UNIT 9: MATERIALS MANAGEMENT AND INVENTORY CONTROL

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9.1 LEARNING OBJECTIVES

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

- explain the basic concept of integrated materials management explain
- the various components of integrated materials management
- describe the concept of inventory control and various related issues

9.2 INTRODUCTION

In this unit, we are going to discuss the concept of integrated materials management, its components, and the concept of inventory control and various related issues. Proper implementation of these three concepts can play an important role in the production of any goods or in the delivery of any service. In fact, these concepts can lead to effective production process or service delivery process.

9.3 INTEGRATED MATERIALS MANAGEMENT

In Production and Operations Management, materials are the components used to produce the final finished product(s) in any organization. Integrated Materials Management is an important component of Production and Operations Management. It includes every aspect of material including their costs, their supply, their production and their utilization as well all concerned functional departments associated with such materials. In fact, Integrated Materials Management involves the process of planning, identification, procurement, storage, receipt and distribution of materials and all other associated activities as mentioned earlier. In this context, it may be mentioned that nowadays many modern production plants (or service delivery units) use computer-aided materials management technique. It is a technique that involves computers for managing the movement of raw materials and component parts into and out of the operating system (manufacturing/ service delivery system) of any such plants of a firm/ company.

Main purposes of Integrated Materials Management: The main purposes of Integrated Materials Management are:

(i) To ensure production and delivery of right materials in the right place when required,

(ii) To ensure production and delivery of right materials in the right quantities when needed,

(iii) To ensure production and delivery of right materials in the right quality when needed,

(iv) To assure production and delivery of right materials in the right price(s) when needed.

Importance of Integrated Materials Management: Integrated Materials Management is important in the field of Production and Operations Management owing to the following reasons:

(i) In any industry, materials represent an essential and indispensable cost component. The total cost of materials normally includes the following:

(a) Manufacturer's selling cost,

(b) Cost of procurement of materials which includes cost of placing and processing order(s), and cost of the material, cost of their physical distribution, costs in distribution, and related costs of transportation, and

(c) Site-handling costs of materials which includes costs of receiving, storage, issue, and disposal of such materials.

(ii) Such materials involves enormous complexities as any manufactured item must be stored and transported before being consumed/utilized by the end user.

(iii) Effective and efficient procurement and handling of material is essential for successful completion of any production process/ work/ assignment.

(iv) Effective management of materials is highly important as poor planning and control of such materials, their unavailability when needed, their improper identification, their improper handling and their improper storage may lead to huge loss in an organization's productivity causing delays in completion of production or project.

Classification of materials: Materials may be classified into the following categories:

(i) Raw materials: These are materials that are processed into finished goods. The latter may also include

(a) Components that are distinctively manufactured for such goods.

(b) Purchased parts that are bought to be included as parts of the above finished goods. These include nuts, bolts etc.

(ii) Purchased parts: Purchased parts, as mentioned earlier, are parts or components that the organization/company has purchased from outside sources. These include nuts, bolts rubber parts, plastic parts etc.

(iii) Manufactured parts: Manufactured parts include those components/ parts built by the organization/company. Examples include the main body of a family car.

(iv) Work-in-process: Work-in-process includes semi-finished products found at various stages in the production process. Examples include a partly finished family car.

(v) Maintenance, Repairing, and Operating (MRO) supplies: MRO supplies are utilized in any manufacturing process but these do not become parts of the final finished product(s). On the other hand, these aid in the completion of the production of final finished product(s). Examples include grease, diesel, lubricant etc.

9.4 COMPONENTS OF INTEGRATED MATERIALS MANAGEMENT

The various components of Integrated Materials Management include Materials Planning, Inventory Control, Purchase Management, and Stores management. These are discussed in sections 9.4.1 to 9.4.4. of this units.

9.4.1 MATERIALS PLANNING

In Production and Operations Management, materials planning is a highly indispensable activity included in Integrated Materials Management as mentioned earlier.

Main purposes of Materials Planning: The main purposes of materials planning for the production process of any product(s) are:

(i) To ensure supply of right materials in the right place in the production plant when required,

(ii) To ensure supply of right materials in the right quantities in the production plant when required,

(iii) To ensure supply of right materials in the right quality in the production plant when required,

(iv) To assure supply of right materials in the right price(s) in the production plant when required.

Main considerations in Materials Planning: The main considerations in materials planning for the production process of any product(s) within a production plant are:

(i) There must be no improper lighting within the production plant,

(ii) There must be proper safety arrangements within the production plant,

(iii) There must be proper material handling arrangements within the production plant,

(iv) The layout of the production plant should be proper so as to allow easy and safe storage of materials,

(v) There must be proper handling and storage arrangements for hazardous items within the production plant,

(vi) The layout of the production plant should be proper so as to allow easy and safe movement of materials, machines, equipments and men,

(vii) Materials planning within and around the production plant should be in accordance to local and national planning policies,

(viii) Materials planning within and around the production plant should be in accordance to environmental considerations.

9.4.2 Inventory Control

Inventory Control aims at making the desired item available in quality and quantity to various departments when needed.

Functions of inventories: The various functions of inventories are as follows:

(i) To ensure against delays in deliveries

(ii) To allow for possible increase in the output

(iii) To maintain smooth and efficient production flow

(iv) To maintain good customer relationships

(v) To take advantage of quantity discounts

(vi) To utilize to advantage price fluctuations

(vii) To ensure against scarcity of materials in the market

(viii) To provide better utilization of men and machinery

Advantages of Inventory Control: The various advantages of inventory control are as follows:

(i) Minimum shortage of materials at any stage of production

(ii) Materials are made available at the most economical rates

(iii) Delays or interruptions in the production due to non-availability of materials are minimized

(iv) Exact and accurate delivery forecasts can be made

(v) Materials are protected from spoilage, deterioration, pilferage etc.

(vi) Increase in overall efficiency of the organization

Important Terminologies:

Reorder Point = It is the point at which materials are reordered at the end of consumption after a certain period. Reorder Point = Minimum Inventory + (Procurement Time × Consumption Time)

Lead Time, Lt = Time interval between the time when need of a material is determined to the time when material is actually received.

$$\text{Lead Time, } Lt = Rt + Pt$$

Rt - Requisition Time: Time required to prepare purchase requisition and placing order to a selected vendor

Pt - Procurement Time: It consists of the following times:

(i) Time taken to deliver purchase requisition to the vendor / seller / supplier.

(ii) Time for the vendor to get or prepare inventory for dispatch.

(iii) Time for inventory to be dispatched from the vendor and reach the customer.

For example, suppose a company has to order 300 units of raw materials for manufacturing its finished goods from a selected vendor (supplier). So, initially, the company has to prepare purchase requisition for the aforesaid 300 units of raw materials in the form of a purchase order copy. Thereafter, the company has to send this purchase order copy to the above vendor. In this way an order is placed to the above selected vendor. Suppose this process takes two days. Thereby, Requisition Time (Rt) in this case will be two days. Say the total time comprising of the time taken to deliver

purchase requisition (purchase order copy) to the vendor, time for the vendor to get or prepare inventory of 300 units of raw materials for dispatch, and the time taken for this inventory to be dispatched from the vendor and reach the customer (i.e. company) takes three days. Then, these three days will comprise Procurement Time (Pt) for these 300 units of raw materials. Therefore, Lead Time (Lt) for the above goods will be five (5) days (i.e. 2 days + 3 days).

Safety Stock = It is the extra inventory needed to protect against unreliable forecast and protection against stock-outs.

Safety Stock = K × Average Consumption during lead time

K- Factor based on acceptable frequency of stock-outs in given number of years

- **Reasons for maintaining Safety Stock:**

(i) Supplier may fail to keep delivery promises

(ii) Forecast of usage rate may be inaccurate

Maximum Inventory = Order Quantity + Safety Stock

9.4.3 Purchase Management

Purchase management is concerned with the procurement of proper equipment, materials and supplies in right quantities, right quality, at the right places, through the right processes, at the right prices at the right time. In case of organizational purchase, purchasing is a complex activity involving several important considerations and many other functional departments. As such, organizational purchase is a very complex activity. Therefore, in any firm, the purchase department is closely linked with other functional departments including marketing, human resource, finance, administration and production departments.

- **Objectives of purchasing in an organization:**

The primary objectives of purchasing in any organization are:

(i) Procurement of proper quantity of materials in order to ensure uninterrupted production.

(ii) Procurement of goods of proper quality.

(iii) Ensuring supply of materials at the right time as needed by production department.

(iv) Ensuring minimum wastage of materials due to spoilage, obsolescence, duplication etc.

(v) Proper scheduling of purchase in line with the production policies of the firm.

(vi) Maintaining suitable sources of supplies and to be connected with alternative sources.

(vii) Procurement of at reasonable price so that investments in stores are minimum.

(viii) Maintaining competitive position for the firm by preserving quality standards positively comparable with those of other rival firms.

(ix) Development of proper relationships with suppliers so as to ensure optimal supply of materials.

(x) Adopting the optimal purchasing method to ensure smooth delivery of materials from suppliers.

(xi) Ensuring avoidance of any risks of any disputes or financial loss in case of any firm.

- **Types of Purchasing:**

On the basis of size and requirements of an organization, purchasing may be of the following types:

(i) Centralized Purchasing: In this type of purchasing, all types of purchases in an organization are conducted from a centralized purchasing department. Here, all functional departments send their purchase requirements to this purchase department. The latter arranges procurement of various goods needed for these purposes.

(ii) Decentralized Purchasing: In this type of purchasing, every functional department in an organization is authorized to make its own purchases. It is also called localized purchasing. This type of purchasing is applicable for firms where there are more than one production plants or when such plants are located at different places. Here, to ensure smooth purchasing practices separate purchase officers/ agents are appointed for every such department or plant. All such purchasing agents are put under the charge of general purchasing officer in order to enforce general purchasing policies. The general purchasing officer gets reports from all such departmental or plant level purchasing officers from time to time. This ensures easier control over material purchases.

(iii) Forward Buying: In this type of purchasing, a buyer purchases items which are not required presently but for future requirements. This type of purchasing is applicable for items that presently abundantly available but may become scarce or costlier in future.

- **Methods of purchasing in an organization:**

Some of the methods of purchasing in an organization are:

(i) Requirement based Purchasing: This method of purchasing is used to purchase those items only which need to be procured as and when required by an organization. In fact, these are items which are not required regularly and therefore, are purchased in this manner. Such items may also be emergency goods needed to meet emergency needs which are not usually kept in store.

(ii) **Market Purchasing:** This method of purchasing is used to purchase goods in order to take advantages of low cost during favourable market conditions. Here, purchases of such goods are made depending on future anticipated needs rather than to meet instantaneous requirements. However, any such future expected needs must be estimated accurately and purchases are made whenever prices of such items are low during favourable market situations. This requires continuous and detailed study of market situation and price of such goods.

(iii) **Speculative Purchasing:** This method of purchasing involves purchasing of items at lower prices with a notion to sell them at higher prices in future. In this method of purchasing, the primary focus is to earn profits arising from sales of goods at higher prices. Here, purchases are not made as per the production requirements of a production plant. However, such purchases are usually higher than such requirements.

(iv) **Purchasing for Specific Future Period:** This method of purchasing involves purchasing of those goods which are frequently required in small quantities with negligible chances of price variations. The requirements of such items in a specific time period are studied on the basis of past experience, period for which supplies are needed, carrying cost of inventory etc. Accordingly, such purchases are carried out.

(v) **Contract Purchasing:** This method of purchasing involves purchase of a specific quantity of materials through contracts at a specific time and taking delivery of such items in future. It is to be noted that although such goods are procured in future but the price and other terms and

conditions are fixed at the time of contract. This method of purchasing is suitable whenever price of such items may increase in future with accurate estimation of material requirements.

(vi) **Scheduled Purchasing:** This method of purchasing involves suppliers being provided with a feasible time schedule for supply of items. This is done so that such suppliers are in a position to arrange these in time. This method of purchasing, therefore, requires accurate production schedules for determining requirement of such items in the future. Such suppliers are informed of probable requirements and on this basis, goods are ordered. This method of purchasing aims at purchasing of quality goods at minimum inventory levels with prompt service.

(vii) **Group Purchasing of Small Items:** This method of purchasing is feasible whenever small items need to be purchased. Besides, this method of purchasing is viable when the prices of these items are so less that costs of placing any orders may be more than such prices. Under such conditions, the buyer places order with a supplier of all these items. In this method of purchasing, the purchase price is agreed to be by adding some percentage of profit in the dealer's cost. This type of purchasing has an advantage in the cost of the buyer is reduced by eliminating much clerical work.

(viii) **Co-operative Purchasing:** This method of purchasing is feasible whenever small industrial units join to pool their requirements and then place bulk orders to suppliers. This enables buyers to obtain huge rebates on large quantity purchases in terms of cash discounts and savings in

transportation costs. On receiving the materials these are divided among the member units.

- **Policy and Procedure of organizational purchasing:**

The purchase policy for any good(s) in an organization depends on the following factors:

(i) Demand of the good(s),

(ii) Supply of the good(s),

(iii) Price of the good(s),

(iv) Supplier of the good(s),

(v) Type of good(s),

(vi) Usage or consumption pattern of the good(s),

(vii) Organisational Set Up,

(viii) Past situations in the organization including decision making, etc.

Some of the policies and procedures of organizational purchasing are:

(i) **Organizational purchasing through cash payment:** This involves purchasing of much needed goods in an organization by payment of instant cash.

(ii) **Organizational purchasing through tender system:** This involves purchasing using tender to select the most eligible supplier of materials. This is done in order to procure materials at the most competitive and reasonable rates.

(iii) **Organizational purchasing through rate and running contract:** This involves purchasing centralized agencies. The latter makes contract with the suppliers of items to supply needed at specific prices for a specified period of time. In rate contracts, only the rates are fixed. On the

other hand, in running contracts quantity variation allowances up to 25% variance are also possible.

(iv) **Organizational purchasing through sub contracts:** This involves purchasing of much needed goods from the sub contractors who specialize in the manufacture of such items. This system of purchasing is usually undertaken for intermittent type of industries. Any such purchase decision to buys such goods from sub-contractors depends

(a) Cost of manufacture,

(b) Availability,

(c) Technology used

(d) Benefit of specialization etc.

9.4.4 Stores Management

Stores management involves proper application of processes and space within stores in an organization to receive the incoming materials and their subsequent movement. In fact, the basic responsibilities of stores management are:

(i) Storage and preservation of components, supplies, and materials, and

(ii) Providing required services to users of such goods.

(iii) Receipt of incoming goods

(iv) Inspection of all receipts

(v) Identification of all materials stored

(vi) Materials handling

(vii) Packaging

(viii) Issue and dispatch

(ix) Maintenance of stock records

(x) Stores accounting (This information is required for identifying and noting the value of stocks in balance sheets which will help in reducing costs of production

(xi) Inventory control.)

(xii) Stock-taking (i.e. verification of stock records with the actual quantity of stocks present)

● **Types of Stores:** Depending upon the nature of business, location of action, raw material, market place etc., stores are classified on the following basis:

(i) Functional Stores: Such stores are classified on the basis of different types of materials to be stored including chemicals, tools, raw materials stores, etc. Functional Stores can be further classified as:

(a) **Raw materials store:** Here, raw materials used in a production plant are stored.

(b) **Production Store:** Here, items aiding the production process in any production plant are stored. Such items include abrasives, gloves, aprons, jigs, small tools etc.

(c) **General Store:** Here, various miscellaneous items aiding the production process in any production plant are stored. Such items include paints, brushes, cleaning materials etc.

(d) **Tool Store:** Here, various tools used in the production process in any production plant are stored. Such items include hammers, screw drivers, hexsaws etc.

(e) **Salvage Store:** Here, various rejected materials from the production process in any production plant are stored.

(f) **Packing Store:** Here, various packing materials for products from the production process in any production plant are stored.

(g) **Spare parts store:** Here, various spare parts for products from the production process in any production plant are stored.

(h) **Receipt Store:** Here, various goods received to be used in a production process in any production plant are stored.

(i) **Quarantine Store:** Here, various goods received from outside to be used in a production process in any production plant but awaiting inspection are stored.

(j) **Finished Goods store:** Here, various finished goods from a production process in any production plant but awaiting inspection are stored.

(k) **Work-in-progress Store:** Here, various work-in-progress from a production process in any production plant but awaiting inspection are stored.

(l) **Stationary store:** Here, various stationary items required in a production process in any production plant but awaiting inspection are stored.

(m) **Refrigerated store:** Here, various goods produced from a production process in any production plant requiring refrigeration in cooler temperatures are stored.

(n) **Flammable materials store:** Here, various flammable materials to be used or produced from a production process in any production plant are stored.

(ii) **Physical Stores:** Such stores are classified on the basis of size and location. Physical Stores can be further classified as:

(a) **Central store:** In the field of Production and Operations Management, there can be a central warehouse or store that serves several production plants within a large organization. Here, there may be issues of high handling costs involved in transferring materials from such several production plants to the central warehouse or store.

(b) **Departmental Store:** Such stores serve a particular department of a production plant. For example, in a plant for production of muga ethnic fabrics there can be several sub-functional departments within the production department like spinning, weaving, cleaning, finishing etc. Each such sub-functional department may be served by separate specialized store for storing separate kinds of materials.



CHECK YOUR PROGRESS

Q 1: In which of the following types of stores are various goods received to be used in a production process in any production plant stored?

(a) Receipt Store (b) Stationary store

(c) Quarantine Store (d) Packing Store

Q 2: Which of the following types of purchasing is feasible whenever small industrial units join to pool their requirements and then place bulk orders to suppliers?

(a) Centralized purchasing (b) Decentralized purchasing

(c) Co-operative Purchasing (d) None of these

Q 3: Which of the following includes semi-finished products found at various stages in the production process?

(a) Work-in-process (b) Raw materials

(c) Finished goods (d) None of these

9.5 INVENTORY CONTROL

In Production and Operations Management, inventory control is a highly important activity. The main points under inventory control are discussed from sections 7.5.1 to 7.5.4.

9.5.1 Inventory Decisions

Inventory decisions covers involves all production activities from the purchase of raw materials to the delivery of finished goods to the customer. Poor inventory decision making can cause the following problems:

(i) Loss of sales because of stock outs.

(ii) Lack of adequate production.

(iii) Increase operating expenses due to unnecessary carrying costs or loss from discarding obsolete inventory.

(iv) Increase in the unit cost of finished goods.

Decisions regarding inventory can be placed in two general categories:

(i) Decisions that affect the quantity of inventory: These are based on the following:

(a) Order size

(b) Number of orders

(c) Safety stock

(d) Lead time

(e) Planned production

(ii) Decisions that affect the cost per unit of inventory: These are based on the following:

(a) Suppliers of raw material

(b) Order size (quantity discounts)

(c) Freight

(iii) Decisions relating to labor and overhead.

9.5.2 Costs Trade-Off

(A) Ordering Costs (Cp): It is the cost of ordering an order to a vendor. It includes all costs incurred from calling for quotations to the point at which the item is taken into stock. It includes the following costs:

(i) Cost of receiving quotation

(ii) Cost of processing purchase requisition

(iii) Cost of receiving materials and then inspecting it

(iv) Cost of follow up and expediting purchase order

(v) Cost of processing seller's invoice

If,

Cp- Cost of placing an order

Q- Order quantity

Therefore, UNIT COST OF PLACING AN ORDER, Co = (Cp ÷ Q) = (Cp / Q)

Cp decreases at a decreasing rate as the order quantity is increased. Bigger the amount purchased in one lot lower is the unit ordering cost.

If A- Annual requirement

Then, ANNUAL COST OF ORDERING = (Cp÷Q) × A = (Cp/Q) × A

For example, suppose a firm requires 12,000 units of a particular material from a selected vendor (supplier) annually. Say, total cost of placing this order (as described above) is Rs.100 per order. Suppose the above firm places 12 orders in one year every month each order comprising 1,000 units of the above item. In this case, A = 12,000 per year, Q = 1,000 units per order, Cp = Rs.100 per order. Therefore, Annual Cost of Ordering = (Cp ÷ Q) × A = (Cp / Q) × A = (100 ÷ 1,000) × 12,000 = Rs.1200

(B) Carrying Costs (Cc): Cost incurred in maintaining the stores in the firm. It includes the following costs:

(i) Storage cost

(a) Rent for storage facilities

(b) Salaries for personnel related to storage - Upkeep of material, Record keeping etc.)

(ii) Cost of obsolescence

(iii) Cost of deterioration and spoilage

(iv) Cost of insurance

(v) Cost of capital

(vi) Special taxes for storing items

(vii) Cost of pilferage (theft) and employing person for safety.

Carrying Costs is proportional to Order Quantity

CARRYING COST? ORDER QUANTITY

If,

Cu- Unit purchase cost

I- Carrying cost expressed as percentage of average inventory (including insurance, obsolescence, taxes etc.) per period

Therefore, **ANNUAL CARRYING COST PER UNIT = (Cu × I)**

Then, **ANNUAL CARRYING COST = (½ × Q) × (Cu × I)**

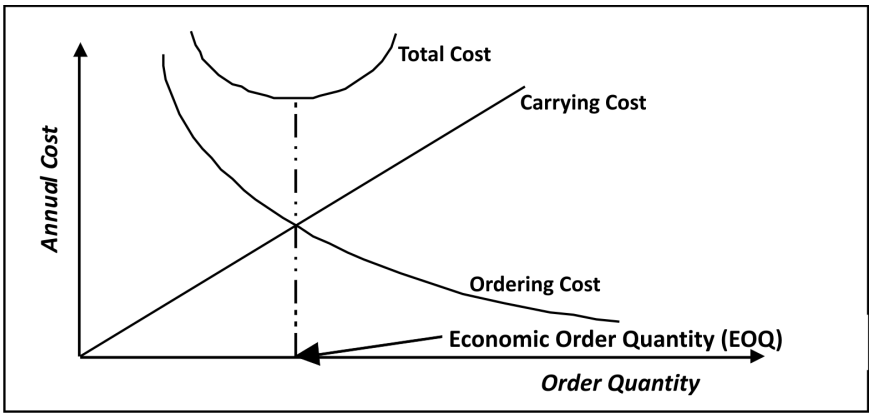


Fig 9.1: Behaviour of various costs associated with inventory

9.5.3 Models Of Inventory

Economic Lot size of an item depends on the following factors:

(i) Possibility of placing repeat orders

(ii) Nature of demand

(iii) Availability of discount

(iv) Single or multiple product manufacture

Inventory models considering the above aspects can be classified as follows:

(i) Static Inventory Models: It is applicable in cases where only one order can be placed to meet the demand. Repeat orders are either impossible or too expensive.

(ii) Dynamic Inventory Models: It is applicable for items where repeat orders can be placed to replenish the stock. These models can be further classified as follows:

(a) Deterministic models based on the assumption that the

demand of na item are deterministic. These models can be further classified into purchase inventory models and production inventory models.

Purchase Inventory models- (a) Fixed price inventory models

(b) Quantity discount inventory models

Production inventory models- (a) Single product inventory models

(b) Multiple product inventory models

(b) Probabilistic models that take into account the variations in demand and lead time of an item.

9.5.4 Operation Of Inventory System

Economic Order Quantity (EOQ): It refers to the optimum quantity of items that can be ordered by any company or firm. The formula for EOQ is: has been derived as follows:

=> Economic Order Quantity, $Q = \sqrt{\frac{(2 \times A \times C_p)}{(C_u \times I)}}$

where,

Q- Economic Order Quantity (EOQ)

Cu - Cost per item

I- Carrying cost expressed as percentage of average inventory (including insurance, obsolescence, taxes etc.) per period

Cp - Cost of placing an order

A- Total quantity of items used / consumed / required annually

Total Cost of managing the inventory = T = {(A / Q) × Cp } + {(½ × Q) × Cu × I}

Special Case: If Carrying cost is expressed in monetary units (Cc) and not in percentage (I),

=> Economic Order Quantity, $Q = \sqrt{\frac{(2 \times A \times C_p)}{C_c}}$

Optimum number of orders per year ,

$$N = \frac{\text{Total quantity of items used / consumed / required annually}}{\text{Economic Order Quantity (EOQ)}}$$

Time between orders (Cycle Time) , CT =

12 ÷ N (considering 12 months in a year)

or 365 ÷ N (considering 365 days in a year)

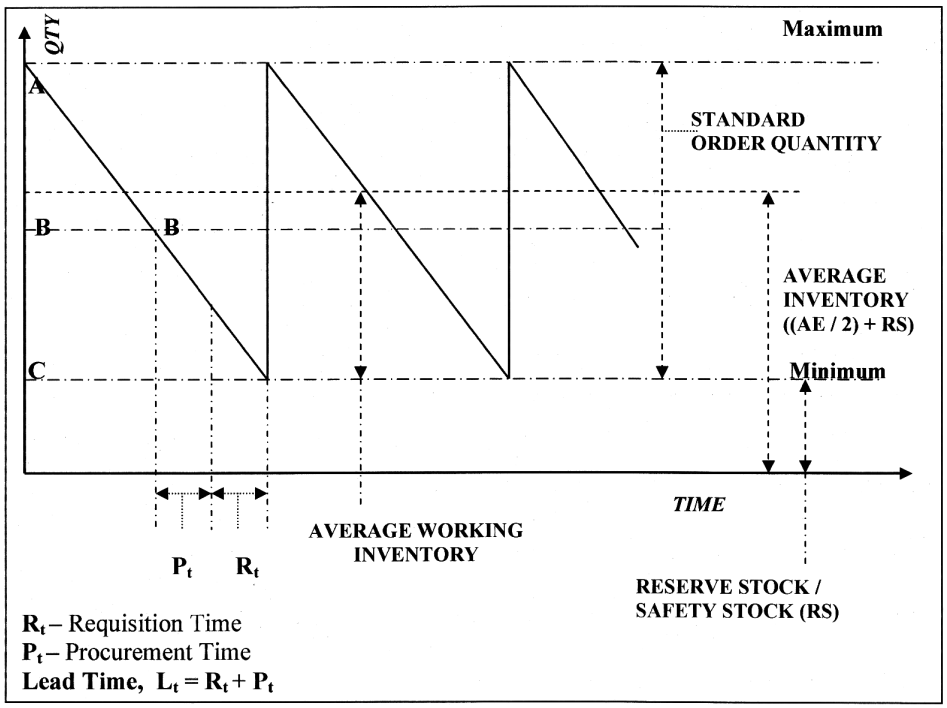


Fig 9.2: Flow of inventory

Example 9.1: JKL company requires 20,000 units of raw material per year costing Rs.3 per unit. The cost of placing an order is Rs.100 and the carrying are 15% per year per unit of the average inventory. Determine:

a. The Economic Order Quantity

b. Cycle Time

c. Total Variable cost of managing the inventory

Solution to Example 9.1: Given for JKL company,

Annual requirement of raw material per year (A) = 20,000 units per year,

Cost per item (C_u) = Rs.3 per unit,

Cost of placing an order (Cp) = Rs.100 per order,

Carrying cost expressed as percentage of average inventory per year per unit (I)

= 15% per year per unit of the average inventory

= 0.15 per year per unit of the average inventory

a. Economic Order Quantity,

$$Q = \sqrt{\frac{(2 \times A \times C_p)}{(C_u \times I)}} = \sqrt{\frac{2 \times 20{,}000 \times 100}{(3 \times 0.15)}} = 2981.42$$

$\approx$2981 units per order

Optimum number of orders per year ,

$$N = \frac{\text{Quantity of raw materials required annually (A)}}{\text{Economic Order Quantity (EOQ)}}$$

20,000 ÷ 2981 = 6.7 $\approx$ 7 orders per year

b. Time between orders (Cycle Time) ,

CT = 365 ÷ N = 365 ÷ 7 = 52.14 $\approx$ 52 days

c. Total Variable Cost of managing the inventory

= T = {(A÷EOQ)×Cp}+{(½×EOQ)×Cu×I}

= {(20,000÷2981)×100} + {(½×2981)×3×0.15}

= Rs.1,341.64

The above results imply that JKL company should order for 7 orders in a year after every 52 days with each order comprising 2981 units of raw materials.

Economic Batch Quantity (EBQ) / Optimum Lot Size (considering non-instantaneous stock replenishment): It refers to the optimum quantity of items that can be produced by any company or firm. The formula for EBQ has been derived as follows:

=> Economic Batch Quantity, $Q = \sqrt{\frac{(2 \times S \times C_{st})}{(1 - {}^{d}/_{R}) \times (C_u \times I)}}$

where,

Q- Economic Batch Quantity (EBQ)

Cu- Cost per item/ unit cost

I- Carrying cost expressed as percentage of average inventory (including insurance, obsolescence, taxes etc.) per period

Cst- Set up cost per production run

S- Annual production

R- Rate of replenishment (production) per day

d- Rate of consumption per day

q- Quantity replenished at time t_1

Total Cost of managing the inventory =

T =

Special Case: If Carrying cost is expressed in monetary units (Cc) and not in percentage (I),

=> Economic Batch Quantity, $Q = \sqrt{\frac{(2 \times S \times C_{st})}{(1 - {}^{d}/_{R}) \times C_c}}$

Number of optimum production runs

$$, N = \frac{\text{Total Annual Production}}{\text{Optimum production quantity per production run, Economic Batch Quantity (EBQ)}}$$

Time Between orders (Cycle Time)

, CT= 12 ÷ N (considering 12 months in a year)

or 365 ÷ N (considering 365 days in a year)

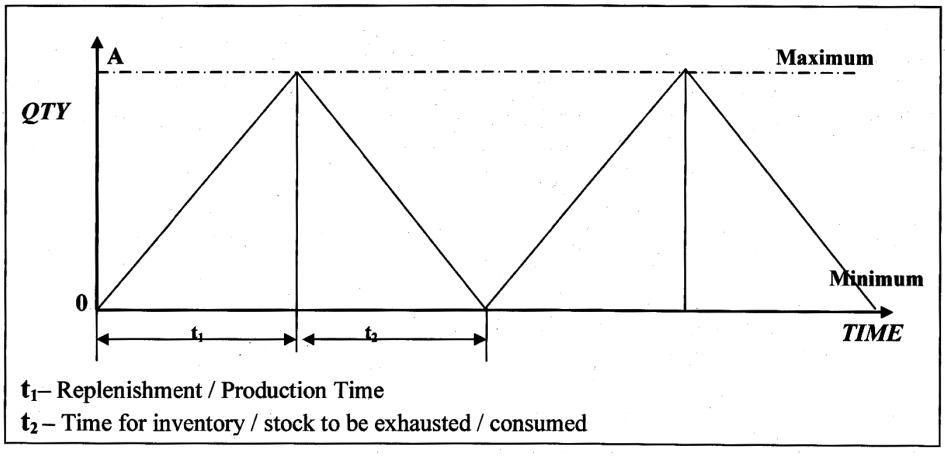


Fig 9.3: Economic Batch Quantity (EBQ) / Optimum Lot Size (considering non-instantaneous stock replenishment)

Example 9.2: A company requires 12,000 units of a particular item every year for manufacturing product AS1234. The average demand occurs at the rate of 20 units per day. The production process is capable of producing 40 units per day. Each item produced in the plant costs Rs.8. The set-up cost per order is Rs.80. The inventory carrying cost is 10% of the average inventory cost. Calculate:

a. The quantity to be produced in each production run

b. Number of production runs per year

Solution to Example 9.2: Given for a company that requires 12,000 units of a particular item every year for manufacturing product AS1234,

Annual requirement of the particular item per year (S) = 12,000 units per year,

Cost per item (Cu) = Rs.8 per unit,

Set-up cost per order (Cst) = Rs.80 per order,

Rate of replenishment (production) per day (R) = 40 units per day

Rate of consumption per day (d) = 20 units per day

Carrying cost expressed as percentage of average inventory per year per unit (I)

= 10% per year per unit of the average inventory

= 0.10 per year per unit of the average inventory

Quantity to be produced in each production run,

=> Economic Batch Quantity,

$$Q = \sqrt{\frac{(2 \times S \times C_{st})}{(1 - {}^{d}/_{R}) \times (C_u \times I)}} = \sqrt{\frac{2 \times 12{,}000 \times 80}{(1 - {}^{20}/_{40}) \times 8 \times 0.1}}$$

= 2190.89 $\approx$ 2190 units per production run (batch)

Number of optimum production runs per year ,

$$N = \frac{\text{Total Annual requirement (S)}}{\text{Optimum production quantity per production run, Economic Batch Quantity (EBQ)}}$$

= 12,000 ÷ 2190 = 5.5 ≈ 6 production runs per year

Time between production runs (Cycle Time)
, CT= 12 ÷ N = 12 ÷ 6 = 2 months

The above results imply that the company should go for 6 production runs in a year after every 2 months with each production runs requiring 2190 units of the particular item.

Inventory Model when shortages are allowed:

The EOQ formula when shortages are allowed is:

=> Economic Order Quantity, $Q = \sqrt{\frac{(2 \times A \times C_p) \times \{(C_u \times I) + C_s\}}{(C_u \times I \times C_s)}}$

Special Case: If Carrying cost is expressed in monetary units (Cc) and not in percentage (I),

=> Economic Order Quantity, $Q = \sqrt{\frac{(2 \times A \times C_p) \times \{C_c + C_s\}}{(C_c \times C_s)}}$

Assumptions:

(i) Replenishment is instantaneous

(ii) Back orders are carried as fresh stock arrives

(iii) Time period of one cycle is fixed

where,

C_p- Cost of placing an order

A- Total quantity of items used / consumed / required annually

C_u - Cost per item

I- Carrying cost expressed as percentage of average inventory (including insurance, obsolescence, taxes etc.) per period

C_s- Shortage cost per unit

q_o- Initial quantity

t_1- Time for initial quantity to be exhausted

t_2 - Time in which shortages are allowed

Q_s- Shortage quantity at time t2

Total Cost of managing the inventory (T)

T = Inventory carrying Cost + Cost of Back Order + Ordering Cost

$$= \frac{½ \times (Q - Q_s)^2}{Q} + \frac{(Q_s)^2}{(2 \times Q)} + \frac{(U \times Cp)}{Q}$$

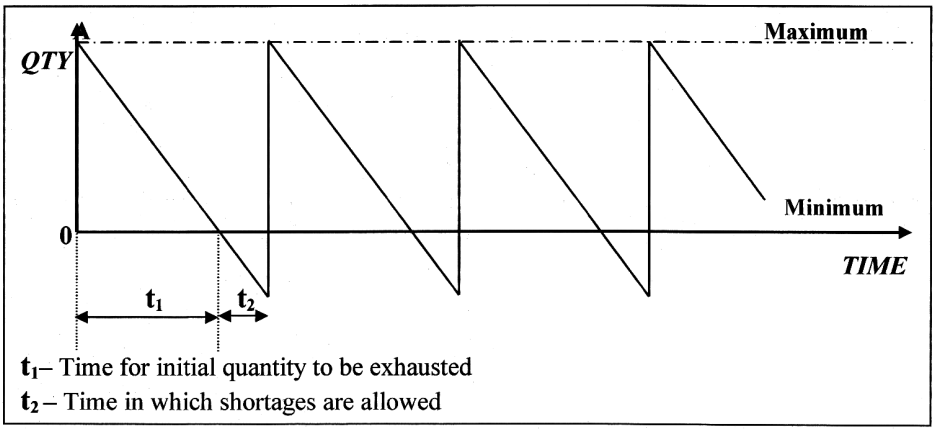


Fig 9.4: Inventory Model when shortages are allowed

Joint Cycle for multiple products:

In this case, the optimal number of joint cycles is:

$$n_{optimal} = \sqrt{\frac{\sum C_{ci} \times A_i \{ 1 - d_i / R_i \}}{2 \sum C_{pi}}}$$

where,

Q_i- Optimum Quantity of product i

R_i- Rate of replenishment per day of product i

d_i- Rate of consumption per day of product i

C_{pi} - Cost of set-up of product i

C_{ci} - Carrying Cost of product i

A_i - Total quantity of items used / consumed / required annually of product i

Fixed Order Period Models: They are also called P-system. Here the purchasing policy is to place an order for materials at definite periodic intervals such as monthly, quarterly, etc. It is to be noted that in this case ordering period is fixed but order size (quantity) may vary. In short here, the order size (quantity) remains fixed but ordering period may vary. These are therefore called "Fixed Order Quantity Models". Here the economic order quantity (EOQ) for the normal inventory is determined and this fixed quantity of order is placed on the supplier every time the inventory level reaches the reorder point.

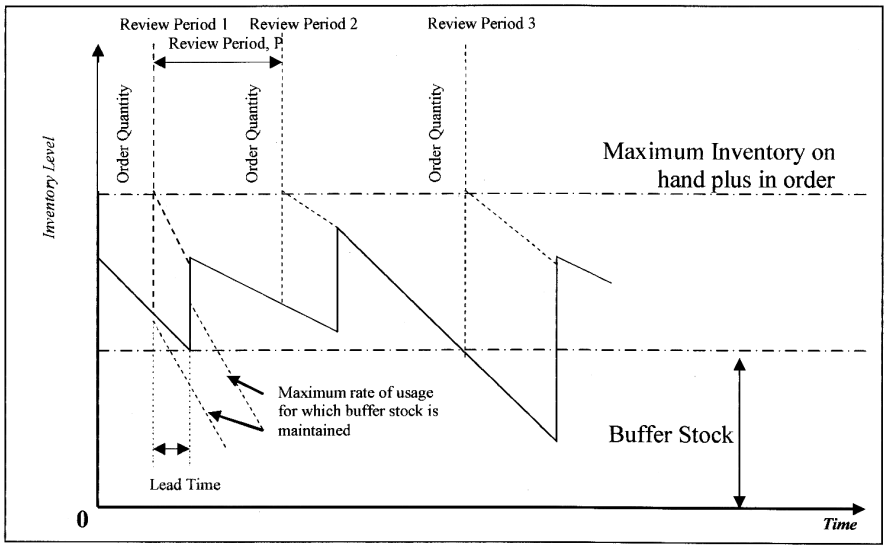


Fig 9.5: Fixed Order Period Models

The procedure of P-system consists of the following:

(i) Determining the optimal order cycle analytically, including some practical considerations.

(ii) Determining the maximum level of inventory on hand plus on order analytically.

(iii) Determining the amount to order at each period by subtracting the actual amount on hand from the earlier determined level of maximum inventory on hand plus on order.

The two quantities which need to be determined in the P-system are:

(i) The order cycle

(ii) The maximum inventory on hand plus on order

Review period for 'P' system:

The optimal review period for 'P' system is given by

$$P = 1 / Nopt$$

Where Nopt is the optimal number of orders = annual requirement of the material divided by the economic order quantity (EOQ). It is calculated by the basic EOQ formula for a Q-system.

Determining the maximum level of inventory on hand plus on order:

(i) The average requirement of material for usage during the review period plus the lead time

(ii) The buffer stock specially designed for the P-system

9.5.5 Quantity Discount

Inventory Model with Purchase Discounts:

Let,

Q- Economic Order Quantity (EOQ)

s - Supply price per item

f- Carrying cost expressed as fraction of inventory value

Cp - Cost of placing an order

A- Total quantity of items used / consumed / required annually

Total Costs (Relevant) = $(C_p \times A)/Q + (Q \times s \times f)/2 + (s \times A)$.....(i)

Differentiating the equation (i) with respect to Q,

=> Economic Order Quantity, $Q = \sqrt{\frac{(2 \times C_p \times A)}{s \ f}}$

Total Costs at optimality, TCopt = ? $(2 \times C_p \times s \times f \times A) + (s \times A)$

9.5.6 Implementation Of Purchase Inventory Model

As stated in section 7.5.3, Purchase Inventory models fall into the following categories:

(i) Fixed price inventory models

(ii) Quantity discount inventory models

The above mentioned Purchase Inventory models may be applied and implemented all the following types of industries.



CHECK YOUR PROGRESS

Q 4: What is the full form of EBQ?

(a) Economic Batch Quantity (EBQ)

(b) Econometric Batch Quantity (EBQ)

(c) Economical Batch Queue (EBQ)

(d) None of these

Q 5: Fixed Order Period Models are also called?

(a) Q-System of Inventory Control

(b) P-System of Inventory Control

(c) Economy in production

(d) None of these



9.6 LET US SUM UP

Integrated Materials Management is an important component of Production and Operations Management. It includes every aspect of material including their costs, their supply, their production and their utilization as well all concerned functional departments associated with such materials. The important points under Integrated Materials Management discussed above are:

- The main purpose of materials planning for the production process of any product(s) is to ensure supply of right materials in the right place, in the right quantities, in the right quality and in the right price(s) in the production plant when required.
- Inventory Control aims at making the desired item available in quality and quantity to various departments when needed.
- Purchase management is concerned with the procurement of proper equipment, materials and supplies in right quantities, right quality, at the right places, through the right processes, at the right prices at the right time.
- Stores management involves proper application of processes and space within stores in an organization to receive the incoming materials and their subsequent movement.
- Inventory decisions covers involves all production activities from the purchase of raw materials to the delivery of finished goods to the customer.



9.7 FURTHER READINGS

Industrial Engineering and Production Management by M.S. Mahajan, Dhanpat Rai and Company Private Limited, pp.780-784.

Operations Management by M.S. Mahadevan, Pearson Education, pp.474-509.

Production and Operations Management by E.E.Adam and R.J. Ebert, Prentice Hall of India Private Limited, pp.521-549.

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Production and Operations Management by S.N. Chary, Tata-McGraw Hill Publishing Company Limited, pp.23.1-23.16.

Production and Operations Management by R. Panneerselvam, Prentice Hall of India Private Limited, pp.264-279.

Production and Operations Management by J.P. Saxena, Tata-McGraw Hill Publishing Company Limited, pp.359-379.



9.8 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No.1: (a) Receipt Store

Ans. to Q. No.2: (c) Co-operative Purchasing

Ans. to Q. No.3: (a) Work-in-process

Ans. to Q. No.4: (a) Economic Batch Quantity (EBQ)

Ans. to Q. No. 5: (b) P-System of Inventory Control



9.9 MODEL QUESTIONS

Q. 2) What is inventory? What are the various types of inventory?

Q. 3) What is inventory control? What are the various methods of inventory control?

Q. 4) ABC company requires 16,000 units of raw material costing Rs.2 per unit. The cost of placing an order is Rs.45 and the carrying are 10% per year per unit of the average inventory. Determine:

a. The Economic Order Quantity

b. Cycle Time

c. Total Variable cost of managing the inventory

Q. 5) XYZ manufacturing company requires 1000 units of a particular item per month. The average demand occurs at the rate of 30 units per day. The production process is capable of producing 50 units per day. Each item produced in the plant costs Rs.10. The set-up cost per order is Rs.100. The inventory carrying cost is 15% of the average inventory cost. Calculate:

a. The quantity to be produced in each production run

b. Number of production runs per year

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