UNIVERSITY OF CROSS RIVER STATE

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE TITLE: PRODUCTION ENGINEERING AND CONTROL

UNIT -II

FORE CASTING

INTRODUCTION

The growing competition, frequent changes in customer's demand and the trend towards automation demand that decisions in business should not be based purely on guesses rather on a careful analysis of data concerning the future course of events. More time and attention should be given to the future than to the past, and the question 'what is likely to happen?' should take precedence over 'what has happened?' though no attempt to answer the first can be made without the facts and figures being available to answer the second. When estimates of future conditions are made on a systematic basis, the process is called forecasting and the figure or statement thus obtained is defined as forecast.

In a world where future is not known with certainty, virtually every business and economic decision rests upon a forecast of future conditions. Forecasting aims at reducing the area of uncertainty that surrounds management decision-making with respect to costs, profit, sales, production, pricing, capital investment, and so forth. If the future were known with certainty, forecasting would be unnecessary. But uncertainty does exist, future outcomes are rarely assured and, therefore, organized system of forecasting is necessary. The following are the main functions offorecasting:

- The creation of plans of action.
- The general use of forecasting is to be found in monitoring the continuing progress of plans based on forecasts.
- The forecast provides a warning system of the critical factors to be monitored regularly because they might drastically affect the performance of the plan.

It is important to note that the objective of business forecasting is not to determine a curve or series of figures that will tell exactly what will happen, say, a year in advance, but it is to make analysis based on definite statistical data, which will enable an executive to take advantage of future conditions to a greater extent than he could do without them. In forecasting one should note that it is impossible to forecast the future precisely and there always must be some range of error allowed for in the **forecast.**

FORECASTING FUNDAMENTALS

Forecast: A prediction, projection, or estimate of some future activity, event, or occurrence.

Types of Forecasts

- 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 orservices.

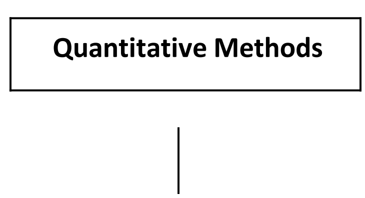
Since virtually all the operations management decisions (in both the strategic category and the tactical category) require as input a good estimate of future demand, this is the type of forecasting that is emphasized in our textbook and in this course.

TYPES OF FORECASTING METHODS

Qualitative methods: 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

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

QUANTITATIVE FORECASTING METHODS



Associative Models

Time-Series Models

Time series models look at past patterns of data and attempt to predict the future based upon the underlying patterns contained within those data.

Associative models (often called causal models) assume that the variable being forecasted is related to other variables in the environment.

They try to project based upon those

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

DECOMPOSITION OF A TIME SERIES

Patterns that may be present in a time series

Trend: Data exhibit a steady growth or decline over time.

Seasonality: Data exhibit upward and downward swings in a short to intermediate time frame (most notably during a year).

Cycles: Data exhibit upward and downward swings in over a very long time frame.

Random variations: Erratic and unpredictable variation in the data over time with no discernable pattern.

ILLUSTRATION OF TIME SERIES DECOMPOSITION

Hypothetical Pattern of Historical Demand

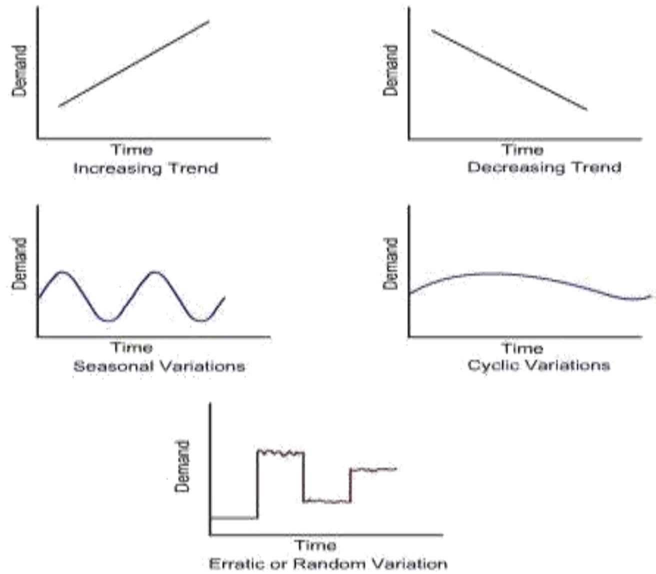
Dependent versus Independent Demand

Demand of an item is termed as independent when it remains unaffected by the demand for any other item. On the other hand, when the demand of one item is linked to the demand for another item, demand is termed as dependent. It is important to mention that only independent demand needs forecasting. Dependent demand can be derived from the demand of independent item to which it is linked.

Business Time Series

The first step in making a forecast consists of gathering information from the past. One should collect statistical data recorded at successive intervals of time. Such a data is usually referred to as time series. Analysts plot demand data on a time scale, study the plot and look for consistent shapes and patterns. A time series of demand may have constant, trend, or seasonal pattern (Figure 1)

Figure 1: Business Time Series



or some combination of these patterns. The forecaster tries to understand the reasons for such changes, such as,

- Changes that have occurred as a result of general tendency of the data to increase or decrease, known as secular movements.
- Changes that have taken place during a period of 12 months as a result in changes in climate, weather conditions, festivals etc. are called as seasonal changes.
- Changes that have taken place as a result of booms and depressions are called as cyclical variations.
- Changes that have taken place as a result of such forces that could not be predicted (like flood, earthquake etc.) are called as irregular or erratic variations.

Quantitative Approaches of Forecasting

Most of the quantitative techniques calculate demand forecast as an average from the past demand. The following are the important demand forecasting techniques.

- Simple average method: A simple average of demands occurring in all previous time periods is taken as the demand forecast for the next time period in this method. (Example 1)

Example 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

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

Simple moving average method: In this method, the average of the demands from several of the most recent periods is taken as the demand forecast for the next time period. The number of past periods to be used in calculations is selected in the beginning and is kept constant (such as 3-period moving average). (Example 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)

$$MA_3 = \frac{40 + 60 + 45}{3}$$
$$= 48.33$$
$$\approx 49 \text{ units}$$

- Weighted moving average method: In this method, unequal weights are assigned to the past demand data while calculating simple moving average as the demand forecast for next time period. Usually most recent data is assigned the highest weight factor. (Example 3)

Example 3
Weighted Moving Average Method :

The manager of a restaurant wants to make decision on inventory and overall cost. He wants to forecast demand for some of the items based on weighted moving average method. For the past three months he experienced a demand for pizzas as follows:

Month	Demand
October	400
November	480
December	550

Find the demand for the month of January by assuming suitable weights to demand data.

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

Ci = Weights for Periods

Di = Demand for Periods

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

$$\therefore WMA = C1D1 + C2D2 + C3D3$$
$$= 0.25*400 + 0.3*480 + 0.5*550$$
$$= 100 + 144 + 275$$
$$= 519 \text{ units}$$

- Exponential smoothing method: In this method, weights are assigned in exponential order. The weights decrease exponentially from most recent demand data to older demand data. (Example 4)

Example 4
Exponential Smoothing :

One of the two wheeler manufacturing company exprienced 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 forecast future demand. Using the simple average method demand forecast for June is found as 320 bikes (Use a smoothing coefficient 0.7 to weight the recent demand 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:

$$= 0.7(420) + (1-0.7)320$$
$$= 294 + 96$$
$$= 390 \text{ units}$$

for August:

$$= 0.7(440) + (1-0.7)390$$
$$= 308 + 117$$
$$= 425 \text{ units}$$

- Regression analysis method: In this method, past demand data is used to establish a functional relationship between two variables. One variable is known or assumed to be known; and used to forecast the value of other unknown variable (i.e. demand). (Example 5)

Example 5

Regression Analysis :

Farewell Corporation manufactures Integrated Circuit boards(I.C board) for electronics 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 advance 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 spend by the client on advertising and sales (in dollar) is given for different periods in following 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

$$b = \frac{n(\sum X_t D_t) - (\sum X_t)(\sum D_t)}{n(\sum X_t^2) - (\sum X_t)^2}$$
$$= \frac{10(1599) - (211)(76)}{10(4597) - (211)^2}$$
$$= \frac{15990 - 16036}{45970 - 44521}$$
$$= \frac{-46}{1449} = -0.0317$$
$$a = \sum D_t - b\sum X_t$$
$$= \frac{76 - (-0.0317)211}{10}$$
$$= 8.268$$

Relationship between future sales F_t and advertising cost X_t is

$$F_t = a + bX_t$$
$$= 8.268 - 0.0317X_t$$

Error in Forecasting

Error in forecasting is nothing but the numeric difference in the forecasted demand and actual demand. MAD(Mean Absolute Deviation) and Biasare two measures that are used to assess the accuracy of the forecasted demand. It may be noted that MAD expresses the magnitude but not the direction of the error.

$$\text{MAD} = \frac{\text{sum of the absolute value of forecast error for all periods}}{\text{number of periods}}$$
$$= \frac{\sum_{i=1}^{n} \left|\text{forecast error}_i\right|}{n}$$
$$= \frac{\sum_{i=1}^{n} \left|(\text{forecasted demand} - \text{actual demand})_i\right|}{n}$$

where n is the number of periods.

$$\text{Bias} = \frac{\text{sum of all forecast errors for all periods}}{\text{number of periods}}$$
$$= \frac{\sum_{i=1}^{n} (\text{forecast demand} - \text{actual demand})_i}{n}$$

where n is the number of periods.

UNIT-III

INVENTORY

Introduction:

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. Inventory may be in the form of,

- Raw material inventory
- In process inventory
- Finished goods inventory
- Spare parts inventory
- Office stationary etc.

As a lot of money is engaged in the inventories along with their high carrying costs, companies cannot afford to have any money tied in excess inventories. Any excessive investment in inventories may prove to be a serious drag on the successful working of an organization. Thus there is a need to manage our inventories more effectively to free the excessive amount of capital engaged in the materials.

Inventory Management:

In any business or organization, all functions are interlinked and connected to each other and are often overlapping. Some key aspects like supply chain management, logistics and inventory form the backbone of the business delivery function. Therefore these functions are extremely important to marketing managers as well as finance controllers.

Inventory management is a very important function that determines the health of the supply chain as well as the impacts the financial health of the balance sheet. Every organization constantly strives to maintain optimum inventory to be able to meet its requirements and avoid over or under inventory that can impact the financial figures.

Inventory is always dynamic. Inventory management requires constant and careful evaluation of external and internal factors and control through planning and review. Most of the organizations have a separate department or job function called inventory planners who continuously monitor, control and review inventory and interface with production, procurement and finance departments.

Different Types of Inventory:

Inventory of materials occurs at various stages and departments of an organization. A manufacturing organization holds inventory of raw materials and consumables required for production. It also holds inventory of semi-finished goods at various stages in the plant with various departments. Finished goods inventory is held at plant, FG Stores, distribution centers etc. Further both raw materials and finished goods those that are in transit at various locations also form a part of inventory depending upon who owns the inventory at the particular juncture. Finished goods inventory is held by the organization at various stocking points or with dealers and stockiest until it reaches the market and end customers.

Besides Raw materials and finished goods, organizations also hold inventories of spare parts to service the products. Defective products, defective parts and scrap also forms a part of inventory as long as these items are inventoried in the books of the company and have economic value.

Types of Inventory by Function:

INPUT	PROCESS	OUTPUT
Raw Materials	Work In Process	Finished Goods
Consumables required for processing. Eg : Fuel, Stationary, Bolts & Nuts etc. required in manufacturing	Semi Finished Production in various stages, lying with various departments like Production, WIP Stores, QC, Final Assembly, Paint Shop, Packing, Outbound Store etc.	Finished Goods at Distribution Centers through out Supply Chain
Maintenance Items/Consumables	Production Waste and Scrap	Finished Goods in transit
Packing Materials	Rejections and Defectives	Finished Goods with Stockiest and Dealers
Local purchased Items required for production		Spare Parts Stocks & Bought Out items
		Defectives, Rejects and Sales Returns
		Repaired Stock and Parts,
		salels promotion & sample stocks

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.

Why Inventories?

Inventories are needed because demand and supply can not be matched for physical and economical reasons. There are several other reasons for carrying inventories in any organization.

- 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.

Relevant 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.

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

- Carrying costs: 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.
- Stock out costs: 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.

If one year planning horizon is used, the total annual cost of inventory can be expressed as:

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

d_l = Demand per unit time during lead time

D_l = Total demand during lead time

TC = Total annual inventory costs

TC* = Minimum total annual inventory costs

Number of orders per year = $\frac{\text{AnnualDemand}}{\text{OrderQuantity}} = \frac{D}{Q}$

Total procurement cost per year = S.D / Q

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

$$= I \cdot C \cdot \left(\frac{0 + Q}{2}\right)$$

$$= I \cdot C \cdot \frac{Q}{2}$$

Cost of items per year = Annual demand * unit cost

= D.C

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 1 . 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.

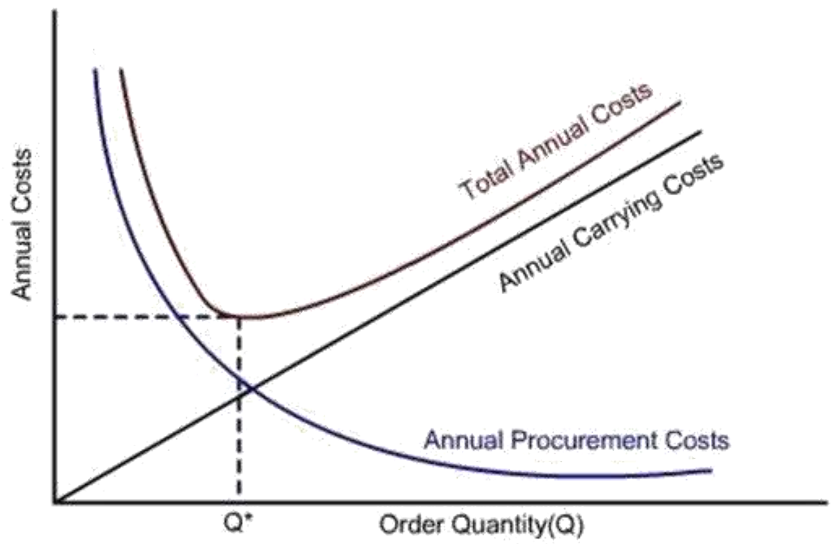


Figure 1: Inventory Related Costs

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.

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 $ spend.
B Category Items Comprise 30% of SKU & Contribute to 15% of $ spend.
C Category Items Comprise 50% of SKU & Contribute to 5% of $ spend.

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.

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 are to be combined.

Inventory Modeling:

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

Economic Order Quantity (EOQ) Model

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.

- Demand per year is deterministic in nature
- Planning period is one year
- Lead time is zero or constant and deterministic in nature
- Replenishment of items is instantaneous
- Demand/consumption rate is uniform and known in advance
- 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.

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

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

$$\frac{\delta(TC)}{\delta Q} = 0 + \left(-\frac{S\,D}{Q^2}\right) + \left(\frac{I\,C}{2}\right)$$

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

$$Q^* = \sqrt{\frac{2\,D\,S}{I\,C}}$$

where Q* is the optimal order quantity.

The graphical representation of the EOQ model is shown in following Figure.

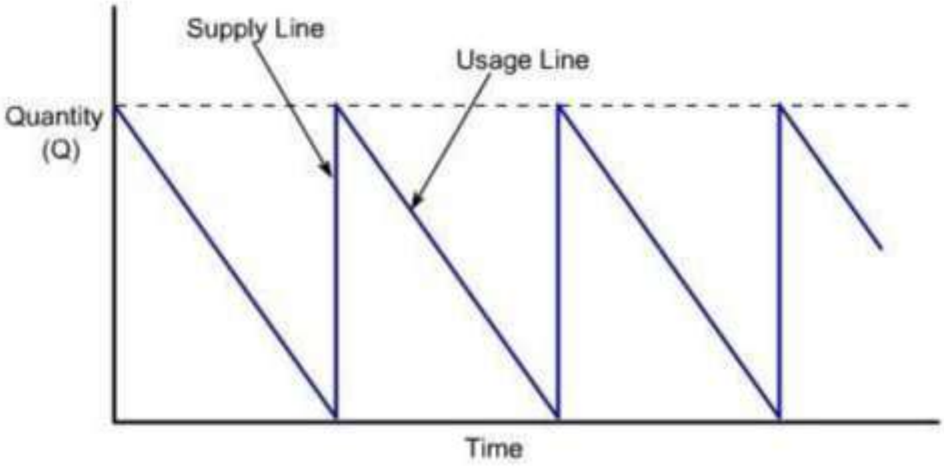


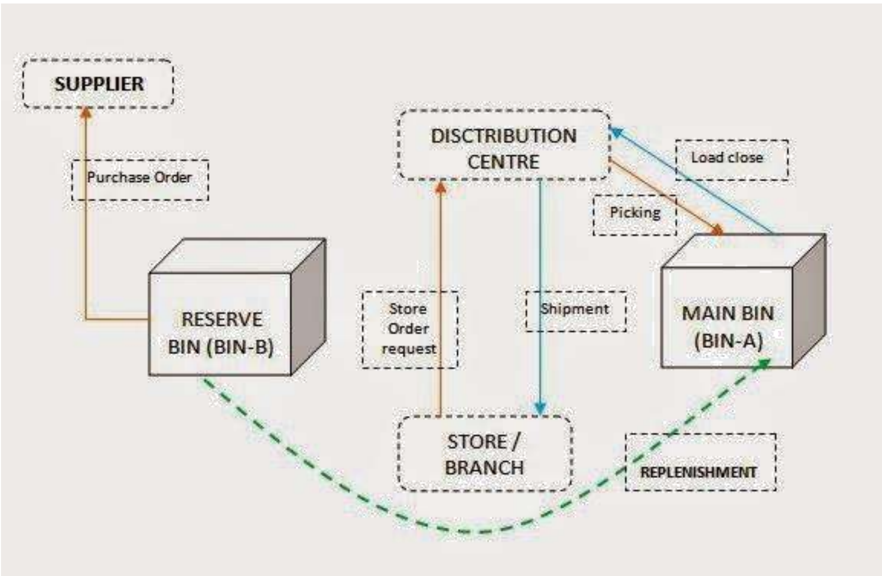
Figure: Economic Order Quantity Model (EOQ Model)

Inventory Control system:

1. **Two Bin System , Fixed order quantity system or Q-System**
2. **Periodic inventory ordering system, or P-System**

Managing our inventory as a retailer is a humongous task. Inventory management grows more and more complicated with increase in sales volume and diversification of product assortments.

Two Bin Systems:



In a **continuous inventory system** (also referred to as a *perpetual system* and a **fixed-order-quantity system**), a continual record of the inventory level for every item is maintained. Whenever the inventory on hand decreases to a predetermined level, referred to as the *reorder point,* a new order is placed to replenish the stock of inventory. The order that is placed is for a fixed amount that minimizes the total inventory costs. This amount, called the *economic order quantity,* is discussed in greater detail later.

A positive feature of a continuous system is that the inventory level is continuously monitored, so management always knows the inventory status. This is advantageous for critical items such as replacement parts or raw materials and supplies. However, maintaining a continual record of the amount of inventory on hand can also be costly.

This is a simple method used usually in warehousing where in an item is stored in two locations or bins in a warehouse and the stock is replenished in the first bin from the second bin once the first bin is consumed completely. The required quantity to be filled in the second bin is placed for ordering.

The availability of stock in each bin is calculated based on reorder lead time to ensure enough stock is made available till the new stock arrives.

Periodic Inventory System

For any business that carries **inventory**, or products stored for future sale, it is necessary to keep track of what is currently on hand. Some businesses keep track of inventory using a periodic inventory system. A **periodic inventory system** is an inventory system that updates inventory at the end of a specified period of time. This may mean that they update their inventory records at the end of each month, quarter, or year. Whenever the period ends, it generally coincides with the end of a **reporting period**, or a timeframe for which a report is drawn on all financial activities that occurred during that time. Common reporting periods conclude on a quarterly or annual basis.

Since a periodic inventory system only keeps track of inventory periodically throughout the year and not as inventory is purchased or sold, a physical count of the inventory must be conducted. A **physical count** is a complete and exact count of each item in the inventory done by hand. Some businesses carry hundreds or thousands of products, so physical counts can be extremely time-consuming. Even for businesses that carry few products, physical counts can be tedious and may take a lot of time to complete if problems, such as missing parts or wrong counts, arise.

MRP:

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 the delivery schedule of end products as specified in the master production schedule.

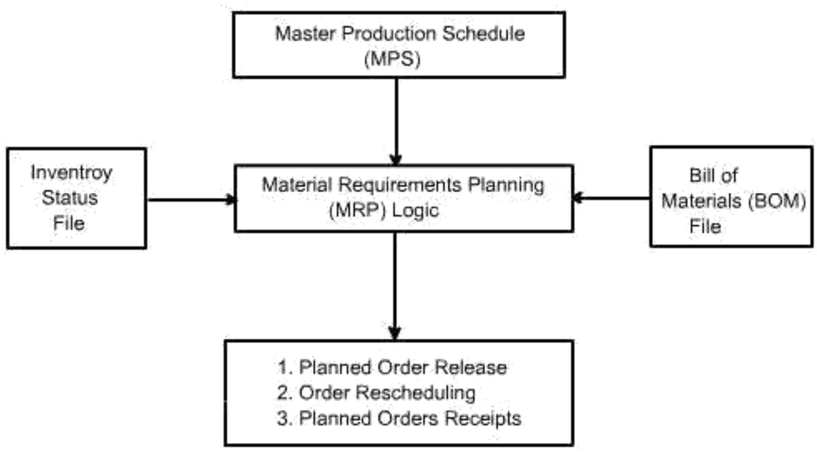
MRP Objectives

MRP has several objectives, such as:

- **Reduction in Inventory Cost**: By providing the right quantity of material 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 meeting delivery schedules more consistently.
- **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.

MRP System

A simple sketch of an MRP system is shown in following figure, it can be seen from the figure that an MRP system has three major input components:



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.

ERP:

Inventory management is critical component in ERP Systems that helps to manage retail locations and warehouses. For example: A wholesale super market has loads of products and collection of stock items. With ERP systems it is very easy to organize the number of items with specific identification number which can be confirmed easily. Also you can check the inventory levels for a particular category of item.

ERP systems provide a proper reporting mechanism of inventory in stores and in ware houses. This helps the manufacturing department in planning their future production schedules accordingly. It helps to track the payments and flow of finances into the Accounts. Inventory management in an ERP systems helps to avoid mistakes and take quick decisions. ERP system enables the most efficient stocking methods for inventory and helps improve all the internal operations. ERP system today has advanced features like double-entry inventory with no stock input, output or transformation. Other important features like Drop-shipping, Cross-docking, and Multi-warehouse etc are also taken care of by ERP systems.

Many small organization and retails stores are using ERP software to manage their warehouse and stocks which calculates surpluses, rejections, repairs and other important planning metrics for the entire inventory.

Line of Balance (LOB)

Line of Balance (LOB) is a management control process for collecting, measuring and presenting facts relating to time (see Schedule Control), cost and accomplishment – all measured against a specific plan. It shows the process, status, background, timing and phasing of the project activities, thus providing management with measuring tools that help:

- Comparing actual progress with a formal objective plan.
- Examining only the deviations from established plans, and gauging their degree of severity with respect to the remainder of the project.
- Receiving timely information concerning trouble areas and indicating areas where appropriate corrective action is required.
- Forecasting future performance.

The LOB itself is a graphic device that enables a manager to see at a single glance which activities of an operation are "in balance" – i.e., whether those which should have been completed at the time of the review actually are completed and whether any activities scheduled for future completion are lagging behind schedule. The LOB chart comprises only one feature of the whole philosophy which includes numerous danger signal controls for all the various levels of management concerned.

To do LOB, the following is needed:

- A contract schedule, or objective chart;
- A production plan or lead-time chart for the production process itself;
- Control points cumulative inventories; and
- A program status chart on which to plot LOB and the cumulative quantities of units that have passed through the control points of the assembly/production process.

Just-in-Time (JIT) Inventory Management:

Just-in-time (JIT) inventory management, also known as lean manufacturing and sometimes referred to as the Toyota production system (TPS), is the process of ordering and receiving inventory for production and customer sales only as it is needed and not before. This means that the company does not hold safety stock and operates with low inventory levels. This strategy helps companies lower their inventory carrying costs by increasing efficiency and decreasing waste.

This method requires producers to forecast demand accurately.

Just-in-time inventory management is a cost-cutting inventory management strategy though it can lead to stock outs. The goal of JIT is to improve return on investment by reducing non-essential costs.

Competing inventory management systems are short-cycle manufacturing (SCM), continuous-flow manufacturing (CFM) and demand-flow manufacturing (DFM).

This inventory system represents a shift away from the older just-in-case strategy, in which producers carried large inventories in case higher demand had to be met.

HISTORY:

The **management technique** originated in **Japan** and is often attributed to Toyota. However, many believe that Japan's shipyards were the first to develop and successful implement this approach. Its origins are seen as three-fold: Japan's post-war lack of cash, lack of space for big factories and inventory and Japan's lack of natural resources.

Thus the Japanese "leaned out" their processes. "

News about JIT/TPS reached western shores in 1977 with implementations in the US and other developed countries beginning in 1980.

Example of JIT:

Toyota started with just-in-time inventory controls in the 1970s and it took more than 15 years to perfect. Toyota sends off orders for parts only when it receives new orders from customers.

For Toyota and just-in-time manufacturing to succeed, the company must have steady production, high-quality workmanship, no machine breakdowns at the plant, reliable suppliers and quick ways to assemble machines that put together vehicles.

Japanese Concepts:

Japanese manufacturing techniques, as an area of influential practices and philosophies, emerged in the post-World War II era and reached the height of their prominence in the 1980s. Many adaptations of Japanese methods, and indeed, Japanese manufacturing vocabulary, have made their way into U.S. and worldwide manufacturing operations. Distinguishing characteristics associated with Japanese manufacturing include an emphasis on designing processes to optimize efficiency and a strong commitment to quality.

Perhaps the most widely recognized collection of Japanese manufacturing techniques is what is known as the Toyota Production System (TPS), the core of which is just-in-time (JIT) production or so-called lean manufacturing. The pioneers of these methods were Tahiti Ohno, a former Toyota executive, and Shigeo Shingo, an eminent engineer and consultant. In his 1989 book *The Study of the Toyota Production System from an Industrial Engineering Perspective*, Shingo identified these basic features of TPS:

1. It achieves cost reductions by eliminating waste, be it staff time, materials, or other resources.

2. It reduces the likelihood of overproduction by maintaining low inventories ("nonstock") and keeps labor costs low by using minimal manpower.
3. It reduces production cycle time drastically with innovations like the Single-Minute Exchange of Die (SMED) system, which cuts downtime and enables small-lot production.
4. It emphasizes that product orders should guide production decisions and processes, a practice known as order-based production.

These and other practices form a contrast to traditional (e.g., pre-1980s) Western manufacturing, which tended to emphasize mass production, full capacity utilization, and the economies of scale that were presumed to follow.

UNIT-IV

ROUTING:

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.

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

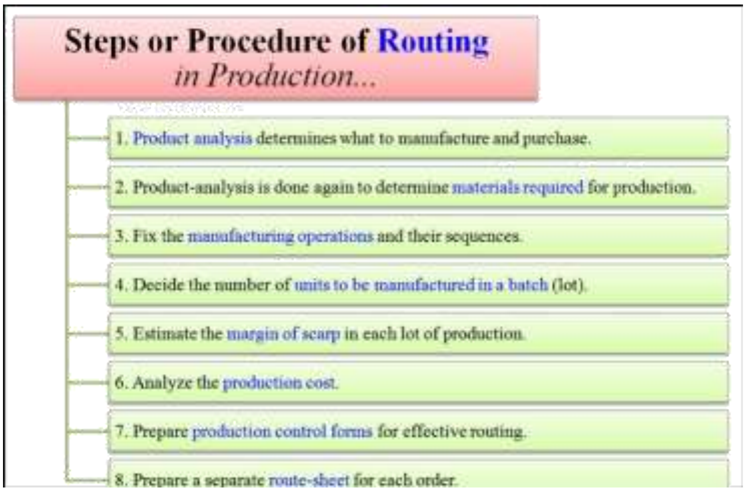
Worksheet: It contains Specifications to be followed while manufacturing. Instructions regarding routing of every part with identification number of machines and This sheet is made for manufacturing as well as for maintenance.

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:

Steps or Procedure of Routing in procedure



Following important steps are involved in the procedure of routing:

1. Product analysis determines what to manufacture and purchase.
2. Product-analysis is done again to determine materials required for production.
3. Fix the manufacturing operations and their sequences.
4. Decide the number of units to be manufactured in a batch (lot).
5. Estimate the margin of scarp in each lot of production.
6. Analyze the production cost.
7. Prepare production control forms for effective routing.
8. Prepare a separate route-sheet for each order.

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.

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.

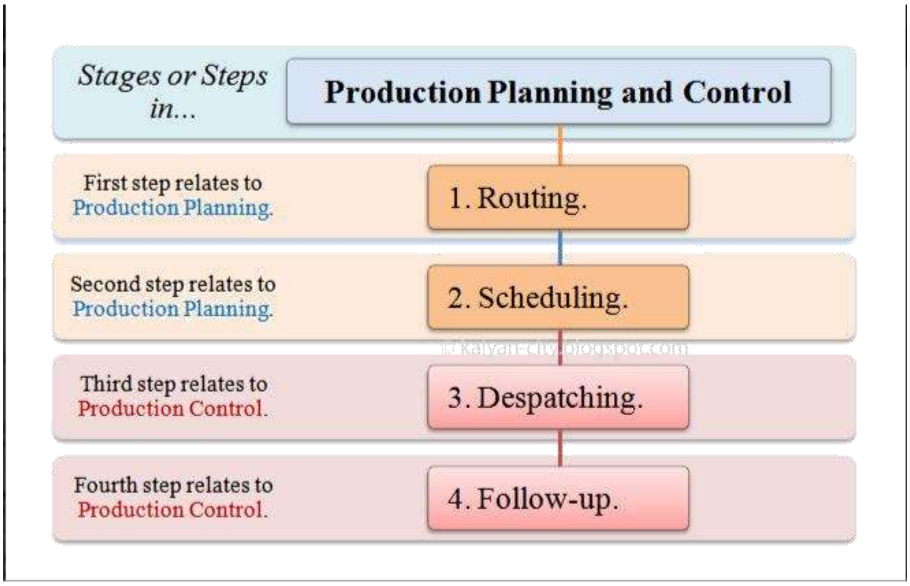
BIL of material:

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.

Factors affecting routing procedure

Steps in Production Planning and Control



The four stages or steps in production planning and control are:

1. Routing,
2. Scheduling,
3. Dispatching, and
4. Follow-up.

Initial two steps i.e. Routing and Scheduling, relate to production planning.Last two steps i.e. Dispatching and Follow-up, relate to production control.Now let's continue our discussion further to understand each step in detail.

1. 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:

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

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

Routing may be either very simple or complex. This depends upon the nature of production. In a continuous production, it is automatic, i.e. it is very simple. However, in a job order, it is very complex.

Routing is affected by the human factor. Therefore, it should recognize human needs, desires and expectations. It is also affected by plant-layout, characteristics of the equipment, etc.

The main objective of routing is to determine (fix) the best and cheapest sequence of operations and to ensure that this sequence is followed in the factory.

Routing gives a very systematic method of converting raw-materials into finished goods. It leads to smooth and efficient work. It leads to optimum utilization of resources; namely, men, machines, materials, etc. It leads to division of labor. It ensures a continuous flow of materials without any backtracking. It saves time and space. It makes the work easy for the production engineers and foremen. It has a great influence on design of factory's building and installed machines.

So, routing is an important step in production planning and control. Production planning starts with it.

2. Scheduling

- Scheduling is the second step in production planning and control. It comes after routing.
- Scheduling means to:
- Fix the amount of work to do.
- Arrange the different manufacturing operations in order of priority.
- Fix the starting and completing, date and time, for each operation.

- Scheduling is also done for materials, parts, machines, etc. So, it is like a time-table of production. It is similar to the time-table, prepared by the railways.
- Time element is given special importance in scheduling. There are different types of schedules; namely, Master schedule, Operation schedule and Daily schedule.
- Scheduling helps to make optimum use of time. It sees that each piece of work is started and completed at a certain predetermined time. It helps to complete the job systematically and in time. It brings time coordination in production planning. All this helps to deliver the goods to the customers in time. It also eliminates the idle capacity. It keeps labor continuously employed.
- So, scheduling is an important step in production planning and control. It is essential in a factory, where many products are produced at the same time.

3. Dispatching

Dispatching is the third step in production planning and control. It is the action, doing or implementation stage. It comes after routing and scheduling.

Dispatching means starting the process of production. It provides the necessary authority to start the work. It is based on route-sheets and schedule sheets.

Dispatching includes the following:

- Issue of materials, tools, fixtures, etc., which are necessary for actual production.
- Issue of orders, instructions, drawings, etc. for starting the work.
- Maintaining proper records of the starting and completing each job on time.
- Moving the work from one process to another as per the schedule.
- Starting the control procedure.
- Recording the idle time of machines.
- Dispatching may be either centralized or decentralized:
- Under centralized dispatching, orders are issued directly by a centralized authority.
- Under decentralized dispatching, orders are issued by the concerned department.

4. Follow Up

Follow-up or Expediting is the last step in production planning and control. It is a controlling device. It is concerned with evaluation of the results.

Follow-up finds out and removes the defects, delays, limitations, bottlenecks, loopholes, etc. in the production process. It measures the actual performance and compares it to the expected performance. It maintains proper records of work, delays and bottlenecks. Such records are used in future to control production.

Follow-up is performed by ‘Expediters’ or ‘Stock Chasers’.

Follow-up is necessary when production decreases even when there is proper routing and scheduling. Production may be disturbed due to break-downs of machinery, failure of power, shortage of materials, strikes, absenteeism, etc.

Follow-up removes these difficulties and allows a smooth production.

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:

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.

Types of Scheduling

Types of scheduling can be categorized as forward scheduling and backward scheduling.

Forward scheduling:

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.

Backward scheduling :

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. Forward and backward scheduling methods are shown in the following figure.

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.

Symbol	*Priority rule*
FCFS	First come, first served
EDO	Earliest due date
LS	Least slack (that is, time due less processing time)
SPT	Shortest processing time
LPT	Longest processing time
PCO	Preferred customer order
RS	Random selection

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.

Line Balancing:

Production Line Balancing:

Line-balancing strategy is to make production lines flexible enough to absorb external and internal irregularities. There are two types of line balancing, which we have explained as –

- Static Balance – Refers to long-term differences in capacity over a period of several hours or longer. Static imbalance results in underutilization of workstations, machines and people.
- Dynamic Balance – Refers to short-term differences in capacity, like, over a period of minutes, hours at most. Dynamic imbalance arises from product mix changes and variations in work time unrelated to product mix.

Labour Balancing and Assignments:

Strategy of production line stability is the tendency for labour assignments to be fixed. Labor feasibility is an important feature in the strategy of production line flexibility linked to individual skills and capabilities –

- When one worker is having problem in performing his assigned task and experiencing delay due to technical problem(s), other worker(s) should move into help.
- The management practice of deliberately pulling worker's of the line when the line is running smoothly.
- The movement of whole crews from one dedicated line to another as the model mix changes.
- Group Technology – In which one worker can handle variety of tasks (automation) in a single work centre.

Equipment Balancing:

While balancing equipment, attempt to ensure that each piece of equipment in the work cell has the same amount of work. Now days every manufacturer is attempting to maximize the utilization of all available equipments. Such high utilization is often counterproductive and may be the wrong goal because; high utilization is usually accompanied by high inventory.

Equipment Failure:

An equipment failure is a major serious matter, with the potential to shut down a production line. To avoid such failures one should not overload the equipments, and workers should be trained to perform a daily machine checking (preventive maintenance) and following standard operating procedures. The advantage for Maintenance and Engineering Department does not lie in running late shifts, hence calculate the preventive maintenance time and schedule the activity.

Analysis:

Analysis is generally performed by Competent Technical Staff. Begin the analysis with division of production-line work into small tasks, determination of task time standards, specification of required task sequencing and notation of constraints. If bottle neck task is in the way of good balance, the Competent Technical Staff should analyze the task to reduce the time it takes to perform.

Line Balancing Leadership:

Workmen should lead the production line balancing effort, so that they can react quickly when line imbalances (static and dynamic) crop up as a result of changeover to make a different item or changes in the output rate.

Conclusion:

Production-line balancing study tends to employ thought and ingenuity to change conditions. Production-line design and operation is more art than science. Labour flexibility is the key to effective resource management. The idea of worker’s checking and doing minor repair work on their own equipment possibly decreases the risk of equipment failure. Selecting an appropriate set of balancing mechanism is a part of work cell design and it must be linked with many other decisions for the system to function well.

Aggregate planning:

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**.**

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

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

Aggregate Planning Methods

1. Trial-and-error method
2. Mathematical methods

Expediting:

Expediting is a concept in purchasing and project management for securing the quality and timely delivery of goods and components. The procurement department or an external expeditor controls the progress of **manufacturing** at the supplier concerning quality, packing, conformity with standards and set timelines.

Expediting is especially needed in large scale projects, for example, when a power plant or a refinery is erected, because of a delay caused by late delivery or inferior quality will get very expensive and could lead to unsatisfied clients, thus the loss of a project. To save these unnecessary costs and minimize potential risks, the supplier and customer may agree on the use of a third party expeditor. These are experts from companies specializing in this field who keep track of the deadlines, supervise progress on site and check whether the components are properly packed. After inspection they notify the involved parties and banks about their findings; if everything is as agreed the bank will initiate the transfer of the price of the goods to the supplier. In this way, the supplier secures his liquidity as he is paid immediately when the components leave his factory (letter of credit) and the customer/bank knows that the goods will be delivered correctly. Expediting is relevant for many industries, such as the oil and gas industry, the general energy industry and the infrastructure industry.

Control Aspects:

Expediting exists in several levels:

Production control: The expeditor inspects the factory whether the production is up to the standards of the country the goods are destined for. This is especially necessary for food or engineering equipment like power plant components. He or she controls as well whether the regular audits for ISO 9001 etc. have been made.

Quality control: The components are tested whether they function as required and whether they are made to the measurements and standards of the customer. A part of this quality control can be the testing for compliance with standards of the destination country, e.g. ASME.

Packing/transport survey: This is the lowest and most used level of expediting, as the goods are only counted and the packing is controlled whether it will withstand the adversities of transport (pre-shipment inspection).

Project management: At a large-scale project, not only goods are controlled. The expeditor also keeps an eye on the deadlines and milestones of the project and whether the supplier will be on time. This way he or she monitors the crucial procurement parts of the project.

UNIT-V

DISPATCHING

Dispatching is the routine of setting productive activities in motion through the release of orders and necessary instructions according to pre-planned times and sequence of operations embodied in route sheets and loading schedules.

In other words, once a job is in an area where an operation is to be performed, it has to be determined when and by whom the job will be processed and also the sequence of waiting orders to be processed. The decision of assigning the various jobs to different machines and equipment is called Dispatching.

Functions of Dispatching:

- To check the availability of input materials and ensure the movement of material from store to first process and then from process to process.
- To ensure the availability of all production and inspection aids.
- To obtain the requisite drawings, specifications and material lists.
- To assign the work appropriate machine, workplace and men.
- The issue of job orders authorizing operations in accordance with dates and times previously planned and entered on load charts and route sheets.
- The issue of time tickets, instruction cards and other required items to the workers who are to perform the various activities.
- The issue of inspection orders after each operation in order to determine result regarding the quality of products if excessive spoilage occurs, to find out its causes.
- Clean up on jobs, collection of time tickets, blueprints and instruction cards and their return to appropriate section of production control deptt.
- To ensure that the work is forwarded to next deptt. or storeroom etc.
- To record the beginning and completion times of jobs on time tickets for calculation of time interval. To forward time ticket to accounts deptt for preparing wages.
- To record and report idle time of men and machines and request for corrective action required.

Dispatching Procedure:

In the decentralized dispatching, the manufacturing orders are issued in blanket way to the Engineer/Foreman/Supervisor. He must then determine the relative sequence in which these orders will be taken up within the department.

It is the duty of the person (may be Foreman/Supervisor) concerned to dispatch these orders and to ensure that the required material is available at each machine and operator. In such cases the dispatch of material must be completed in the department on or before the prescribed date.

Chart in Fig. illustrates the sequence of dispatching operation for intermittent manufacturing system from the issue of manufacturing orders to the end of dispatching operation.

From the manufacturing order list of assemblies, sub-assemblies and parts is prepared. Route sheets are prepared for various components/parts and assemblies etc.

These route sheets indicate the input materials operation to be performed and their sequence. Further the time allowances are entered against each operation along with the date when it should start and finish. Along-with details of tools, jigs and fixtures required.

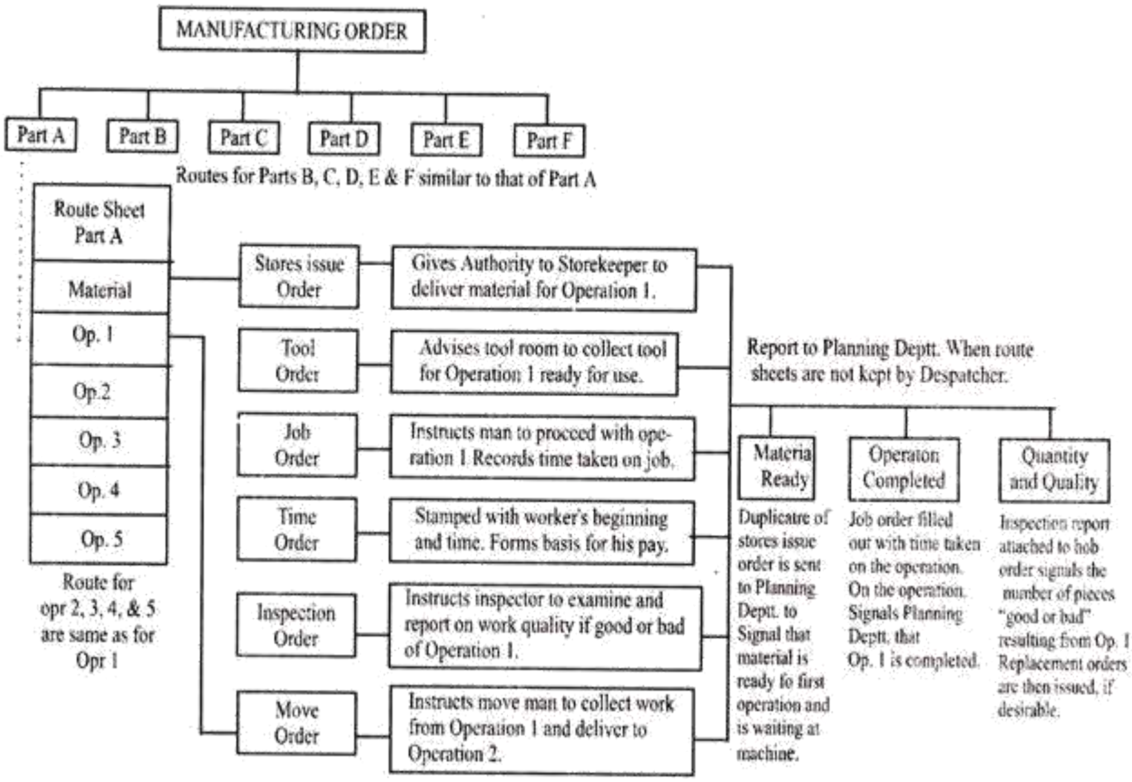


Fig. 7.14. Chart showing the sequence of dispatching operaton for intermittent manufacture.

The blue prints supplies the limits and tolerances for the purpose of inspection. In order to give effect to this information, required materials, tools, job orders, inspection tickets and move orders are prepared. So all working papers should be ready a day or two before the job should start.

These are further made available to the various persons concerned by the dispatcher. The material, tools and jigs & fixtures will be issued to the machine operators.

Inspection shall be performed after the first operation is over and the part shall move to next work station for second operation if it passes inspection.

The purpose of decentralized dispatching is to minimize the duplication of postings and elaborate reporting etc. In centralized dispatching which is applicable for continuous manufacturing system that involves a single standardized product and no assembly, dispatching requires that the concerned shops be informed about the decided rate of production.

The routine of dispatching under these circumstances shall be quite different from decentralized dispatching discussed earlier. This is called centralized control.

This system involves the dispatching orders from the central dispatching division directly to work stations. The working capacity & other characteristics of the machines/equipment as well as the back log and work ahead of it are known and recorded in the central dispatch office. In this case the whole dispatching is controlled from that point.

In both types of dispatching, it is traditional for the departmental supervisor or his clerk to keep themselves informed about the starting date and progress of each order by means of various dispatching displays.

Meaning of Follow Up:

After the dispatching function is completed, processing of various operations has been authorized to begin in time as planned by scheduling department, the follow up is to check the progress of the order undertaken as it is being produced from the first operation until the order is converted into final product. Thus it regulates the progress of material and parts through the production processes.

Follow up is checking the manufacturing activities systematically so that production may be carried out according to plan. It is the measurement of output against plan, analysis of the performance for shortcomings if any and following up the management in order to apply corrective action to prevent excessive shortfall.

Thus Progress Reporting is the function by which one can give an early warning when the actual production deviates from planned production thus making it possible to apply corrective action.

Follow up is the most important part of production control. This step is to ascertain from time to time that the production operations are going on according to the plan. The expeditor or chaser is meant for observing that anything overlooked or not properly executed is set right.

This ensures proper coordination of production activities and plans in order to take corrective action if necessary. Follow up functioning checks and measure the effectiveness of previous production control functions like routing, scheduling and dispatching. Expediting is a special form of follow up or progress reporting.

Expeditors are Used:

a. To help to eliminate particular difficulties which are throwing production off the schedule.

b. To speed up the processing of certain orders.

In short the purpose of active functions of dispatching and expediting are:

(i) To release the production orders at the appropriate time and provide the flow of necessar y information.

(ii) To record the flow of materials and tools and make adjustment if needed.

(iii) To record progress of production activities and make necessary adjustments.

(iv) To compare and record amount of work in process with schedule.

(v) To record the amount of faulty work and rejections, issue orders for the production of replacements.

(vi) To record the machine and manpower idleness and investigate the reasons for it.

(vii) To record the breakdowns, held up or stoppage of production activities and classify them according to:

- Lack of instructions and blue prints etc.
- Lack of input materials and components.
- Work held up due to stoppage at previous workstations.
- Equipment break down.
- Non availability of manpower.

Functions and Purpose of Follow Up:

Its main function is to bring up together all the variables of production activities and thus to show progress or boost production. It is the duty of follow up people to see whether the production is being performed according to the schedule and to provide feedback on the production data.

Follow up is done for the following purposes:

(i) Follow Up for Materials:

Logically it is the duty of the purchase department to ensure that the requisitioned material should reach the requisitioned on or before the date of delivery to meet the production schedule promises.

But in case of very important orders which must be met in time, the follow up section of the production control department, takes steps for collection of the materials. In such cases follow up is accomplished by filing one copy of the requisition slip in a daily follow up file according to the due date the material is to be received.

(ii) Follow Up of Work in Progress:

In case of serialized production, it consists of check on the required materials for specific process and recording the production output of the production deptt. to see whether it is in accordance with schedule. In this case follow up is very simple and can be trusted to daily production records as shown in Fig. 7.21.

Daily Production Record

Date.............. From Deptt. No.................. To Deptt. No...............

Part No.	Description	Quantity	Remarks

Fig. 7.21

In order to meet schedule promises, some priority may be given to the late jobs. In case of job order manufacture, where the different products are produced at the same time, the sequence of orders may be changed in order to meet certain specific situations.

The section in charge or production engineer should be advised by the follow-up man regarding the best sequence in which orders should be taken up in order to provide the completion of the assembly at proper time and place. A time record of job or order showing the start and completion time, number of pieces produced and rejection is made.

(iii) Follow Up for Assembly and Erection:

In such situations one follow up man is given the entire responsibility. The various parts and components being manufactured at various work stations may be temporarily stored at those very places so that the follow up man shall release them when the rest of the component parts forming the assembly are ready for final assembly purposes.

In case of very complex and large equipment/products, the work of installation erection and servicing is done at purchaser's place. The requirement will be that the follow up man should be well acquainted with the engineering details, trouble shooting and servicing of the equipment/machine at the consumer's plant.

Follow up or Progress Reporting can do following tasks:

(I) Recording of actual production.

(ii) Compare the actual production with the planned production.

(iii) Can measure the production variability.

(iv)Can report the excessive variance to the production planning department for corrective action.

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.