility or any department is clear at a glance,*** and available or spare capacity is easily identified. *The major disadvantage* is that the *dependencies* between operations are not shown and, consequently, any readjustment of such schedules necessitates reference back to operation planning documents. Notice that, in scheduling the processing of items, total throughput time can be minimized by the batching of similar items to save set-up time, inspection time, etc.

A



Mechanic	8–9	9–10	10–11	11–12	12–1	1–2	2–3	3–4	4–5
Bob	JOB A			JOB G		JOB I			
Sam	JOB B			JOB H		JOB J		JOB N	
Alex	JOB C		JOB E			JOB K			JOB O
J.J.	JOB D		JOB F			JOB L	JOB M		

B

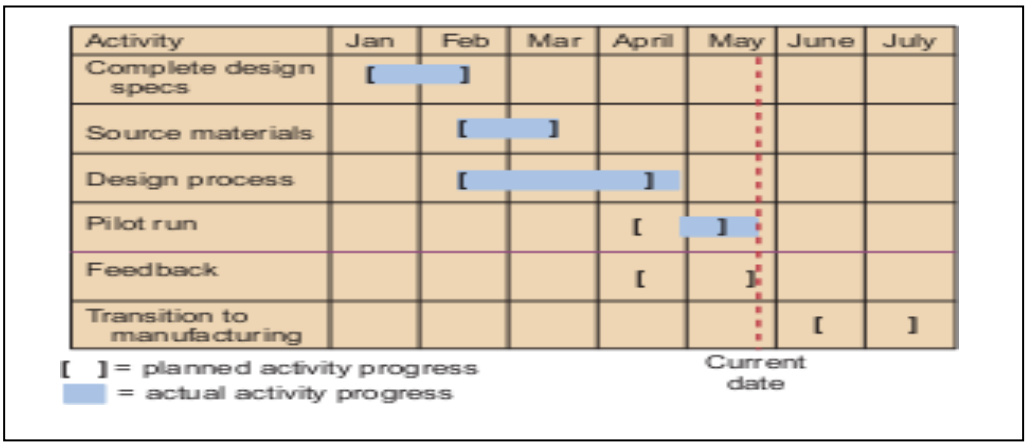


Fig.4.6: Gantt Charts: A- Sample load chart / B- Sample progress chart

***(d) Forward Scheduling*:** For a manufacturing or supply organization a forward scheduling procedure will in fact be the opposite of that described above. This approach will be particularly relevant where scheduling is *undertaken on an internally oriented bas*is and the objective is to determine the date or times for subsequent activities, given the times for an earlier activity, e.g. a starting time. In the case of supply or transport organizations, the objective will be *to schedule forward from a given start date,* where that start date will often be the customer due date, e.g. the date at which the customer arrives into

the system. In these circumstances, therefore, *forward scheduling will be an appropriate method for dealing with externally oriented scheduling activities.*

(e) Optimized Production Technique (OPT): It is a program help to recognizes the existence of ***bottlenecks*** through which the flow gets restricted. It consists of modules that contain data on products, customer orders, work center capacities, etc., as well as algorithms to do the actual scheduling. *A key feature of the program is to simulate the load on the system, identify bottleneck (as well as other) operations,* and develop alternative production schedule.

Example: A job is due to be delivered at the end of 12th week. It requires a lead time of 2 weeks for material acquisition, 1 week of run time for operation-1, 2 weeks for operation-2, and 1 week for final assembly. Allow 1 week of transit time prior to each operation. Illustrate the completion schedule under (a) forward, and (b) backward scheduling methods.

Solution: the solution is illustrated in fig.

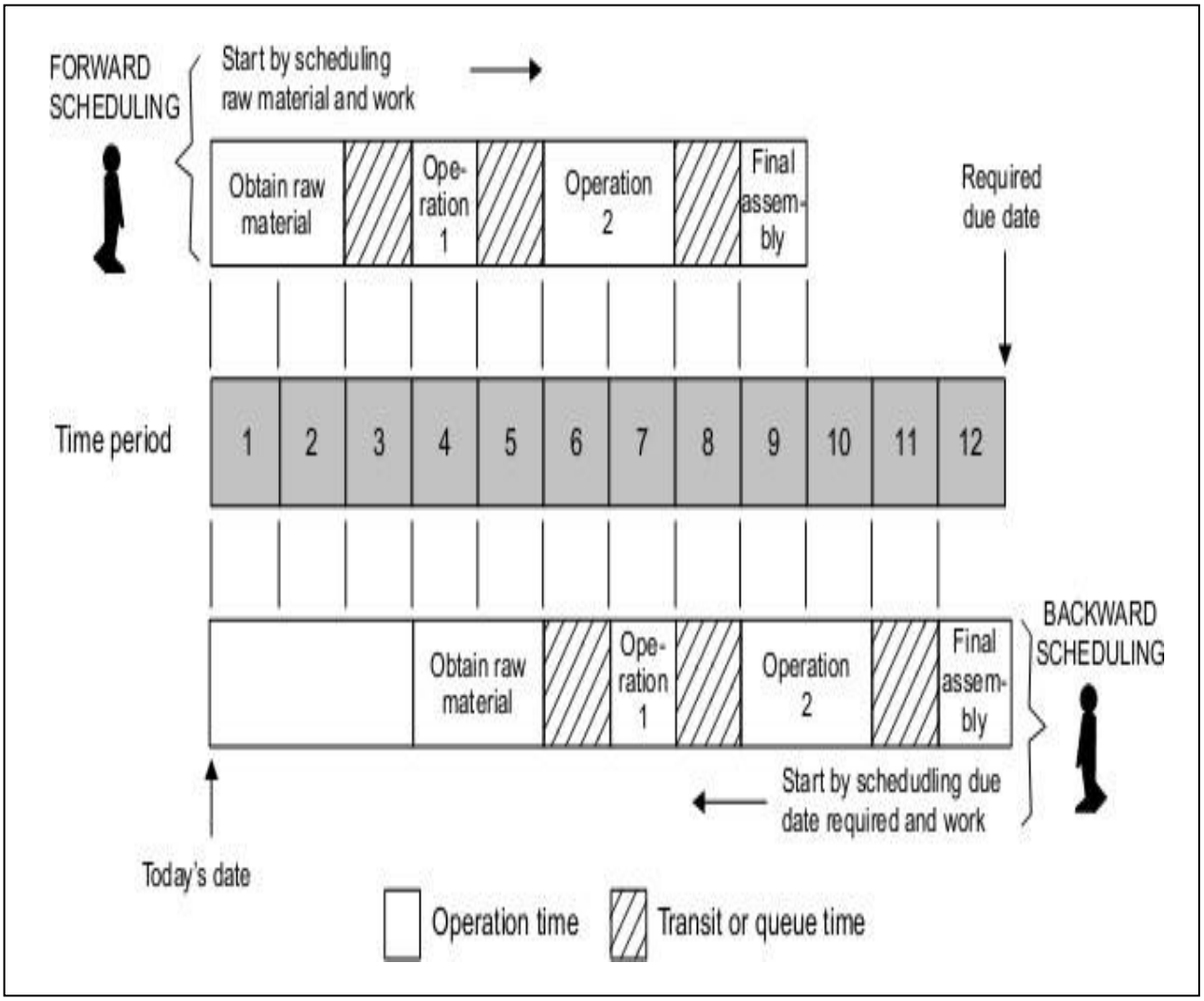


Fig.4.7: Forward and Backward Scheduling

SEQUENCING AND DISPATCHING PHASE

Sequencing activities are closely identified with detailed scheduling, as they specify the order in which jobs are to be processed at the various work centers. Dispatching is concerned with starting the processes. It gives necessary authority to start a particular

work, which has already been planned under ‘routing’ and ‘scheduling’. For starting the work, essential orders and instructions are given. Therefore, the definition of dispatching is ‘release of orders and instructions for starting of the production for an item in accordance with the ‘route sheet’ and schedule charts’.

Dispatching functions include:

1. Implementing the schedule in a manner that retains any order priorities assigned at the planning phase.
2. Moving the required materials from stores to the machines, and from operation to operation.
3. Authorizing people to take work in hand as per schedule
4. Distributing machine loading and schedule charts, route sheet, and other instructions and forms.
5. Issuing inspection orders, stating the type of inspection at various stages.
6. Ordering tool-section to issue tools, jigs and fixtures.

Dispatching or Priority Decision Rules

Job shops generally have many jobs waiting to be processed. The principal method of job dispatching is by means of priority rules, which are simplified guidelines (heuristics) to determine the sequence in which jobs will be processed. The use of priority rule dispatching is an attempt to formalize the decisions of the experienced human dispatcher.

Some of the rules used job assignment are: first come, first served (FCFS), earliest due date (EDD), longest processing time (LPT), and preferred customer order (PCO). These rules can be classified as: Static or Dynamic.

Static rules do not incorporate an updating feature. They have priority indices that stay constant as jobs travel through the plant, where ***as dynamic rules*** change with time and queue characteristics.

Table.4.3: Priority Rules

Commonly Used Priority Rules

First come, first served (FCFS): Jobs are processed in the order in which they arrive at a machine or work center.

Last come, first served (LCFS): The last job into the work center or at the top of the stack is processed first.

Earliest due date (EDD): The job due the earliest has the highest priority.

Shortest processing time (SPT): The job that requires the least processing time has the highest priority.

Longest processing time (LPT): The job that requires the longest processing time has the highest priority.

Critical ratio (CR): The job with the smallest ratio of time remaining until due date to its processing time remaining has the highest priority.

Slack per remaining operations (S/RO): The job with the least slack per remaining operations is given the highest priority. Calculate by dividing slack by remaining operations.

JOHNSON'S PROBLEM

For a problem with 2 machines and n jobs, Johnson had developed a polynomial algorithm to get optimal solution, i.e., in a definite time, one can get the optimal solution. Consider the following flow shop problem:

In the table below, t ij represents the processing time of the job i on the machine j.

Table.4.4: Johnsons Problem

Job	Machine 1	Machine 2
1	t_{11}	t_{12}
2	t_{21}	t_{22}
3	t_{31}	t_{32}
n	t_{n1}	t_{n2}

Johnson's Algorithm

Step 1: Find the minimum among various ti1 and ti2.

Step 2a : If the minimum processing time requires machine 1, place the associated job in the first available position in sequence. Go to Step 3.

Step 2b : If the minimum processing time requires machine 2, place the associated job in the last available position in sequence. Go to Step 3.

Step 3: Remove the assigned job from consideration and return to Step 1 until all positions in sequence are filled.

The above algorithm is illustrated using the following problem:

Example 1: Consider the following two machines and six jobs flow shop- scheduling

Table.4.5: Problem no.1

Job	Machine 1	Machine 2
1	5	4
2	2	3
3	13	14
4	10	1
5	8	9
6	12	11

problem. Using Johnson's algorithm, obtain the optimal sequence, which will minimize the makespan.

The optimal sequence is **2-5-3-6-1-4**. The makespan is determined as shown below.

Table.4.6: Solution for problem no.1

[Time-in on M/c 2 = max *[M!c* 1 Time-out of the current job, M/c 2 Time-out of the previous job]

	Processing time				Idle time on machine
Job	Machine 1		Machine 2		
	Time-in	Time-out	Time-in	Time-out	
2	0	2	2	5	2
5	2	10	10	19	5
3	10	23	23	37	4
6	23	35	37	48	0
1	35	40	48	52	0
4	40	50	52	53	0

The makespan for this schedule is 53.

Example.2: Consider the following 3 machines and 5 jobs flow shop problem:

Table.4.7: Problem no.2

	Processing time		
Job	**M/c–1**	**M/c–2**	**M/c–3**
1	8	5	4
2	10	6	9
3	6	2	8
4	7	3	6
5	11	4	5

Solution: we can extend the Johnson's algorithm to this problem. So the modified problem may be given as follows:

Table.4.8: Solution for Problem no.2

Job	Machine A	Machine B
1	13	9
2	16	15
3	8	10
4	10	9
5	15	9

The optimal sequence for the above problem: **3-2-5-1-4**

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SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SPR1306 – PRODUCTION PLANNING AND CONTROL

COURSE MATERIAL

UNIT – V – SPR1306 - PRODUCTION CONTROL

Phases of production control – principles and documents for dispatching, expediting and follow up – progress report – Gantt charts and Schedule graphs – Japanese techniques of production control – JIT system – kanban – system and procedures for PP & C, application of computers in PP & C

V. PRODUCTION CONTROL

PRODUCT LIFE CYCLE:

The product life cycle has 4 very clearly defined stages, each with its own characteristics that mean different things for business that are trying to manage the life cycle of their particular products.

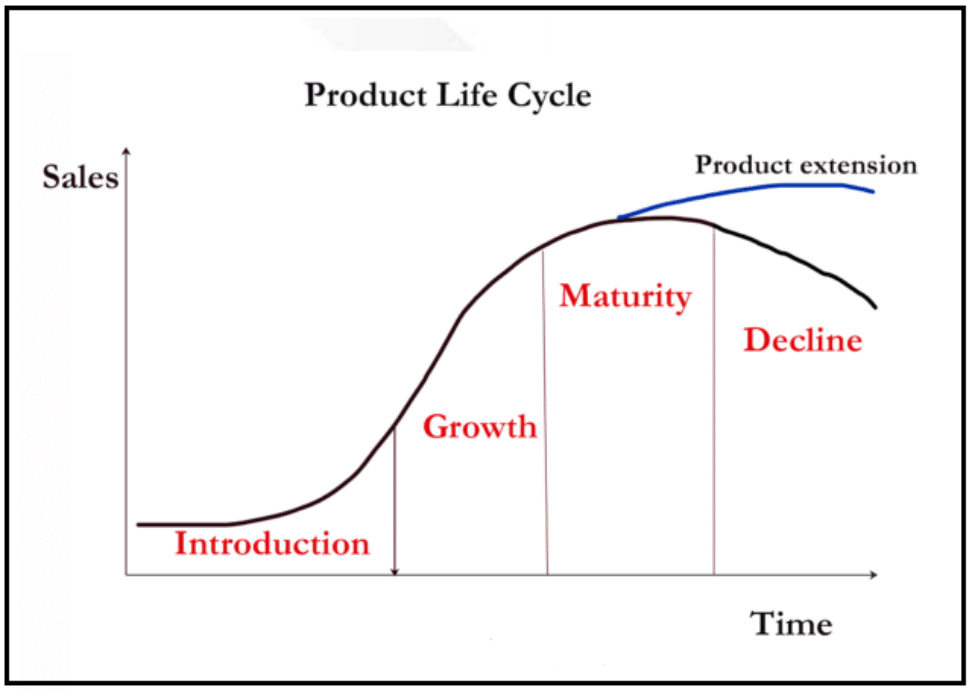

Fig.5.1: Product Life Cycle

Introduction Stage – This stage of the cycle could be the most expensive for a company launching a new product. The size of the market for the product is small, which means sales are low, although they will be increasing. On the other hand, the cost of things like research and development, consumer testing, and the marketing needed to launch the product can be very high, especially if it's a competitive sector.

Growth Stage – The growth stage is typically characterized by a strong growth in sales and profits, and because the company can start to benefit from economies of scale in production, the profit margins, as well as the overall amount of profit, will increase. This makes it possible for businesses to invest more money in the promotional activity to maximize the potential of this growth stage.

Maturity Stage – During the maturity stage, the product is established and the aim for the manufacturer is now to maintain the market share they have built up. This is probably the

most competitive time for most products and businesses need to invest wisely in any marketing they undertake. They also need to consider any product modifications or improvements to the production process which might give them a competitive advantage.

Decline Stage – Eventually, the market for a product will start to shrink, and this is what's known as the decline stage. This shrinkage could be due to the market becoming saturated (i.e. all the customers who will buy the product have already purchased it), or because the consumers are switching to a different type of product. While this decline may be inevitable, it may still be possible for companies to make some profit by switching to less-expensive production methods and cheaper markets.

PHASES OF PRODUCTION CONTROL

- Production control, is a directive function which involves the coordination and integration of operations and activities of different factors of production with a view to optimizing efficiency.
- Optimum efficiency is attainable by proper planning of work, laying down of exact routes which operations shall follow, correct fixing of time-table within which productive operations shall start and come to a close, uninterrupted releasing of orders and work facilities, and timely initiation of appropriate follow-up steps to ensure smooth functioning of the enterprise.
- Production control involves planning, routing, scheduling, dispatching and follow-up.
- The main functions are progress reporting and corrective actions.

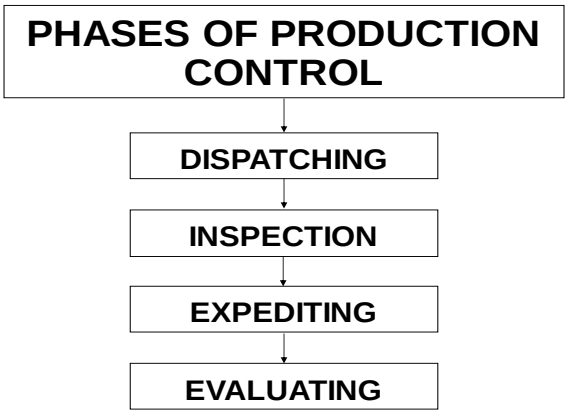

Fig.5.2: Phases of Production Control

DISPATCHING

Dispatching: Dispatching is nothing but issuing orders and instructions to start a particular work which has already been planned under routing and scheduling. Dispatching is the part of production control that translates the paper – work into actual production. It is the group that coordinates and translates planning into actual production.

Dispatching function proceeds in accordance with the details worked out under routing and scheduling functions. As such, dispatching sees to it that the material is moved to the correct work place, that tools are ready at the correct place for the particular operations that the work is moving according to routing instructions.

Dispatching carries out the physical work as suggested by scheduling. Thus, dispatching implies the issuance or work orders. These work orders represent authority to produce. These orders contain the following information:

- The name of the product;
- The name of the part to be produced, sub-assembly or final assembly;
- The order number;
- The quantity to be produced;
- Descriptions and numbers of the operations required and their sequence,
- The departments involved in each operation
- The tools required for particular operation; and
- Machines involved in each operation and starting dates for the operations.

Functions of Dispatching

(i) Assignment of work to individual man, m/c or work place.

(ii) Release necessary order and production firm.

(iii) Authorize for issue of materials, tools, jigs, fixtures, gauges, dies for various jobs.

(iv) Required materials are authorized to move from stores or from operation to operation.

(v) Issue m/c loading and schedule chart, route sheet, etc.

(vi) To fix up the responsibilities of guiding and controlling the materials and operation processes.

(vii) To issue inspection order.

(viii) Issue of time tickets, drawing, and instruction cards.

Dispatch procedure

The product is broken into different components. For each component, operations are mentioned in order as shown in Figure aside.

The various steps of dispatch procedure for each operation are listed below:

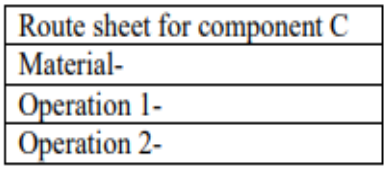

Fig.5.3: Dispatching Procedure

(a) **Store issue order:** Authorize store department to deliver required material.

(b) **Tool order:** Authorize tool store to release the necessary tools. The tools can be collected by the tool room attendant.

(c) **Job order**: Instruct the worker to proceed with operation.

(d) **Time tickets:** It records the beginning and ending time of the operation and forms the basis for workers' pay.

(e) **Inspection order:** Notify the inspectors to carry out necessary inspections and report the quality of the component.

(f) **Move order**: Authorize the movement of materials and components for one facility to another for further operation.

Dispatch Aspects

(1) All production information should be available beforehand.

(2) Various order cards and drawing with specification should be ready.

(3) Equipment should be ready for use.

(4) Progress of various orders should be recorded.

(5) All production records should be on Gantt chart.

CENTRALIZED AND DECENTRALIZED DISPATCHING

(a) Centralized Dispatching: In centralized dispatching system, a central dispatching department orders directly to the work stations. It maintains a full record of the characteristics and capacity of each equipment and work load against each m/c. The orders are given to the shop supervisor who runs his machine accordingly. In most of the cases, the supervisor can also give suggestions as regards to loading of m/cs under him.

Advantages: A greater degree of overall control can be achieved.

- Effective coordination between different facilities is possible.
- It has greater flexibility.
- Because of urgency of orders, changes in the schedule can be made easily without upsetting the whole system.
- Progress of orders can be readily assessed at any time because all the information is available is available at a central place.
- There is effective and better utilization of manpower and machines.

(b) **Decentralized Dispatching**: In decentralized dispatching system, the shop supervisor performs the dispatch function. He/she decides the sequence of handling different orders. He/she dispatches the orders and materials to each equipment and worker, and is required to complete the work within the prescribed duration. In case suspects delay, he/she informs the production control department.

Advantages: (i) Much of red tape (excessive adherence to official rules) is minimized.

(ii) Shop supervisor knows the best about his shop.

(iii)Communication gap is reduced.

(iv) It is easy to solve day to day problem.

Levels of Dispatch office:

- At plant manager's level.
- At shop superintendent level.
- At shop supervisor's level.
- At specialist level.

INSPECTION:

Inspection is the quality control aspect of production planning and control. It ensures that goods produced are of the right quality. The inspectors may inspect materials, semi-finished and finished products either at the work bench or in special laboratories or testing rooms.

EXPEDITING OR PROGRESSING OR FOLLOW-UP:

Expedition or progressing or follow-up is the last stage in the process of production control. This function is designed to keep track of the work effort. The aim is to ensure that what is intended and planned is being implemented. "Expediting consists in reporting production data and investigating variances from predetermined time schedules. The main idea behind expedition is to see that promise is backed up by performance".

Expediting and dispatching are frequently performed under the same agency, particularly in special project control. An expeditor follows the development of an order from the raw material stage to the finished product. He/she is often given the authority and facilities to move materials or semi-finished products to relieve congestion in production flow.

It includes the following functions:

1. Check-up to ensure that all materials, tools, component parts, and accessories are available at all work centers in specified quantities for starting and carrying out manufacturing operations.
2. Check-up on the status of work-in-progress and completed work at various work stations. This includes collecting information relating to the starting and completion time and date of work completed, status of work-in-progress relative to scheduled completion dates, position of movements of materials, component parts, and sub-assemblies within the plant, and inspection results.
3. Preparation of progress records and keeping the control boards up-to-date.

4. Reporting to manufacturing management on all significant deviations so that corrective action may be taken. It also includes reporting to production planning department so that future plans may be adjusted.

PROGRESSING OR FOLLOW-UP:

Follow-up is examining production activities methodically so that production may be done according to plan. It is the measurement of output against plan, analysis of performance for deficits and following up the line management to apply corrective action for excessive

underperformance. Progressing is the function by which one can give an early warning when actual production diverges from planned production and thus makes it possible to take remedial action. Follow-up is significant step of production control. This step is to determine from time-to- time that the production operations are progressing according to the plan. The follower is accountable for observing that any detail which is ignored or not correctly executed is set right. This makes sure proper synchronization of production plan and to take corrective measures if necessary. Follow-up can be performed at three stages, for materials, work-in-progress and stage during assembly and execution. It determines causes of delay which may be loss-making lot sizes; schedule beyond the capacity of the machine, underestimation of material, tools and manpower, errors in processing and inspection. The need of progressing arises due to:

1. Failure to deliver materials on time.
2. Machines/power breaks down.
3. Workers absenteeism.
4. Faults of design, planning or human activity,
5. Unnecessary delays/bottlenecks.

Expediting or progressing ensures that, the work is carried out as per the plan and delivery schedules are met.
Progressing includes activities such as status reporting, attending to bottlenecks or holdups in production and removing the same ,controlling variations or deviations from planned performance levels following up and monitoring progress of work through all stages of production, co-ordinating with purchase, stores, tool room and maintenance departments and modifying the production plans and re plan if necessary.

Need for expediting may arise due to the following reasons

1. Delay in supply of materials.
2. Excessive absenteeism.
3. Changes in design specifications.
4. Changes in delivery schedules initiated by customers.
5. Break down of machines or tools, jigs and fixtures.

Errors in design drawings and process plans.

Progress chasers are charged with the responsibilities of checking the progress continuously, Causes of discrepancy, if any, in programmed and actual performance, authorising and signing requisitions and liaison with other departments supplying materials and components to the particular department of the progress chaser.The following are the

Steps in Progressing or Follow-up:

1. Flowcharts indicating the planned sequence of operations.
2. Production schedules to compare targets with performances.
3. Machine loading charts indicating different operations performed by each machine.
4. Inspection schedules to establish a programme for inspection.

Progressing can perform following tasks:

1. Recording actual production.
2. Compare it with planned production.
3. Measure the variability in production.
4. Reporting the excessive variance to the authority responsible for execution of the production plan.

Progressing can be in the form of Programme control, Order progressing, Progressing of shortages, Daily plan progress, and Departmental progressing.

GANTT CHARTS

The GANTT procedure produces a Gantt chart that is a graphical scheduling tool for the planning and control of a project.

- In its most basic form, a Gantt chart is a bar chart that plots the tasks of a project versus time. It illustrates a project schedule. Gantt charts illustrate the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Modern Gantt charts also show the dependency (i.e., precedence network) relationships between activities.

Gantt charting: Gantt charts are a commonly used tool for determining and/or representing the exact sequence of operations at different work centers as well as waiting times and project completion times.

What Is a Gantt Chart?

A Gantt chart is a timeline of a project. The top of the chart shows the time frame and the left side of the chart lists the project activities.

A Gantt chart, commonly used in project management, is one of the most popular and useful ways of showing activities (tasks or events) displayed against time. On the left of the chart is a list of the activities and along the top is a suitable time scale.

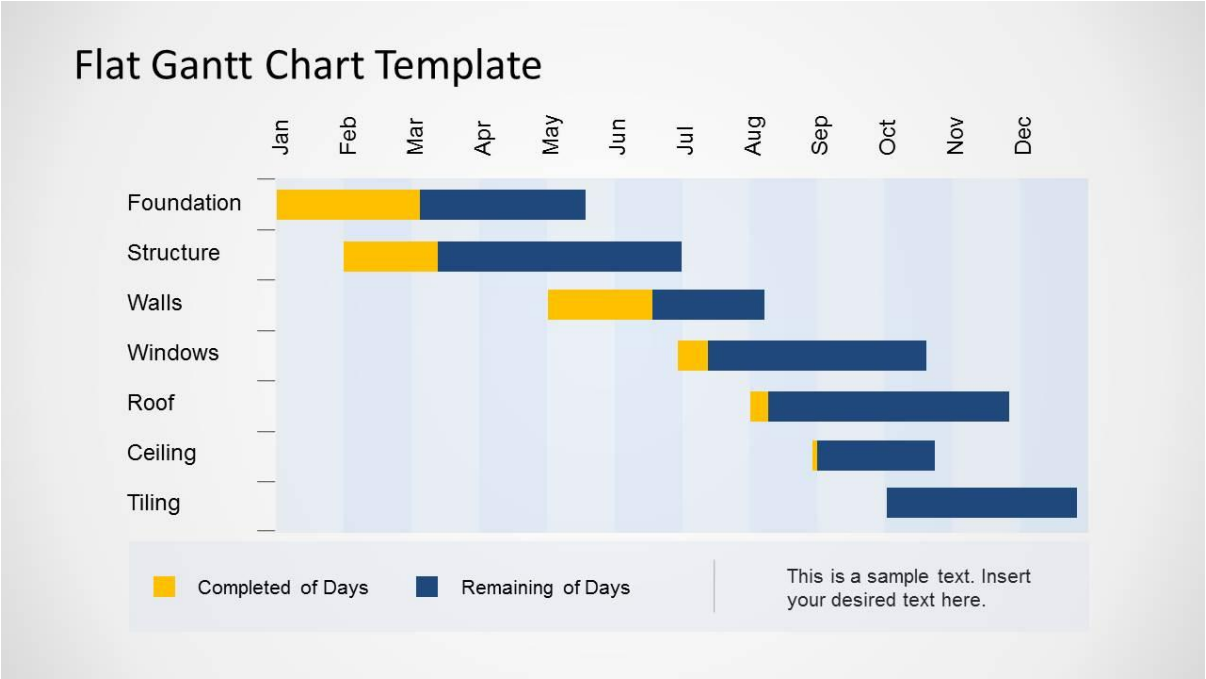

Fig.5.4: Gantt chart

Gantt charts are drawn with:

(1)Time across the top, (2) Either scarce resources or jobs are listed down the side.

(3) Sequences of activities for individual jobs are marked on timelines for each resource.

Gantt charts come in two forms:

1) by job or activity; **2) by machine.**

Gantt charts can be used to evaluate both job and machine performance. Thus, alternative sequencing options can be evaluated and the best (depending on the weighting of objectives) can be chosen.

Machine performance can be evaluated by make span and by machine or work center utilization. Job performance can be evaluated by the sum of delivery times for all jobs scheduled.

- Make span is the time required to complete all work on all jobs
- Machine or work center utilization is expressed at the percentage of time the machine is busy. To calculate this we start with calculating idle time
- Sum of delivery times. Since work time is fixed, delivery times are inversely related to waiting time. So to minimize delivery times, minimize waiting time. Alternative plans can be evaluated with alternative Gantt chart
-

JUST-IN-TIME / TOYOTA PRODUCTION SYSTEM

"A production system to produce the kind of units needed, at the time needed and in the quantities needed"

"A Philosophy of manufacturing based on planned elimination of all waste and continues improvement of productivity"

JIT was originally developed by Toyota Motor company in Japan

Producing quantity of units that is needed, no more, no less

Producing them on the date and time required, not before not after

Just-In-Time (JIT) manufacturing has been implemented successfully in Japan for the past 20 years. It is a philosophy as well as a technique that guides a manufacturing company in organizing and managing its business more effectively, and in planning and controlling its operations more efficiently. It is a way to achieve high velocity manufacturing.

High Velocity Manufacturing

Traditionally, a manufacturing business competes on price, quality, variety, after service, etc. Now, these conditions are merely prerequisites. Few businesses exist today without

offering low prices, high quality, and good service. The key competitive factor has become speed. All else being equal, the faster a business responds to its customers, the more profitable it is. The shorter the lead-time in which a manufacturer can supply its products, the higher the probability that it will survive. High velocity manufacturing is a common goal for all manufacturing businesses. In high velocity manufacturing, everything is moving. Machines, people, funds and materials are constantly moving. Therefore, inventories in storage or on the shop floor are moving inventories rather than sitting inventories. Inventories are stocked only for a very short time, and will move to other locations only moments after being stocked. The conditions of high velocity manufacturing include flow manufacturing, line balancing, level schedule, and linearity.

- *Flow Manufacturing*

  A product or a group of similar products are processed through a series of workstations arranged in a fixed sequence. The materials flow through each workstation at a constant production rate.

- *Line balancing*

  Line balancing is required in high velocity manufacturing. Under this condition, tasks must be designed so that the work assigned to each workstation will require about the same amount of time to complete. There is no bottleneck and no buildup of work-in-process (WIP) inventories. For cases where bottlenecks are unavoidable, the theory of constraints (TOC) is applied. TOC will be discussed later.

- *Level Schedule*

  The schedule sets the flow of material coming into and passing through the manufacturing system. Since the flow of materials must be even in a high velocity manufacturing system, the schedules are designed to be level.

- *Linearity*

  Linearity refers to production at a constant rate or the use of resources at a level rate that is measured at least daily.

Objective of JIT

JIT Manufacturing tries to smooth the flow of materials from the suppliers to the customers, thereby increasing the speed of the manufacturing process. The objectives of JIT is to change the manufacturing system gradually rather than drastically:

1. To be more responsive to customers,

2. To have better communication among departments and suppliers,
3. To be more flexible,
4. To achieve better quality,
5. To reduce product cost.

JIT Concept

The operations planning and control system is an information system running throughout the manufacturing environment. Although there is a common system framework as discussed in Chapter one, systems run in different ways in different environments. For example, dedicated special facilities are used in make-to-stock environments; general purpose machines are used in make-to-order environments. Dedicated production lines can be designed in a balanced way with minimal setups in order to maximize the flow rate of the materials, while a general purpose machine must be set up before producing a specific item. In setup operations, the material flow is interrupted.

Manufacturing environments can be changed to make planning and control systems simpler and more effective. For example, products are designed to have high similarity in processing and are mixed in a dedicated production line with negligible setups. Since lead-times are shortened, this turns a make-to-stock product into a make-to-order product. Just-in-time is not only a control technique, but also a way to improve the manufacturing environment. JIT control systems are only effective in JIT environments. Introducing kanban systems into a non-JIT environment means nothing to a company.

JIT Control can be incorporated into an ERP system as a control part with a condition that the system has to be in a JIT environment. The JIT philosophy guides the development of the JIT environment. The JIT environment provides the foundation for implementing the JIT control techniques. The JIT philosophy, JIT environment, and the JIT technique can be expressed in Figure 1.

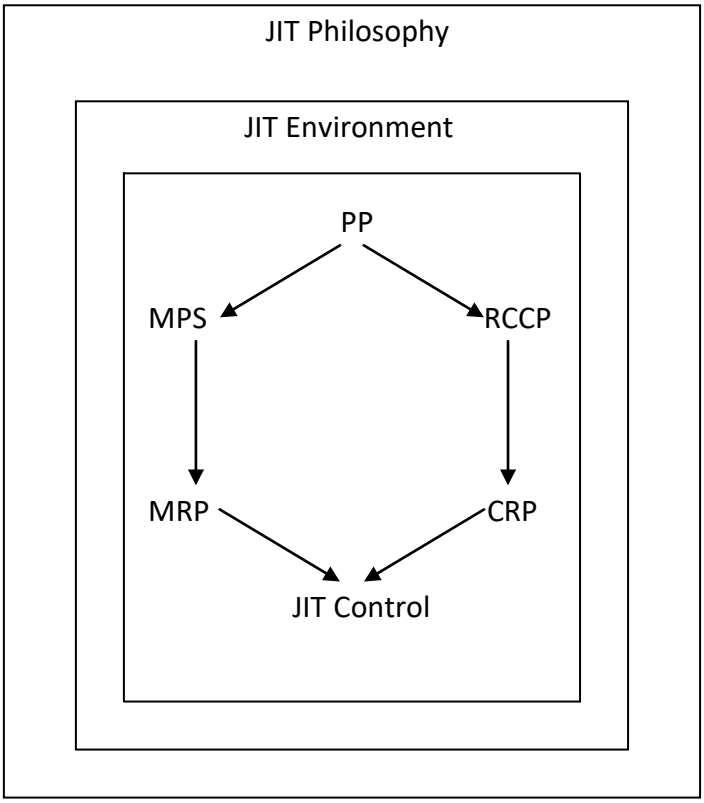

Fig.5.5: JIT Concept

JIT as a Philosophy

- *Elimination of waste*

  Any activity that does not add value to the product or service in the eyes of the customer is a waste. Poor product design such as the inclusion of fancy functions not required by the customer is a waste. A product design causing difficulty in manufacturing is a waste. Standardization reduces the planning and control efforts, the number of parts, and the inventory required. A poor product design without enough standardization leads to waste. In addition to waste resulting from poor design, Toyota identifies seven examples of waste resulting from poor manufacturing methods.

1. **Waste of overproduction**

   Overproduction is the production of goods more than what are immediately needed. Overproduction causes extra material handling, quality problems, and unnecessary inventories. Consuming materials for unnecessary products may cause a shortage of material for other products that are needed. Never overproduce

products to keep men and machines busy. If the required loading is less than the capacity, leave it alone. The labor can be switched to other departments, cleaning or maintaining the machines, accepting training and education, etc.

2. **Waste of waiting**

   A material waiting in queue is a waste. An operator waiting for material or instruction and having no productive work to do is a waste.

3. **Waste of movement**

   Poor plant layout results in materials having to be moved extra distances and cause unnecessary material handling costs. Work centers should be close to each other in order to reduce the move distance. Someone may say that close work centers provide no room for WIP inventories. That is fine! No room for WIP inventory forces the WIP to decrease.

4. **Waste of inventories**

   Inventory causes costs of interest, space, record keeping, and obsolescence. Moreover, inventory can mask problems which could cause more inventory buildup. For example, WIP inventory between work centers can hide the symptoms of an unbalanced production rate. Finished goods inventory can mask poor forecasting, poor quality, and poor production control. Inventory is not an asset; it is a waste!

5. **Waste of motion**

   Improper methods of performing tasks by the operators cause wasted motions. Reaching far for materials or machine buttons is a waste of motion. Searching for tools is a waste of motion. Any activity that does not add value to the products should be eliminated. Bad layout or training causes waste of motion.

6. **Waste of making defects**

   The cost of scraps is a waste. But it is the least important compared with other wastes caused by making defects. Defects interrupt the smooth flow of materials in the production line. If the scrap is not identified, next workstation will try using it to produce more wastes, or waste time waiting for good materials.

7. **Waste of process itself**

   Bad process design is a waste. For example, wrong type or size of machines, wrong tools, and wrong fixtures are wastes.

The principle of eliminating the wastes includes:

1. All waste should be eliminated.
2. Waste can gradually be eliminated by removing small amounts of inventory from the system, correcting the problems that ensue, and then, removing more inventory.
3. The customers' definitions of quality should drive product design and manufacturing system.
4. Manufacturing flexibility is essential to maintain high quality and low cost with an increasingly differentiated product line.
5. Mutual respect and support should exist among an organization, its employees, its suppliers, and its customers.
6. A team effort is required to achieve world class manufacturing capability.
7. The employee who performs a task is the best source of suggested improvements.

- *Continuous improvement/One Less at a Time*

  As we have mentioned before, JIT improves the manufacturing system gradually rather than drastically, as in business process reengineering (BPR). This gradual continuous improvement is defined by APICS Dictionary as "one less at a time": a process of gradually reducing the lot size of the number of items in the manufacturing pipeline to expose, prioritize, and eliminate waste. "One less at a

  time" is a constant, step-by-step methodology for making JIT work in any manufacturing environment. JIT is a never-ending series of small, controlled steps, not one great leap forward. In the JIT philosophy, not the same product is produced over and over again; instead, the same process is used repeatedly to produce different products.

  The procedure of "one less at a time" is as follows:

1. If the inventory is equal to zero then stop, else
2. Select the most prioritized process to be improved.
3. Improve the process.
4. Is the process economical? If no, go to step 3.
5. Reduce the inventory by a small amount.

6. Go to step 1.

The third step “Improve the process” in the above procedure can be broken down into following steps:

1. Observe the existing method and collect related data on the selected process.
2. Investigate and analyze the data to generate alternatives to improve the process.
3. Evaluate the alternatives to determine the new method for the process.
4. Install the new method and educate the operator.
5. Maintain the new method.

The effects of “One inventory less” can be expressed as in Figure 2. Reducing inventory forces the setup times to decrease for more frequently the products have to be produced to maintain lower inventory level. In order to have shorter setup times, processes must be designed to be more flexible and workers must be trained to do multiple jobs. The need for shorter setup times also demands that the number of items be fewer. The number of items can be reduced through a design of more common parts and modules in different products. Shorter setup times lead to smaller lot sizes and shorter lead times. Shorter lead times result in more frequent product delivery and decrease the need for accurate forecasting and planning which increase the schedule stability. More frequent distribution forces people to reduce paper work and material move distance, and to develop more efficient material handling and transportation systems. Less inventory demands a higher quality level, zero defect

process, and better preventive maintenance. Less inventory also requires better communication between departments, customers, and suppliers, and hence requires a smaller number of suppliers.

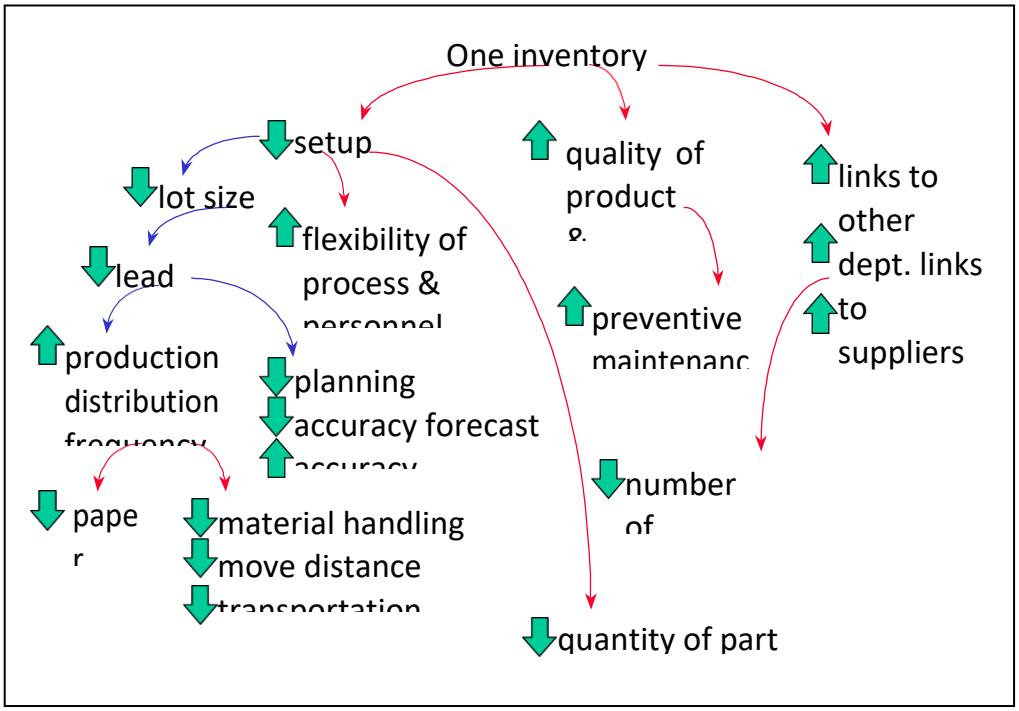

Fig.5.6: Effects of Less Inventories

- *Problems as opportunities*

  JIT philosophy sees the problems as the opportunities. A problem is an opportunity to improve. JIT exposes problems rather than covering them.

- *Quality at the source*

  Defects may occur at the design stage, any workstation in the production line, or the suppliers' plants. Quality does not come from inspection. It does not come from manufacturing either. Quality comes from good design. The quality of a product is determined at the design stage, including product design and process design. A poor design will never result in good quality. In a production line, it is not adequate to inspect the products at the end the line. Inspections should be executed by the operators themselves at each step of the line before the parts are passed on to the following process. The operator in the next workstation has no obligation to inspect an incoming part. A defect must be screened out immediately after it occurs. For purchased parts, the inspection should be completed before delivery. Incoming inspection is not required.

- *Simplification*

  Simplicity is a key to successful manufacturing. Products should be designed to be easy to manufacture, install, and repair. Only 2 or 3 levels should exist in the bill of

material. Suppliers deliver the materials regularly and purchase orders are not required. Materials are stored at the point of use (POU), and picking orders are not required. Work centers produce the items when they are consumed and shop orders are not required. Material inventory records are not updated until the finished goods are reported complete. Simplifying the system is central to the philosophy of JIT.

- *Visual Control*

  Visible control tools are used wherever possible. Cards attached to the materials, containers at sight, tags in stock indicating order points, etc. are examples of visual control tools. These signals are processed by human intelligence at the speed of light, and are superior to any computer in the world. JIT philosophy reminds us that natural human senses are effective tools but are frequently ignored.

- *Focus on Customer Needs*

  In JIT philosophy, only values in customers' eyes are real values. Values perceived by engineers but not accepted by customers are wastes. All activities from production design, material procurement, fabrication, assembly, distribution to after service, focus on customer needs. Any motion of the operator on the shop floor not adding value to customer needs is a waste.

- *Production to Customer Demand*

  In JIT philosophy, only immediate customer demands are produced. Extra items not required immediately by the customers are not put into production. Without customer demand, there should be no production.

- *Respect for Individual*

  Each individual in a company is an important asset. Education and training are frequently conducted to enhance the capability of the employees. Employee involvement and empowerment are part of JIT philosophies. Employee involvement is the concept of using the experience, creativity, and intelligence of all employees by treating them with respect, keeping them informed, and including them and their ideas in decision making processes (Apics, 1995). Employee empowerment is the practice of giving non-managerial employees the responsibility and power to make decisions that can effect their jobs or tasks. It allows employee to take responsibility for tasks normally associated with staff specialists, such as scheduling, inspection, etc. (Apics, 1995).

JIT as an Environment

In addition to philosophical concepts, JIT also provides an environment in which products are manufactured in a simpler way.

- Repetitive Manufacturing

  Repetitive manufacturing is the production of discrete items in a production line with fixed routings. The items can be a product or a family of products. The product is standard or made from standard modules. The manufacturing environment is make-to-order (MTO) or assemble-to-order (ATO). The production line consists of workstations located close together and in sequence. Materials flow from a workstation to the next at a relatively constant rate. Material handling systems are normally used to move the materials from process to process in the production line. Normally, the capacity of the production line is kept sufficient. The repetitive manufacturing is based on an uninterrupted flow of materials.

Three fundamental concept of JIT

1. Elimination of waste and variability

2. Pull versus Pull system

3. Manufacturing cycle time

1). **Elimination of waste and variability**

- "Anything that does not add value" is described as waste in production of G & S.
- Products being stored, inspected or delayed, products waiting in queue and defective product do not add value hence they are 100% waste
- JIT Speeds throughput (converted from raw materials into finished goods) allowing faster delivery and reducing work in process.

2) **Pull Vs Push system**

- The pull inventory control system begins with a customer's order. With this strategy, companies only make enough product to fulfil customer's orders.
- One advantage to the system is that there will be no excess of inventory that needs to be stored, thus reducing inventory levels and the cost of carrying and storing

goods. Ex. JIT (The goal is to keep inventory levels to a minimum by only having enough inventory, not more or less, to meet customer demand)

- The push system of inventory control involves forecasting inventory needs to meet customer demand. Companies must predict which products customers will purchase along with determining what quantity of goods will be purchased.
- The company will in turn produce enough product to meet the forecast demand and sell, or push, the goods to the consumer. Ex. MRP (it combines the calculations for financial, operations and logistics planning.)

3) **Manufacturing cycle time**

- It is time between the arrival of raw material and shipping of finished products.
- JIT helps to reduce the manufacturing cycle time.

OVERVIEW OF JIT MANUFACTURING

Inventory reduction: JIT is system for reducing inventory levels at all stages of production

Quality Management: JIT provide procedure for improving both quality within the firm

Lead time reduction: With JIT, lead time components such as Set up and move times are significantly reduced.

Continuous Improvement: JIT system, existing problems are corrected and new problem identifies

CHARACTERISTICS OF JIT

JIT system focus on reducing inefficiency and unproductive time in production process to improve continuously the process and quality.

1. Pull method of material flow
2. Constantly High Quality
3. Uniform Workstation Loads
4. Standardized components and work methods
5. Close Supplier Ties
6. Flexible workforce
7. Automated Production

Elements of JIT

1. Eliminating waste
2. Enforced Problem Solving
3. Continuous Improvement / Kaizen
4. Involvement of People
5. Total Quality Management

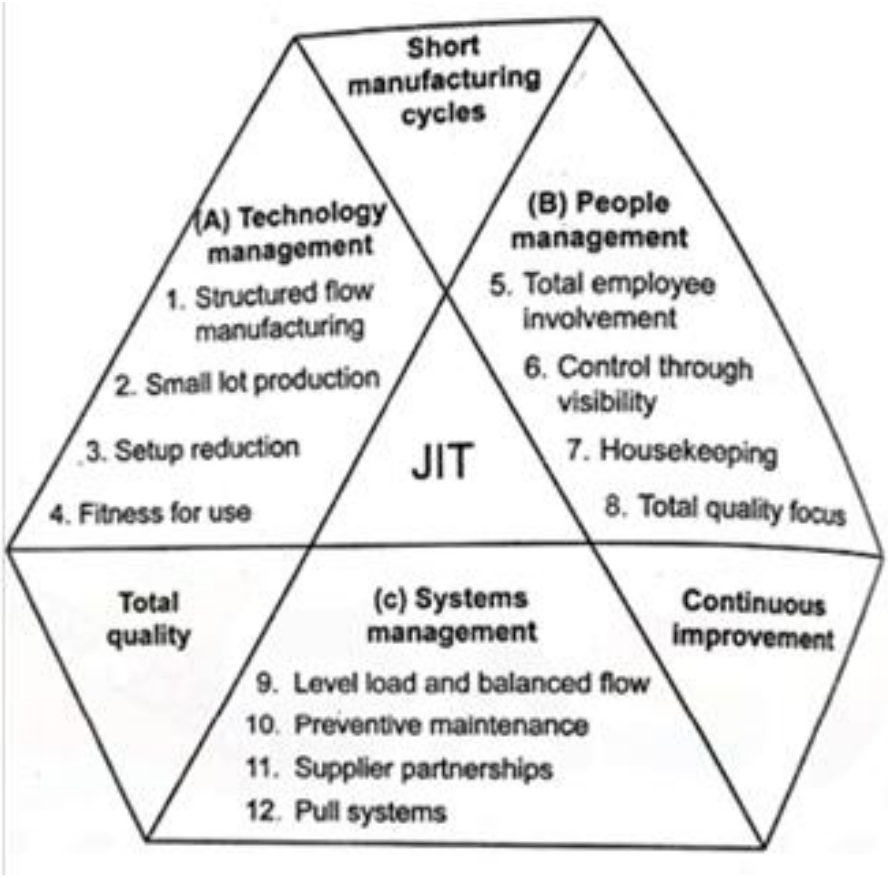

Fig.5.7: Elements of JIT

Benefits of JIT

- Lower Warehouse Costs (Storing excess inventory can cost a lot of money)
- Better Customer Satisfaction (model can allow companies to serve their customers faster and more efficiently)
- Reduce Waste Improved Supplier Relationships

Drawback of JIT

- A supplier that does not deliver goods to the company exactly on time
- An investment should be made in information technology to link the computer systems of the company and its suppliers,

- A company may not be able to immediately meet the requirements of a massive and unexpected order
- Risk of running out of stock
- More Planning required

Lean manufacturing

- Lean manufacturing or lean production, is a systematic method for the elimination of waste (Muda) within a manufacturing system.
- Lean also takes into account waste created through overburden ("Muri") and waste created through unevenness in work loads ("Mura").
- Lean manufacturing is a management philosophy derived

Key Lean Manufacturing Techniques

- 5S
- Kanban

5S

Strategy for creating a well-organized, smoothly flowing manufacturing process

Benefits of 5S

- Increases organization and efficiency
- Avoids wasted motion
- Increases safety
- Eliminates unnecessary inventory
- Offers improvements

KANBAN

- It is a scheduling system for lean and just-in-time (JIT) production.
- Kanban is a system to control the logistical chain from a production point of view, and is an inventory control system.
- Kanban is a tool for managing the flow of materials or information (or whatever) in a process. Not having the materials, whether it is a part, a document, or customer information, at the time you need it causes delay and waste. On the other hand, having too many parts on hand or too much work in process (WIP) s also a form of waste.
- Kanban is a tool to learn and manage an optimal flow of work within the process.

- Kanban aligns inventory levels with actual consumption. A signal tells a supplier to produce and deliver a new shipment when material is consumed. These signals are tracked through the replenishment cycle, bringing visibility to the supplier, consumer, and buyer.
- Kanban uses the rate of demand to control the rate of production, passing demand from the end customer up through the chain of customer-store processes.
- Kanban cards are a key component of kanban and they signal the need to move materials within a production facility or to move materials from an outside supplier into the production facility.
- The kanban card is, in effect, a message that signals depletion of product, parts, or inventory. When received, the kanban triggers replenishment of that product, part, or inventory. Consumption, therefore, drives demand for more production, and the kanban card signals demand for more product—so kanban cards help create a demand-driven system
- Visualize Workflow - A visual representation of the process lets you see exactly how tasks change from being “not done” to “done right”. The more complex a process is, the more useful and important creating a visual workflow becomes, but kanban can be used if there are just a few steps (do, doing, done) or a lot of steps (plan, design, draft, approve, schedule, implement, test, integrate, deploy). However complex the project may be, creating a kanban board allows you to see the status of the work being done at a glance.
- Limit Work in Process (WIP) - Get more done by doing less. It may seem counterintuitive, but it is a powerful idea that has been proven time and time again to be true. There is a limit to the number of things you can be working on and still do them well, and that limit is often lower than you think. Whether a project is simple or complex or whether the team is small or large, there is an optimal amount of work that can be in the process at one time without sacrificing efficiency. It’s not uncommon to find that doing ten things at once takes a week, but doing two things at once takes hours, resulting in twenty things being done by the end of the week. Kanban metrics lets you find that optimal number.
- Measure and Improve Flow - Improvement should always be based on objective measurements, and kanban is no different. Finding and applying good metrics is usually a difficult step, but a few simple measures automatically generated by an

application like Kanbanery can give you the information you need to tweak your process to optimize flow and maximize efficiency

Types of kanban systems:

· In a kanban system, adjacent upstream and downstream workstations communicate with each other through their cards, where each container has a kanban associated with it. The two most important types of kanbans are:

· Production (P) Kanban: A P-kanban, when received, authorizes the workstation to produce a fixed amount of products. The P-kanban is carried on the containers that are associated with it.

· Transportation (T) Kanban: A T-kanban authorizes the transportation of the full container to the downstream workstation. The T-kanban is also carried on the containers that are associated with the transportation to move through the loop again.

- Kanban cards are a key component of kanban and they signal the need to move materials within a production facility or to move materials from an outside supplier into the production facility.
- In the last few years, systems sending kanban signals electronically have become more widespread. In various software systems, kanban is used for signalling demand to suppliers through email notifications.
- Electronic kanban help to eliminate common problems such as manual entry errors and lost cards

Benefits of Kanban

- Highly visible systems
- Simple, effective, and inexpensive
- Reduces inventory and eliminates stock-outs
- Improves the quality of service
- Improves lead times

Kaizen

- Kaizen (改善), Japanese for "improvement“
- kaizen refers to activities that continuously improve all functions and involve all employees from the CEO to the assembly line workers.
- By improving standardized activities and processes, kaizen aims to eliminate waste

- Kaizen is a daily process, the purpose of which goes beyond simple productivity improvement.
- The Toyota Production System is known for kaizen, where all line personnel are expected to stop their moving production line in case of any abnormality

Procedures for PPC:

Production planning and control is a device that regulates the movements of materials, performance of machines and operation of labour in the best technical and economical manner; so as to obtain right quantity of production of required quality – at a time which is promised for delivery of goods to customers.

Steps in Production Planning and Control:

(i) Planning
(ii) Routing
(iii) Scheduling
(iv) Dispatching
(v) Follow-up or checking the progress
(vi) Inspection

Out of these six steps involved in production control, the first three steps relate to planning; the fourth relates to execution of plan and the last two refer to the control aspect of planning.

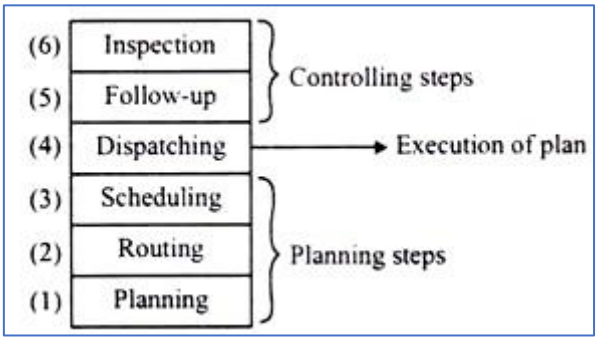

Fig.5.8: Steps in Production Control

Four steps to ensure efficient use of resources.

The primary activity of a PPC is to collect and analyze data so that we may draw conclusions about and ultimately improve our production processes. In many industrial applications, access to production facilities for the purposes of conducting experiments is

very limited. Thus we must be very careful in how we go about these activities so that we can be sure of doing them in a cost-effective manner

Step 1: Plan

The most important step by far is the planning step. By faithfully executing this step, we will ensure that we only collect data in the most efficient manner possible and still support the goals of the PPC. Planning should generate the following:

- a statement of the goals
- a descriptive process model (a list of process inputs and outputs)
- a description of the sampling plan (including a description of the procedure and settings to be used to run the process during the study with clear assignments for each person involved)
- a description of the method of data collection, tasks and responsibilities, formatting, and storage
- an outline of the data analysis

All decisions that affect how the characterization will be conducted should be made during the planning phase. The process characterization should be conducted according to this plan, with all exceptions noted.

Step 2: Collect

Data collection is essentially just the execution of the sampling plan part of the previous step. If a good job were done in the planning step, then this step should be pretty straightforward. It is important to execute to the plan as closely as possible and to note any exceptions.

Step 3: Analyze and interpret

This is the combination of quantitative (regression, ANOVA, correlation, etc.) and graphical (histograms, scatter plots, box plots, etc.) analysis techniques that are applied to the collected data in order to accomplish the goals of the PPC.

Step 4: Report

Reporting is an important step that should not be overlooked. By creating an informative report and archiving it in an accessible place, we can ensure that others have access to the information generated by the PPC. Often, the work involved in a PPC can be minimized by using the results of other, similar studies.

Application of computer in production planning & control

Over the last 40 years, the role of computers in the production planning process has changed dramatically. In the 1970's, a calculator was considered a high-priced luxury item, and business mainframe programs were stored on cards. Today, every production planner has a personal computer with more processing capability than the mainframes of the past.

Advances in computer hardware and software have enabled production planning processes to operate more efficiently and effectively than ever before.

Some of the areas where computers are used in business and industry are as follows:

[a] Inventory Control,

[b] Production Planning,

[c] Budgeting and Variance Analysis,

[d] Plant Capacity Utilization,

[e] Quality Control,

[f] Market Research,

[g] Purchase Accounting,

[h] Sales Accounting,

[i] Payroll Accounting,

[j] Information Management, and so.

Role of Computer:

With the expansion of business activities, the volume of business transactions has increased. The manual method of maintaining books of accounts is found to be unmanageable and

gradually computers have replaced the manual method of accounting. And finally the database technology has revolutionized the accounting departments of business organizations.

Computer is an electronic device that can perform a variety of operations in accordance with a set of instructions called program.

It is fast electronic data processing machine, which can provide solutions to all complicated situations. It accepts data from the user, converts the data into information, and provides the desired results.

APPLICATIONS OF COMPUTERS IN PRODUCTION PLANNING CONTROL

Over the last 40 years, the role of computers in the production planning process has changed dramatically. In the 1970's, a calculator was considered a high-priced luxury item, and business mainframe programs were stored on cards. Today, every production planner has a personal computer with more processing capability than the mainframes of the past. Advances in computer hardware and software have enabled production planning processes to operate more efficiently and effectively than ever before.

Enterprise Resource Planning (ERP)

In the 1990's, ERP (enterprise resource planning) systems gained in popularity. ERP systems, such as SAP and Oracle, provided a "massive software achitecture" to support key business functions such as finance, accounting, materials management and production control. Specific to production control, users now have the ability to access all their key data within a single source. Inventory, forecast, customer orders, bills of materials, manufacturing routers, planning parameters and mrp output all reside within the ERP system and are readily accessible to production planners.

Automation of Repetitive Processes

ERP software, combined with increased hardware processing speeds have enabled companies to automate repetitive processes. Where 20 years ago employees had to manually calculate production requirements for each item to determine what to produce, computer software now nets forecast and orders against inventory and schedules to project

future inventory balances. Calculating how much stock is "available to promise" is now instantly updated as each sales order is processed. MRP (material requirement planning) processes explode bills of materials against production plans to determine what raw materials must be purchased to support the production schedule. In the past, these calculations were performed manually. Today, computers have reduced processing time, allowing production planners to focus on data analysis rather than data collection.

Recommend Solutions

Along with automating repetitive processes and calculations, computers generate recommended schedules and purchases to planners. The key output of an MRP system is a set of planned orders. Planned orders are calculated within the production and inventory parameters maintained by the planner and represent a view of what items and quantities need to be produced or purchased to fulfill demand. Utilizing system-generated planned orders allows a planner to quickly and easily identify what is needed and also allows the planner to manage a larger number of products than if the planning process were peformed manually. Another tool used by production planning to recommend solutions is advanced planning and scheduling (APS). APS software works to optimize schedules within capacity constraints. Optimization logic can focus on order fulfillment, inventory investment, production cost control or any combination of the three. The complex Monte Carlo simulation logic used in most APS software would be nearly imposisble for users to re-create manually.

Exception-Based Planning

Another important aspect of MRP and APS software is the provision of exception-based planning. For example, a company that offers more than 5,000 products to its customer base has requirements for a fraction of those products at any given time. For a planner to review all 5,000 products daily would be nearly impossible. If a planner spends only five seconds on each item, it would take seven hours to review all 5,000 products. Exception-based planning tools, such as MRP and APS, allow production planners to review only the items where action is needed, while ignoring the items with no requirements.