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**BUSINESS ADMINISTRATION**

**OPERATION RESEARCH I (120301451)**

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**TRAINING UNIT #3**

**3. INVENTORY CONTROL METHODS**

**3.1 INTRODUCTION**

An Inventory may be defined as a stock of idle tangible resources of any kind having an economic value. The inventories can be in the form of raw materials, semi-finished goods or finished products not delivered to the consumer. These could even be the human resources such as available unused labour or financial resources such as working capital etc. For many organisations, inventories may be using 30 to 70% of the total assets. It varies from organisation to organisation. It is the level of inventories that matters for any organisation due to capital investment tied up in these resources.

Since it is blocking the working capital, which is so costly, it is not desirable to have a high inventory. The inventory requires holding and maintenance/preservation cost. It carries the risk of theft, spoilage, leakage or obsolescence. The cost of keeping inventory may be very high. Hence it is imperative to have a tight control over the level of inventory build up. It is a 'necessary evil, a must to keep uncertainty away in order to have business going, but should be kept only to the extent of minimum desired.

Controlling is a process by which the change in the system is modified to maintain the system on an optimal performance level. Hence in case of inventory also, the control is absolutely essential to release working capital from unwanted inventory, at the same time, to keep the inventory affecting cash flow and liquidity. Few of the examples of inventory in Product/Service industry are given below :

Factory: Raw materials, parts and components, semi-finished inventory and finished goods.

Bank: Cash reserve tellers.

Hospitals: Number of beds, specialised personnel and stocks of drugs.

Airline: Aircraft seat miles per route, parts for repairs of aircrafts, stewards and other specialist persons for repair and maintenance.

**3.2 CATEGORIES OF INVENTORY**

There are inventories maintained for various purposes. Since inventory normally consumes and blocks a substantial amount of working capital, it is imperative for all managers to understand the types and purpose of inventory. Also there has to be a system of knowing the existence of inventory, otherwise it

may not come to the notice at the right time of taking crucial decisions. In any organization, inventories can be classified under various categories, all of these may not exist at any one time.

1. Movement or Process Inventory: These inventories exist because transportation takes time in reaching the inventory to the point of consumption. These could be in the form of finished goods inventory in transit from manufacturing base to the market or the raw materials in transit from source to the place of utilisation.

2. Buffer Inventory: It is kept in the form of safety stock to cater for the uncertainty of demand or supply. Future demands are normally forecasted, but forecasts may not depict changed situation or uncertain environment, thereby demands changing without notice. Shortage cost may be very large, when customer demands are not met for want of lag-behind production due to non-availability of raw material, or finished good inventory at sufficient level in case of spurt in seasonal demand. Buffer stocks also act as safety against uncertain lead time or delays due to natural calamities.

3. Seasonal Inventories: Seasonal inventories are kept to cater for higher demand during a particular period of the year. Instead of increasing the production level, which may be quite capital-intensive to provision new facilities, it may be economical to manufacture product during the lean or off-season, when demands are low, and production facility can be gainfully utilised to build up stock for a higher demand period. Here a balance of capital investment and cost of its procurement with that of cost of carrying seasonal inventories has to be judiciously worked out. It can also be called 'Anticipation' inventory as items like airconditioners, air coolers, crackers, umbrellas and raincoats are required against very specific sudden demand and for a very short duration, but in large quantity.

4. Decoupling Inventory: These inventories are necessary to reduce dependence of various stages of production. These may be raw materials, work in process inventories or finished goods, under the conditions when certain production facility may not match with the system due to poor condition of machine, machine breakdown or working efficiency differential of workers. This inventory is also required for after-sales service, where demands do not follow a pattern.

### **3.3 REASONS FOR CARRYING INVENTORY**

Some of the important reasons for carrying inventory emerge out of the environmental conditions and can be summarised as follows :

1. Variation in production
2. Variable customer lead time
3. Uncertain vendor reliability in quality
4. Financial gains when prices are uncertain or fluctuate or else when quantity discounts are attractive.

### **3.4 INVENTORY MANAGEMENT**

Inventory management is necessary in the follows areas:

1. Accounting for inventories to workout lead time, source order restrictions, receipt quality and time, audit and control of cash flow.
2. Operating constraints-These are considered for working out optimal inventory policy, limited merchandising and limited budgeting etc.
3. Planning and control
  - (a) what to buy and where from?

(b) when to buy and how much?

4. Measure of performance - for the purpose of satisfaction of forecasted demand.

### 3.5 COST ASSOCIATED WITH INVENTORY

Operations Research There are following types of costs involved, while discussing and making decision on inventory.

1. *Ordering Costs:* Inventory, when necessary, need be created and in order to achieve this, we have to go through certain administrative functions while ordering the items. The documentation, the cost of ordering organisations, the communication cost like telephones, fax, postage etc. need be considered. In addition, we have to cater for the transportation of items, inspection at vendors end or at the stores when received, the cost of receiving and then processing the payments etc.

2. *Purchase Costs:* The cost of purchasing, after due negotiations, per unit item is called the purchase cost. Discounts and price breaks can be secured during negotiations for reducing the purchase cost, when large quantity is ordered.

3. *Carrying Costs:* The costs associates with holding inventories are called carrying costs. The quantity of items actually held in stock only need be considered for such costs. Larger quantity kept for longer period would mean larger carrying costs. It includes the cost of storage, maintenance, depreciation, cost of security and accounting and taxes paid for the inventories etc.

4. *Shortage Costs:* These are the costs incurred for not holding the inventory, when needed. It is the penalty for running out of stock and is due to the fact that the product is not available to the customer when in demand. This cost would include the loss of opportunity and credibility of the organisation for not meeting the demand of the customer. The loss of goodwill and reduction in further procurement of business are important effects and hence shortage costs can be very large, still may not be quantifiable and very apparent. Certain effects are felt over a long period.

There may be situations when customer can wait for the demand to materialise, but procurement of such stocks would involve additional efforts of special order and emergency price paid for such an eventuality. This cost is worth the efforts, if good-will is to be saved. To minimise shortage costs, additional stock of appropriate level can be kept in the form of safety or Buffer Stocks. These are essential when items are of critical nature from the business point of view.

5. *Salvage Costs:* When the demand for an item ceases to exist, the decision to dispose off or sell the item may be taken or, if the item is in inventory and is deteriorating, it needs be either used fast or sold at a discount. The cost normally gets associated with storage or holding cost and is not normally considered separately.

Therefore, in order to decide on the optimal inventory policy, as the costs described above need be considered dispassionately and level of inventories worked out based on a balanced view of the business situation.

Thus, Total Inventory Cost Hence optimisation. when to order = Ordering Cost + Purchase Cost + Holding Cost + Shortage Cost.

Hence when to order and how much to order becomes important inventory decisions for optimization.

The relationship of various costs 'on the inventory level is shown in the Fig. 14.1:

Point A indicates optimum ordering quantity for minimum total inventory costs.

Fig. 14.1

### 3.6 IMPORTANT DEFINITIONS FOR INVENTORY SYSTEM

1. *Demand*: In order to decide on optimum level of inventory and its control policy, customers requirement in terms of its size (number of items required), the rate (how many items are required and when) and the pattern (whether continuously increasing or decreasing and at what rate, or whether a seasonal demand) need to be collated. Hence demands can be deterministic or probabilistic. Deterministic demands are those types of demands, which can be predicted or known with certainty with a definite time frame whereas probabilistic demands are those, which cannot be known in either form i.e., neither its quantity, nor time schedule nor the pattern be predicted.
2. *Order Cycle*: It is the time period between two successive orders placed to meet the demand. It need to be established, if there is a set pattern in placing the orders. This is possible for such situations when demands are known with a definite pattern and are constantly reviewed. But for situations like large scale projects, environmental factor take toll of the pattern and order cycle may be difficult to adhere to. Then items are ordered as and when required.
3. *Time Horizon*: It is the period over which the inventory level will be controlled. It can be finite or infinite depending on the nature of demand.
4. *Lead Time*: It is the time elapsed between the time of ordering the item and its actual receipt at stores/place of requirement. Lead time plays a very important role in the inventory control policy. The costs associated with inventory are largely dependent on the lead time, which can be constant, variable, deterministic or probabilistic. The best situation can be JIT (Just-in-time) i.e., the situation of zero lead time. If the material can be received when item is required, the order need not be placed in advance and there may be no requirement for carrying cost. Another good situation exists when lead time is deterministic. All functions of inventory are then under control with definite system. But when lead time is uncertain, then ordering and carrying costs can disturb the balance of inventory control.
5. *Safety Stock or Buffer Stock*: It is the level of inventory kept procured when either the lead time is uncertain or the demand is critical and shortage cost may be high. This inventory is planned to meet the demand during uncertain supply period or else to cater for sudden spurt in demand for a short duration,
6. *Re-order Quantity*: It is the quantity of items ordered to replenish the exhausted or utilised inventory with a comprehensive inventory policy. It should be the Economic Order Quantity (EOQ) which should be procured when required.
7. *Re-order Level*: It is the level of stock inventory at which it is decided to replenish the stock. It is connected with the lead time, such that the item should be received just at a time when the stock level is at the minimum desired level. In quite a few cases, when safety of buffer stock is planned, the ROL (Re-order level) should cater for the level of consumption of inventory just sufficient to reach safety stock level during the lead time.

### 3.7 INVENTORY MODELS

To meet various life situations, we need the consideration of relevant factors to determine inventory models which help in an effective inventory control policy.

#### **Model I - Let D Economic Order Quantity Model with Uniform Demand**

In this case, we keep a watch on the inventory, which is deterministic due to uniform demand levels and we need developing a model, which caters for replenishment at a time, when lead time provides just

sufficient opportunity of replenishment. EOQ is the quantity required to be ordered to keep the total inventory cost, at the minimal level.

- Let  $D$  = Demand (uniform and deterministic during lead time)
- $R$  = Rate of replenishment
- $L$  = Lead time
- $C_p$  = Unit purchase cost
- $C_h$  = Unit holding cost
- $C_o$  = Unit ordering cost
- $C_s$  = Shortage cost
- $Q$  = Decision variable i.e., Quantity to be procured.

Fig. 14.2

Let us draw a graphical representation of the situation of EOQ Model with uniform demand.

Referring to Fig. 14.2 above, maximum inventory level is taken as  $Q$ , with uniform rate of consumption of inventory i.e., uniform demand. It is shown as a sloping straight time to reach zero level at a uniform rate. Since the demand is uniform, the re-order cycle also become definite. Average inventory can be worked out as follows:

$$\frac{\text{Max level} + \text{Min level}}{2} = \frac{Q + 0}{2} = \frac{Q}{2} = \text{Average Inventory}$$

We have to find optimum level  $Q$  such that the total inventory costs are minimised.

$$(a) \text{ Ordering Cost} = \frac{D}{Q} C_o$$

$$(b) \text{ Carrying Cost} = \frac{Q}{2} C_h$$

$$\text{Hence Total inventory Cost} = \frac{D}{Q} C_o + \frac{Q}{2} C_h$$

In this case, lead time being constant,

ordering cost = carrying cost

$$\frac{D}{Q} C_o = \frac{Q}{2} C_h \quad Q = \sqrt{\frac{2DC_o}{C_h}} \quad \text{This model is known as WILSON LOT SIZE FORMULA.}$$

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