Inventory Control

12

Unit Introduction

Inventory management is very important to both product and service oriented businesses. How much wealth to stock has been a puzzling question since man's existence as an economic being. While the accumulation of wealth has always been cheered, subject to religious and moral constraints, the acquisition of goods for anticipated use is of a peculiar nature. It is the stick that should be *neither too long nor too short*, which King Solomon ordered his bird to find, and which, according to Middle Eastern tale, the generations of that bird are still looking for in the trees. Thus in real business life situation raw materials must be scheduled and stock-piled for the production, operating supplies must be delivered and placed on hand in the proper quantities for the operation, large stocks of materials must be kept to operate, maintain, and expand the extensive distribution system. If proper materials are not available when needed, it will be difficult to extend services in a timely fashion. These demand large volumes of materials on hand to ensure that there will be no shortage. This will increase cost, but the customers prefer low rates. Thus a proper balance must be struck to maintain proper inventory with the minimum financial impact on customers. This demands maintaining stock keeping items at a level which is neither too much nor too less and must be Just-In-Time (JIT). Focussing this the unit will cover the issues of inventory concepts; inventory control; the operating doctrine of inventory, Just-In-Time Management (JIT)

Lesson One: **Why-What-How Issues of Inventory**

Lesson Objectives

After completing this lesson you will be able to:

- Understand the meaning of inventory
- Identify the reasons for keeping inventory
- Explain the and inventory system concepts
- Discuss how to control the inventory
- Comments on the importance of different inventory

The pressure for operating capital has made business increasingly aware of inventory as a form of earning investment. The basic problem of inventory policy is to strike a balance between operating savings and costs of capital requirements associated with larger stocks. Striking this balance is easier to say than to do. Why are we always out of stock? A complaint from a large number of businessmen faced with the dilemmas and frustrations of attempting simultaneously to maintain stable operations, provide customers with adequate service, and keep investment in stocks and equipment at reasonable levels. In order to get the answer to this question as a basis for taking action, it is necessary to step back and ask some rather different kinds of questions:

- Why do we have inventories?
- What affects the inventory balances that we maintain?
- How do these effects take place?

From these questions a picture of the inventory problems can be built up which shows the influence on inventories and cost of various alternative decisions, which the management may ultimately want to consider. Before answering these questions let's start defining inventory and understand different types of inventory.

What is Inventory?

Inventory can be defined as idle resources awaiting activation. Inventory is made of all those items ready for sale or of items, which keep the process running. From firm's point of view, inventories represent an investment; capital is required to store materials at any stage of completion. Inventory is store of goods and stocks. In manufacturing, items in inventory are called stock-keeping items held at a stock (storage) point. Stock-keeping items usually are raw materials, work-in-process, finished products and supplies stocked in order to meet an expected demand for distribution in the future (figure 12.1.1).

Inventory is an idle resource for later use.

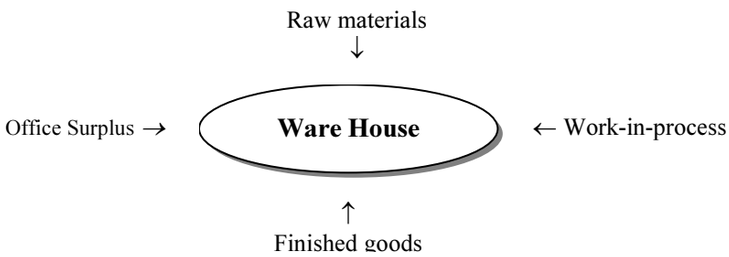


Figure 12.1.1: Different items of inventory in manufacturing kept in ware house

Even though inventory of materials is an idle resource in the sense it is not meant for immediate use. It is almost a necessity for some inventories for the smooth functioning of an organization – manufacturing or service. Let us take the example of a commercial bank with full-line services. The typical individual account involves various transactions, such as, checking, savings, lock boxes, and loans. For the teller operation, the service is to convert labor and materials into money management. Such materials as deposit slips, withdrawal slips, and loan payment coupons are more like operating supplies than raw materials. For the accounting operation, slips and coupons could be viewed as work-in-process, and money account statements awaiting mailing as finished goods (services).

Types of Inventory

Inventory can be classified into three different categories:

i. Transaction inventory
ii. Speculative inventory
iii. Precautionary inventory

i. **Transaction inventory**: It is formed basically of those items, which are mainly needed for transaction, e.g., transaction of finished saleable products or transaction of raw materials.
    a. De-linking Production with Purchasing Department is one of the functions of this, i.e., receipt of raw material is stored in the form of inventory and whenever production department needs raw material it put indent to inventory organization rather than to purchase department.
    b. De-linking Production with Sales Organization. Similarly it delinks sales and production departments.
ii. **Speculative inventory**: It is basically kept as a measure of speculation of increase in the price of raw material or increases the sale price of finished goods. It is generally resorted to before the budget proposals.
iii. **Precautionary inventory**: The machines are to be kept running. There may be breakdown of machines at any time due to damage of any part due to wear and tear. At that time it cannot be purchased immediately. Therefore, such items, which are essential to keep the process running, are to be stored like machine parts, tools, etc. It is also called maintenance repair and operation inventory.

Why Inventory?

As noted, inventory is an idle resource for later use. An idleness is always associated with a cost, maintaining inventories is expensive in terms of the working capital tied up in them, either directly or indirectly through alternative uses of the tied-up funds. In addition, the process of ordering goods, whether from an external supplier or from the firm's own production, is expensive due to the costs arising from checking the actual levels of stock, contacting suppliers, checking their products, and the applicable costs of credit facilities, shipping, and forwarding. A parallel type of cost, the set-up cost, arises in production-by-lot processes, where production is discontinuous and thus the equipment used, being not strictly specialized, needs adjustment and retooling for every production run. Uncertainty has also its cost. Uncertainly regarding demand expectations and time lags between ordering and receiving, or starting a run and finishing it,

results in overages and shortages. To these conflicting costs must be added the cost of designing and handling inventory systems.

In some circles inventories are thought of as a sign of wealth, even excess inventories in relation to the magnitude of production and distribution function are considered advantageous. On the other hand, the wise businessmen place more emphasis on having working capital on the form of cash and securities. In recent years a greater emphasis has been placed on having the means of purchasing materials than having the materials themselves. Excessive inventories have been the reasons for death of many a business and very high inventory levels has tipped the scale in our economy. Finished product after packaging are first stored and sent to the market as the need arises or orders are received. Also the raw materials needed for the finished product cannot be directly fed to the production department from the market. These have to be stored first after procurement. These things put together give an idea of storing these items. This process of storing is called inventory. The fundamental reason for carrying inventories is that are:

Excessive inventories have been the reasons for death of many a business.

- Physically impossible for each stock item to arrive exactly where and when it is needed and
- Economically impractical for each stock item to arrive exactly where and when it is needed.

Even if it were physically possible for a supplier to deliver raw materials every few hours, for example, it could still be prohibitively expensive. The manufacturer must therefore keep extra supplies of raw material inventory to use when they are needed in the conversion process. The other reasons for keeping inventories include:

a. **Buffer stock**: Buffer stock can be defined as the inventory against stock-outs from uncertain demand during lead-time. When demand is highly variable, some protection is needed against the chances of high stock-out costs. In such cases inventory can be used as a *buffer*. Likewise this also buffers against highly varied lead-time (time between ordering and receiving goods).

b. **Decoupling**: Decoupling means breaking down operations apart so that one operation's supply is separated from another's supply. Through decoupling by procuring inventories separately, breakdowns, material shortages, or other production fluctuations at one stage of operations do not cause any disruption in later stages of operation. Also through decoupling one organizational unit can schedule its operations independently. Decoupling through in-process inventory is common in automobile industry, where, engine build-up, seat assembly, body making, etc. are done separately (in many cases in distant locations).

Decoupling is breaking down operations apart so that one operation's supply is separated from another's supply.

c. **Production smoothing**: Products can be built during slack demand periods for using in peak demand periods. This will reduce high costs of production rate, work force level changes, set-up costs, etc. Inventories can help in this production leveling.

d. **Materials handling**: In some operations parts can be accumulated and stocked in container (tote) boxes or baskets and transported hand-jack dollies (wheelbarrow) or forklift trucks much more economically than can be carried manually. This is particularly true of intermittent systems, since they involve less automation of material handling than do continuous

systems. In continuous manufacturing, automated materials handling systems are designed to reduce overall handling costs, resulting in less work-in-process.

e. **Bulk purchase**: Bulk purchase gives quantity discount. This also gives a cost advantage of materials inventories.

> **Activity:** Assume that you are the owner of an export quality man's garments manufacture firm. Do you think for your products 'inventory management issue' should be a key success factor? Why or why not? Discuss with your study partners.

Evils of Excess Inventory

From the above discussion you can be well aware of the importance of inventory and its management. But excess inventory is no doubt an evil for an organization. It blocks the money taking away opportunities for the firm. Some of the bad impacts of excess inventory are mentioned below:

- Essential though they are, inventories also mean lock up capital of inventories, which could be invested in more profitable operations.
- Excess inventory adds to the cost of carrying the inventory more store space, equipment and personnel, insurance, taxes, pilferage etc.
- Excess inventory invites risk of deterioration and obsolescence.
- Changes in the prices of inventory materials sometime go unfavorable.
- Maintenance of cost money.

Inventory Control

Inventory constitutes one of the most important elements of any system dealing with the supply, manufacture and distribution of goods and services. The concept of inventory control is very old but it came in light when F. W. Harris published his work on classical order size model. F.E. Raymond (1931) and R.M. Wilson (1934) extended this work. But only after the second world war with the development of operational research and computer technology that the theoretical concepts got a practical application. The basic purpose of inventory holding stocks in a material flow system is to de-couple successive stages of system. Following are important purpose of inventory:

- Existence of time lags between manufacturing and transport operations.
- The need to schedule various stages of the system independently.
- The need to meet the fluctuation in demand and production rates.
- The need to maintain control over the quality of the finished production.
- The need to exercise influence over changes of material prices particularly basic raw materials.

The inventory control mainly concerned with making optimum decision with respect to the variables, which are subject to control.

The inventory control mainly concerned with making optimum decision with respect to the variables, which are subject to control. Inventory control is a multi-item and multi-stage in nature. As noted inventory is an idle resource, which is useable, has value and awaiting activation. The idle resource may be men, money, materials, and plant acquisition. The manpower, capital and plant acquisition problems are essentially control problems. Inventory control determines the levels of composition of inventories of parts, materials and products that will protect most effectively the production, sales, and financial

requirements of the business. A system of production planning and control is not and end in itself. It can only be justified because it (a) provides the means for effective coordination of the Production department with other departments of the business; and (b) promotes effective shop operation through its control of activities within the production department itself.

Advantages of inventory control

i. Introduction of a proper inventory control system helps in keeping the investment in the inventories as low as feasible.
ii. Ensures availability of material by providing adequate production against uncertainties of supplies and consumption of materials.
iii. Allows full advantage of economies of bulk purchases and transportation.
iv. Reduces changes of going out of stock.
v. Leads to reduction in inventory levels.
vi. Releases more of capital for other operations.
vii. Increases profitability of an organization.
viii. Adequate customer service.
ix. Advantage of price discounts by bulk purchasing.
x. Providing flexibility to allow changes in production lines due to changes in demands or any other reason.

Which Inventory to Emphasize?

As you can understand that all the items held in inventory are not of equal importance in terms of monetary value, profit potential, sales or usage volume, or stock-out penalties. For example, a retail store can have a lot of items like, rice, sugar, butter, pencil batteries, etc. It would be unrealistic to devote equal attention to each of these items. Instead, a more realistic and reasonable approach would be to allocate control efforts according to the relative importance of various items in inventory. Hence the question arises which inventory to emphasize?

A-B-C Classification

The simple answer to this question is to apply the theory of *Vital Few and Trivial Many* by Velfredo Pareto. When an organization's inventory is listed by Taka values, generally a small number of items account for a large Taka volume, and a large number of items for a small Taka volume. In inventory management we focus this view by classifying the inventories into three categories A, B and C (Figure 12.1.1).

A-B-C classification of inventory is listed by taka values.

An A-grouping is made for those few items with large Taka value; a B-grouping for items with moderate unit and Taka value; and a C-grouping for the large number of items accounting for a small Taka value. Thus A-group might contain, for example, about 15% of the number of items in the inventory costing about 60-70% of the total Taka usage; B-group might contain, for example, about 30% of the items costing about 25% of the total Taka volume; C group might contain, for example, about 55% of the number of items costing only about 10% of the total Taka volume 12.1.1. These percentages vary from firm to firm, but in most instances a relatively small number of items will account for a large share of the value or cost associated with an inventory.

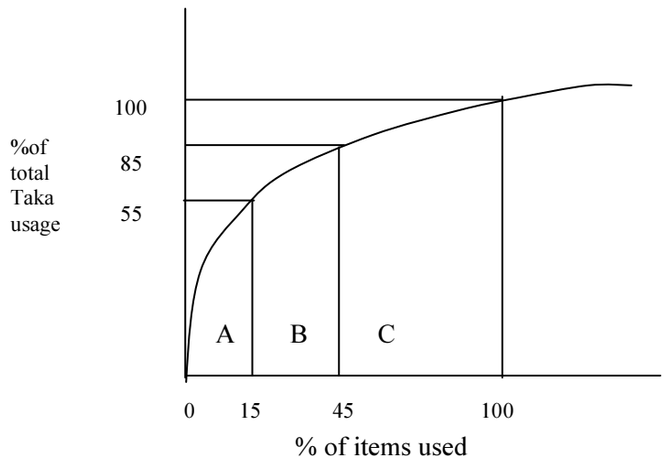


Figure 12.1.1: A-B-C classification of items

These items (A-category) should receive relatively close attention through frequent reviews of amounts on hand and control over withdrawals, where possible to make sure that customer service levels are attained. The C-items should receive only loose control, whereas, the B-category should have controls that lie between the two extremes.

Activity: Chose a medium or big in size departmental store from any super market. Carefully examine its inventory management system. Do you think the store manager should take any further action(s) that will help him/her to increase performance.

Exceptions to A-B-C classification

There are few exceptions to ABC classifications. Items in C category can demand special emphasis if they meet in any of the following criteria:

- Materials critical to production
- Materials with short shelf lives
- Materials that are very large and bulky
- Valuables materials subject to pilferage
- Materials with highly erratic lead-times
- Materials with highly erratic demand
- Standard packaging, shipping, container, or vehicle size

Questions for discussion

1. Give specific examples of each of the following types of inventories

   (i) Raw materials; (ii) Work-in-process materials; (iii) Office supplies; (iv) Finished goods.
2. What are the evils of excess inventory? Give some example with respect of Bangladesh scenario.
3. You are a manufacturer of a product. You are using your own premises for holding the finished goods. Do you think it has a cost? How will you calculate it?
4. Find the amount of average inventory carried for a family against each of the following purchases for a period of one month. Make necessary assumptions.
5. The family consumes 30 kg of rice @ Tk. 17.00. They purchase the whole amount at the first day of the month.
   a. The family consumes 4 kg of sugar @ Tk. 32.00. They purchase the required sugar two times a month at equal gap.
   b. The family purchases two bottles of pickle (@ Tk. 55.00 per bottle). They purchase both the pickle bottles at the first day of the month.
   c. The family makes weekly purchase of one 200 gm packet of butter (@ Tk. 50.00 per packet) for weekly consumption.
   d. The family needs one 18-slice packet of bread (@ Tk. 20.00 per packet) for their breakfast everyday. They purchase it from the local grocery every morning.
7. A family with three children and their parents is living at Dhanmondi. They have a working maid living with them. Normally at the beginning of every month they make a shopping for the whole month. The shopping chart follows:

Item	Unit Price	Quantity	Item	Unit Price	Quantity
Rice	Tk. 18.00	30 kg	10. Jelly	Tk. 76.00	3 bottles
Flour	Tk. 9.00	15 kg	11. Tooth pick	Tk. 12	1 packet
Pulses	Tk. 35	12 kg	12. Onion	Tk. 14.00	7 kg
Pickle	Tk. 42	2 bottles	13. Salt	Tk. 8.00	5 kg
Biscuit	Tk. 28	4 packet	14. Spices	Tk. 22.00	1 kg
Potato	Tk. 9.00	6 kg	15. Tooth Paste	Tk. 36.00	2 pieces
Soap	Tk. 6.00	4 pieces	16. Butter	Tk. 64	3 pieces
Oil	Tk. 105.00	6 litre	17. Hair Oil	Tk. 25	1 bottle
Tang	Tk. 85.00	2 bottles	18. Match box	Tk. 1.00	5 boxes

The family also subscribes two newspaper (one Bengali and one English) every day, each costing Tk. 8.00, which they sell at the end of the month for Tk. 24. Also they purchase two cans of powder milk every month, one at the beginning and one halfway through. Each of the cans *costs Tk. 490. Considering above make an ABC classification of the inventory items of the family.*

Lesson Two: The operating Doctrine

Lesson Objectives

After completing this lesson you will be able to:

- Understand the costs of inventory
- Explain the cost of tradeoff
- Discuss the Economic Order Quantity (EOQ) model

Costs of Inventory

Operations managers must make two basic inventory policy decisions. These are:

i. When to reorder stock and
ii. How much stock to reorder

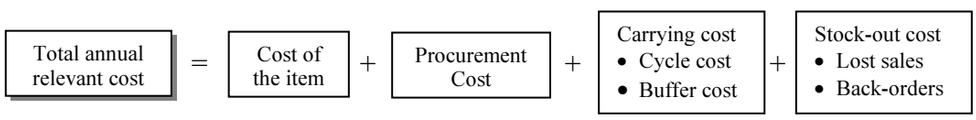
These decisions are referred to as the inventory control operating doctrine. In operating an inventory system managers should consider only those costs that vary directly with the operating doctrine in deciding when and how much to reorder; costs independent of the operating doctrine are irrelevant. Basically, there are five types of relevant costs:

In the inventory system managers should consider only those costs that vary directly.

i. Cost of Item: The cost, or value, of the item is usually its purchase price or the amount paid to the supplier for the item.
ii. Procurement Costs: It is the cost of placing a purchase order, or the setup cost if the item is manufactured at the facility.
iii. Carrying Cost: Carrying or holding costs are the costs of maintaining the inventory warehouse and protecting the inventoried item. It is calculated on the basis of the percentage (%) of the average inventory carried over a period of time.
iv. Stock Out Costs: Stock out costs are associated with demand when stocks have been depleted, take the form of lost sales or backorder costs.
v. Cost Of Operating The Information Processing System: Whether by hand or by computer, someone must update records as stock levels change. For systems in which inventory levels are not recorded daily, the cost is primarily incurred in obtaining accurate physical counts of inventories.

Cost tradeoff

Our objective in inventory control is to find the minimum cost operating doctrine over some planning horizon. We need to consider all relevant costs, which discussed in inventory cost. Using a one-year planning horizon, these costs can be expressed in a general cost equation:



Economic Order Quantity Models

In a continuous, or fixed-order-quantity, system when inventory reaches a specific level, referred to as the *reorder* point, a fixed amount is ordered. The most widely used and traditional means for determining how much to order in a continuous system is the Economic Order Quantity (EOQ) model, also referred to as the economic lot-size model. The earliest published deviation of the basic

EOQ model formula occurred in 1915 and is credited to Ford Harris, an employee at Westing-house. The function of the EOQ model is to determine the optimal order size that minimizes total inventory costs. There are several variations of the EOQ model, depending on the assumptions made about the inventory system.

The Basic EOQ Model

EOQ is the optimal order quantity that will minimize total inventory costs. The simplest form of the economic order quantity model on which all other model versions are based is called the basic EOQ model. It is essentially a single formula for determining the optimal order size that minimizes the sum of carrying costs and ordering costs. The model formula is derived under a set of simplifying and restrictive assumptions, as follows:

EOQ is the optimal order quantity that will minimize total inventory costs.

- Demand is known with certainty and is relatively constant over a period of time.
- No shortage (stock outs) is allowed.
- Lead-time for the receipt of order is constant and independent of demand.
- The order quantity is received all at once.

Figure 12.2.1 describes the continuous-inventory *order cycle system* inherent in the EOQ model. An order quantity, X_o, is received and is used up over time at a constant rate. When the inventory level decreases to the reorder point, R^*, a new order is placed; a period of time, L, referred to as the *lead-time*, is required for delivery.

The order is received all at once just at the moment when demand depletes the entire stock of inventory, thus allowing no shortages. This cycle is repeated continuously for the same order quantity, reorder point and lead-time. As we have seen that the economic order quantity is the order size that minimizes the sum of carrying costs and order costs. These two costs react inversely to each other in response to an increase in the order size. As the order size increases, fewer orders are required, causing the cost to decline, whereas the average amount of inventory on hand will increase, resulting in an increase in carrying costs. Thus, in effect, the optimal order quantity represents a compromise between these two conflicting costs.

The total annual ordering costs is computed by simply multiplying the cost per order, designated as C_r, times the number of orders per year. Since annual demand (Z) is assumed to be known and to be constant, the number of orders will be Z/X, where X is the order size and

$$\text{Annual ordering cost} = (C_r * Z) / X$$

The only variable is this equation is X; both C_r and Z are constant parameters. Thus, the relative magnitude of the ordering cost is dependent upon the order size.

Total annual carrying cost is computed by multiplying the annual per unit carrying cost (%), designated as C_c, times the average inventory level, determined by dividing the order size, X, by 2 (X/2):

$$\text{Annual carrying cost} = C_c \times (CX)/2$$

The total annual inventory cost (TC) is simply the sum of the ordering and carrying costs:

$$TC = C_r \times Z/X + C_c \times CX/2$$

These three cost functions are shown in figure 1.2. Notice the inverse relationship between ordering cost and carrying cost, resulting in a convex total cost curve.

Differentiating the TC curve with respect to X and equating it to Zero can calculate the economic order quantity (X_o). By differentiating again with respect to x we can check for minima of this cost curve. Hence,

$$\frac{dTC}{dx} = \frac{d}{dx}(C_r Z / X) + \frac{d}{dx}(C_c CX / 2) = \frac{-C_r Z}{X^2} + \frac{C_c C}{2} = 0$$

$$\Rightarrow X_o = \sqrt{\frac{2C_r Z}{CC_c}}, \textit{the economic order quantity}$$

$$\textit{to check for } \min \textit{ima}$$

$$\frac{d^2 TC}{dx^2} = \frac{2C_r Z}{X^3}, \textit{a positive number}, \textit{hence } \min \textit{ima.}$$

The optimal order quantity occurs at the point in figure 1.2 where the total cost curve is at a minimum, which also coincides exactly with the point where the carrying cost curve intersects with the ordering cost curve. This enables us to determine the optimal value of Q by equating the two cost functions and solving for Q, as follows:

$$(C_r Z)/X_o = (C_c CX_o)/2$$

$$X_o^{\,2} = (2C_r Z)/(CC_c)$$

$$X_o = \sqrt{\frac{2ZC_r}{CC_c}}$$

For example, the demand for a product over a period of one year is 75,000 units. The unit cost of the items is Tk. 10. The ordering cost and carrying costs are Tk. 10 and 15% of the average carried inventory respectively. The company policy is to place an arbitrary order of 2,000 units each time an order is placed. Find the EOQ? See what affect the optimal order size has on current ordering and storage costs? Now the EOQ would be,

$$X_o = \sqrt{\frac{2 \times 75{,}000 \times 10}{10 \times .15}} = 1{,}000 \textit{ units}$$

If we order 1,000 units each time we place an order, we will need to place 75 orders per year, and our average inventory will be 500 units. Our total ordering and storage cost will then be,

Total ordering and storage cost = $75 \times 10 + 500 \times 10 \times 0.15$ = Tk. 1,500

If they follow current order policy,
The order size = 2000 units
Average inventory = 1000 units
No of orders = 37.5 nos
Total ordering and storage cost = $37.5 \times 10 + 1000 \times 10 \times 0.15$
= Tk. 1,875
Hence the optimal policy would save approximately Tk. 375

Lead Time in Deterministic Model

In EOQ model we assumed that the lead-time is constant and independent of demand. This model can easily be adjusted for lead-times with certainty. We can calculate the reorder point (R*) as follows:

R* = Buffer stock + Demand during lead time (D_L)
= 0 + (Lead time)(Demand/unit time)
= Ld_L

The reorder point is now set and shown in figure 13.3. At R*, an order will be placed for X_o units, which will arrive L units of time later. During the time between ordering and arrival, d_L units per time unit, D_L in total unit will be demanded, and inventory will be reduced accordingly.

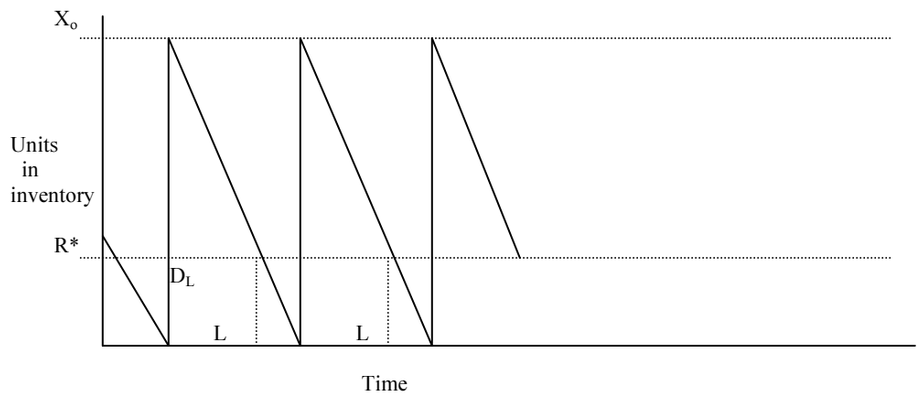


Figure 12.2.1: the continuous-inventory order cycle system

For example assume that A restaurant uses 730 dozens of 8-ounce paper cups annually. The cost per dozen of these cups is Tk.30.00. The ordering costs are Tk.37.50.; carrying costs are 30% of average carried inventory. Delivery lead-time is known with certainty to be five days. Establish the optimal operating doctrine.

$$Here, X_o = \sqrt{\frac{2ZC_r}{CC_c}} = \sqrt{\frac{2(730)(37.50)}{(30.00)(0.30)}} = 77.99 \approx 78\ dozens$$

Reorder point, R* = Ld_L = 5 × (730/365) = 10 dozens

The operating doctrine would be to order 78 dozens when stocks on hand reaches 10 dozens.

Using Computers to Manage Independent Inventory

Computer software keep track of the perform functions of inventory that need the economic quantity to buy or produce.

Computers can use data on receipts and withdrawals to maintain the amount of stock on hand for all the inventory items controlled by the computer system. Computer companies and commercial software companies offer software packages that will keep track of the on-hand balance and perform other functions, such as reporting items that are below their reorder levels and recommending the economic quantity to buy or produce. The computer may print a list each day, showing the items that need to be replenished. Sometimes preferred vendor identification for each item is stored in the database, so the computer can automatically prepare the purchase orders if instructed to do so.

Use history can be used to calculate a forecast of the expected annual demand. Estimates of the holding cost, setup cost, or order cost for each item can be stored in the database, from which order quantity recommendations can be calculated. The reorder level for each item can be stored in the database, but often only the lead-time and the desired service level are stored. The program can compute the reorder level on the basis of current estimates of the average use rate and a calculation standard deviation or MAD. This type of system maintains a large amount of data and performs numerous calculations to assist inventory managers. Of course, the system only makes recommendations, which can be overridden or implemented according to the decisions of the appropriate person.

Economic Order Quantity (EOQ) relevant cost determination

EOQ is the quantity of an inventory item to order so that total inventory costs are minimized over the firm's planning period. Information required to determine optimal order size are:

- The total unit to be used during a period
- The cost associate with placing an order, i.e., ordering cost per order
- The cost of holding one unit in inventory for the entire period, i.e., carrying cost per unit per period.

Criteria for determining ordering cost

The company in the purchasing of raw materials incurs ordering costs. Included in this cost are the processing and receiving costs incurred for the each purchase order. Key to recognizing ordering cost is to ask if level of this cost will change if we place two orders instead of one, i.e., whether total cost for a cost element will change if more than one order is placed. Such as,

- For making an order Mr. Kamal needs to make a long distant telephone call, which cost him Tk. 120. As more is the number of orders the more is the cost arising from the telephone calls, e.g., for two orders it is Tk. 240, for 3 orders it is Tk. 360. Hence this is an ordering cost.

- Again for example, let's assume that Mr. Khaleque has a quarterly demand for potatoes of 4500 kg for his grocery business and transportation cost is Tk. 25 per kg. Now if only one order is placed the transportation cost will be Tk. 112,500. But if Mr. Khaleque places two orders, then each time his cost will be Tk. 56,250 without changing the total cost. As the total cost remains the same irrespective of the number of orders this is not an example of ordering cost in this situation.

Criteria for determining carrying cost

Carrying costs are those costs for holding inventory. These costs generally include insurance, personal property tax, cost of storage space, breakage, obsolescence, and the rate of return on the investment in inventory forgone by the company. The carrying cost can be expressed as cost per unit per year or as a percentage of unit inventory value. Key to referring a cost element as carrying cost if the total cost for that element vary with respect to average number of units in inventory (again not those costs that vary with the total number of unit acquired). This time we have to ask whether total cost will change if we increase the average number of units residing on inventory over the period by one unit.

The carrying cost can be expressed as cost per unit per year or as a percentage of unit inventory value.

Therefore a cost for having inventory may or may not be included in the carrying cost depending on whether its total for the period depends on the average inventory level. This is why fixed cost should not be included in the decision process whether it is related to having inventory or not. As an example assume that rent for inventorying bags of potato may or may not be a carrying cost depending on whether total rent for the period depends on average level of inventory. Following table illustrates this with quarterly demand of 4500 bags.

Rent Payment Agreement	No. of orders	Average inventory	Rent payment for The quarter
1. Taka 25 for each bag kept in inventory	1	2250	4500x25=112500
	2	1125	2250x25+2250x25 =112500
2. Taka 25 for each unit in the average inventory	1	2250	2250x25=56250
	2	1125	1125x25 = 28125

Here under agreement 1 rent is not a carrying cost because the total rent payment for the period is same even if the average inventory level is changed. On the other hand under agreement 2, rent is a carrying cost as total payment of rent for the quarter is different for different level of average inventory. Hence we can conclude that all cost of holding inventory is not relevant for determining carrying cost. Only those costs of inventory that in total for the period varies with the average inventory/order size should be included under carrying cost.

Lesson Three: Just-In-Time Inventory System

Lesson Objectives

After completing this lesson you will be able to:

- Understand the Just-In-Time (JIT) inventory system
- Identify the different features and building blocks of JIT
- Explain the goal of JIT
- Analyze the advantages and disadvantages of JIT
- Discuss JIT in Bangladesh

What is Just-In-Time (JIT) inventory system

> *Harley-Davidson saw its commanding lead in heavyweight motorcycle falter when powerful Japanese bikes appeared in the U.S. market. If Harley was to stay on the road, the management had to uncover the key element of Japanese success. Initially they were baffled. Honda's motorcycle plant in Maryville, Ohio was staffed by US workers, just like Harley's. It bought parts from US suppliers, just as Harley did. And it had no clear technological advantages. After touring the plant in Maryville, they found what they were looking for. Honda turned out better motorcycles because of their Japanese production system, specifically -- the just in time inventory control system.*

JIT is a manufacturing system with the goal to optimize processes and procedures by continuously pursuing waste reduction

The term just-in –time is used to refer to a production system in which both the movements of goods during production and deliveries from suppliers are carefully timed so that at each of the process the next (usually small) batch arrives for processing just as the preceding batch is completed – thus the name," Just–in-Time". The result is a system with no idle items waiting to be processed. Although it has no single, agreed-upon definition, one definition that can be adopted for our discussion is: *Just - in - time (JIT) is a manufacturing system whose goal is to optimize processes and procedures by continuously pursuing waste reduction.*

> *"If American automobile king Henry Ford were alive today, I am positive he would have done what we did with our Toyota production system."*
>
> *- Taiichi Ohno*
> *The Toyota Production System (1978)*

The quotation above is the confidant word from the man behind the concept itself. The JIT approach was developed and generated at the Toyota Motor Company of Japan by Taiichi Ohno and several of his colleagues. They have introduced a system, which concentrates on avoiding end-item and intermediate-item storage. The benefits were Toyota's no necessity of people to control inventories, space for inventory, or borrowed money to finance inventory. Besides it gives the Toyota officials to take a very little time (only three minutes) to change the mold. It also allows Toyota to realign its workforce more efficiently when business is bad because company can train workers to do more

than one job. In the United States, JIT was first adopted by the automobile industry. Leading firms in other industries – Xerox, IBM, Apple, Black & Decker, and General Electric, has picked up the concept to name just a few.

Features of JIT

JIT manufacturing is a broad philosophy of continuous improvement, which indicates three major categories of effort that are mutually supportive:

a. Low Inventory
b. People Involvement
c. Total Quality Control

a. **Low inventory:** 'Inventory is regarded as evil' according to JIT philosophy. Its main purpose is to minimize the amount of idle resources. That is why this effort is sometimes called zero inventory program of stockless production.

b. **People involvement:** JIT has a strong management component. Much of the success of JIT can be traced to the fact that the companies that use it train the employees to have the appropriate skills, give them responsibility and coordinate and motivate them. JIT philosophy of continuous improvement and minimization of waste considers any activity that does not add value to the product or serve the customers in some way to be waste. One form of waste that is inconspicuous and difficult to combat is the under utilization of human talent. JIT seeks to utilize more fully the creative talents of the employees, suppliers, contractors, and others who may contribute to the company's improvement. JIT is a philosophy that cuts across all phases of the manufacturing and marketing activities in an organization. It is a strategy marked by an environment of cooperation and coordination between buyers and sellers. Short-term relationships are replaced by long-term commitments.

JIT is a philosophy that cuts across all phases of the manufacturing and marketing activities in an organization.

c. **Total quality control:** JIT interprets the term Total Quality Control as the achievement of zero defect products that involves every department and every employee of the company. According to the philosophy, quality should be ensured at the source, that is quality should be assured for every set of activities at the beginning level – automatically the output of the corresponding activities will be improved quality.

Activity: How the JIT can help you to perform better with your MBA program of Bangladesh Open University (BOU)?

Building Blocks of JIT

The design and operation of JIT (Figure 12.3.1) system provide the foundation for accomplishing the aforesaid goal. The foundation is made up of four building blocks. These blocks are:

a. **Product design :** In product design, three elements are key to the JIT system – standard parts, modular design and quality. The first two elements relate to speed and simplicity. Quality is the sine qua non ("Without which not") of JIT because poor quality can create major disruptions as the JIT is designed to gear up a smooth flow of work; the appearance of problems due to quality creates disruption in this flow.

b. **Process design:** Some aspects of process design are important for JIT system: small lot sizes, set up time reduction, manufacturing cells, limited work in process, quality improvement, production flexibility and little inventory storage.

c. **Personnel / organizational elements:** There are five elements of personnel and organization that are particularly important for JIT system: workers are assets, cross-trained workers, continuous improvement, cost accounting and leadership / project management.

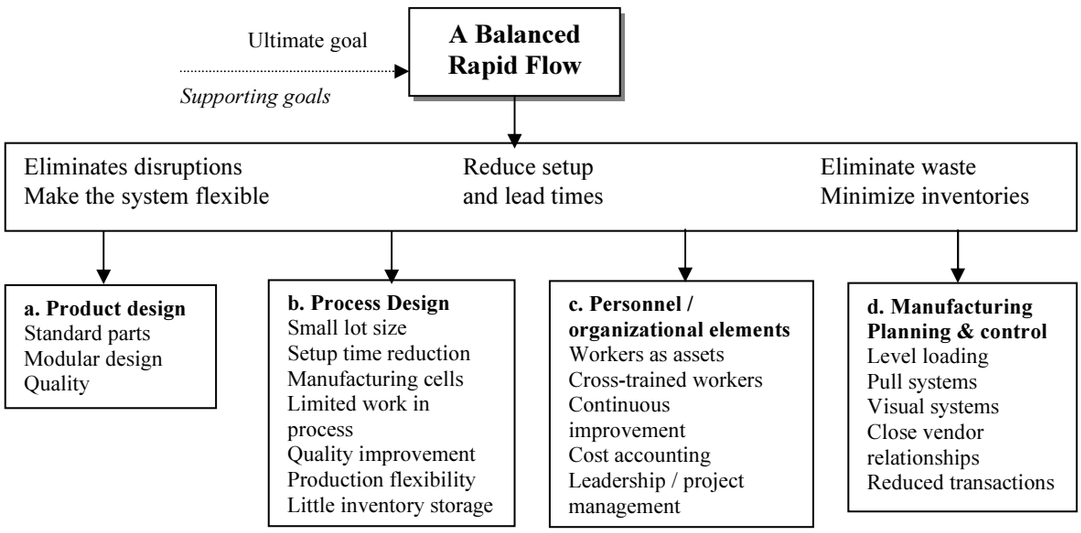


Figure 12.3.1: Building blocks of JIT

d. **Manufacturing planning and control:** Under this, five elements are considered vital: level - loading, pull systems, visual record systems (Kanban system), close vendor relationships and reduced transaction processing.

The JIT Goal

A major objective of JIT is to have only the right item at the right place at the right time.

A major objective of JIT is to have only the right item at the right place at the right time, or to say it another way, to purchase and produce items only a short time before they are needed so that work-in-process inventory is kept very low. The practice not only reduces working capital requirements, it also reduces the need for floor space and shortens the flow through time because materials spend very little time in queues. The ultimate goal of JIT is a balanced system that is, one that achieves smooth, rapid flow of materials through the system. The goals are:

- Eliminate disruptions
- Make the system flexible
- Reduce setup times and lead times
- Minimize inventory investment
- Eliminate waste associated with queues
- React faster to demand changes
- Uncover any quality problem

Disruptions are occurred by a variety of factors, such as poor quality, equipment breakdowns, changes to the schedule, and late deliveries. These should be

eliminated as much as possible. A *Flexible System* is one, which is robust enough to handle a mix of products, often on a daily basis, and to changes in the level of output while still maintaining balance and throughout speed. *Setup Time And Deliveries Lead Times* prolong a process adding a value to the product. The continuous process of JIT reduces the disrupting setup times and the lead times, as next batch of production is ready exactly when the preceding batch is completed. *Inventory (idle resources)* takes up space and adds cost to the system, which should be minimized. JIT can minimize the inventory a lot. As the requirements and the deliveries coincide, so no need of storing for the future requirements. *Waste* represents an unproductive resource. In the JIT philosophy, waste includes: over production, waiting line, unnecessary transporting, inventory scrap, inefficient work.

The Seven Wastes

Shigeo Shingo, a recognized JIT authority and engineer at the Toyota motor Company identifies wastes (Table 1) as being the targets of continuous improvement in production processes. By attending to these wastes, improvement is achieved.

Table 12.3.1: The Seven Wastes

Waste of production	Eliminate by reducing set up times, synchronizing quantities and timing between processes, compacting layout, visibility, and so forth. Make only what is needed now.
Waste of waiting	Eliminate through synchronizing workflow as much as possible, and balance uneven loads by flexible workers and equipment.
Waste of transportation	Establish layouts and locations to make transport and handling unnecessary if possible. Then rationalize transport and material handling that cannot be eliminated.
Waste of processing itself	First question why this part or product should be made at all, then why each process is necessary. Extend thinking between economy of scale or speed.
Waste of Stocks	Reduce by shortening setup times and lead times, by synchronizing work flows and improving work skills, and even by smoothing fluctuations in demand for the product. Reducing all the other wastes reduce the waste of stocks.
Waste of Motion	Study motion for economy consistency. Economy improves productivity, and consistency improves quality. First improve the motions, then mechanize or automate. Otherwise there is danger of automating waste.
Waste of making defective products	Develop the production process to prevent defects from being made so as to eliminate inspection. At each process, accept no defect and make no defect. Make processes failsafe to do this. From a quality process comes a quality product – automatically.

Benefits of JIT System

JIT system has a number of overwhelming benefits that are attracting the attention of traditional companies. The main benefits are:

JIT reduce process time and increase product quality & skill of the workers.

- Reduced levels of in-process inventories purchased goods and finished goods.
- Reduced space requirements.
- Increased product quality and reduced scrap and rework.

- Reduced manufactures lead times.
- Greater flexibility in changing the production mix.
- Smoother productivity flow with fewer disruptions caused by problems due to quality, shorter setup times, and multi-skilled workers who can help each other and substitute for others.
- Increased productivity levels and utilization of equipment.
- Worker participation levels and utilization of equipment.
- Worker participation in problem solving.
- Pressure to build good relationships with vendors.
- Reduction in the need for certain indirect labor, such as material handlers.

JIT: A success story

There are numerous success stories of JIT. A review of successful implementation in five US companies showed an average lead-time reduction of 90%. Inventory was reduced by 35 to 73%. Purchase cost was reduced by 6 to 11%. A few of the more specific examples are enumerated follows.

A Harley Davidson Case

Harley-Davidson, an eighty year old US motorcycle manufacturer, suffered such strategic losses in 1981 and 1982 that the future of the company was seriously in question. Some of the external problems were Honda, Suzuki, Kawasaki, and Yamaha – four Japanese competitors that had taken most of the market. Harley – Davidson's major internal problem was an over-priced product that received numerous customer complaints about quality – a result of what seemed to be a long series of quick fixes to help the company get along. Between 1982 and 1986, the firm made significant improvements. Inventory turnovers increased from less than seven to about twenty a year. Productivity per employee rose about 50 %. Rework costs were reduced by 80% and warranty costs down by 46 %. The motorcycle part of the company has been profitable since 1983. The reason for this dramatic turnaround is a company wide effort based on the JIT manufacturing philosophy.

Chrysler Case

For Chrysler, a car manufacturing company, which has 70 percent of its parts, made by outside suppliers, JIT is obviously quite critical. Chrysler achieved a 9 % reduction in inventory and an increase in average quarterly inventory turnover from 6.38 times to 13.9 times. A single corporation wide network connects Chrysler's large and mid-sized computers from various vendors and gives engineering workstations access to the large computers. This makes it easier to transfer data from one system, stage of production, or plant to another and facilitates just-in-time inventory management.

Activity: How the JIT can help the Bangladeshi manufacturing firm to do a better competition within the global environment? Explain your arguments with taking example from your chosen industry.

St. Luke's Hospital

Organizations that use JIT report enormous return on investment. St. Luke's Episcopal Hospital in Houston saved $1.5 million over three years when it closed its enormous supplies warehouse and set up "stockless distribution". Rather than

storing and handling thousands of items, the hospital receives daily deliveries from Baxter International (the nation's largest hospital supplier), whose computers communicate directly with St. Luke's inventory management system. Each day, Baxter pulls together the materials needed and delivers them directly to each area inside the hospital.

Drawbacks of JIT System

A recently published report in Business Week by Brian Milligan has stated:

> *"…… Those who believe in the (JIT) system say it eliminate wastes and frees up much needed space that was once used to house large chunks of inventory. But the system obviously has some bugs in it, and purchasing managers say they need to be worked out. This is evident from the survey, which reported that 47% of participants say … they are having efficiency problems.*
>
> *……and partial success can be very troublesome. The 47% who report JIT-related efficiency problems say these problems can quickly become big problems when assembly lines are forced to shut down.*
>
> *Some purchasing managers say they have run into problems with getting suppliers to keep the needed stock ready to be delivered. In fact, 33% of the survey participants say missed supply deadlines are a problem. Twenty one percent of those surveyed say supply quality is a problem. And 33% say supplier commitment is an area that needs to be improved."*

JIT is not free from defects. The potential shortcomings of the system are as follows

JIT may increase worker idle time & decrease the production rate.

- JIT may result in increased worker idle time.
- May decrease the production rate.
- Slow to react to changes in demand.
- It ignores known information about future demand patterns.
- Decrease opportunity for multiple sourcing.
- Suppliers must react more quickly.
- Improved reliability required of suppliers.

Activity: Ask your study partners to do a debate with you regarding the advantages and disadvantages of JIT. After that make new list of advantages and disadvantages of JIT and compare with the old one.

The Instances of Failure

JIT makes manufacturers more vulnerable to work stoppages at suppliers' plants and to delivery disruptions. During the 199 Ontario truckers' dispute, traffic tie-ups at the Canada-United States border caused big losses to manufacturers and showed them the importance of keeping their supply routes open. JIT poses even bigger problems in international situations where supply channels are much longer.

General Motor Incident
In 1996, a 17-day strike by 3000 union employees at two of General Motor's Dayton, Ohio brake plants made it drop the production of 250,000 vehicles. The resultant loss amounted to hundreds of millions of dollars and caused GM to lay off 175,000 of its employees.

Comparison of JIT and Traditional Approach

Factors	JIT	Traditional Approach
Inventory	A liability. Every effort must be expended to do away with it.	An Asset. It protects against forecast errors, machine problems, and late vendor deliveries.
Lot Size	Immediate needs only. A minimum replenishment quantity is desired for both manufactured and purchased parts.	Formulas.
Setups	Make them insignificant. This requires either extremely rapid change over to minimize the impact on production or the availability of extra machines.	Low priority issue. Maximum output is the usual goal.
Queues	Eliminate them. When problem occur, identify the causes and correct them.	Necessary investment. Queues permit following operations to continue in the event of a problem with feeding operation.
Vendors	Co-workers. Multiple deliveries for all active items are expected daily. The vendor takes care of the needs of the customer, and the customer treats the vendor as an extension of the factory.	Adversaries. Multiple source are the rule, and it's typical to play them off against each other.
Quality	Zero effects. If quality is not 100 %, production is in jeopardy.	Tolerate some scram.
Equipment Maintenance	Constant. Machine breakdowns must be minimal. As required. Not critical because of queues.	It is not given that much importance.
Lead Times	Keep them short. This simplifies the job of marketing, purchasing, and manufacturing, as it reduces the need for expanding.	The longer the better. Most foreman and purchasing agents want more lead-time not less.

Plan for JIT Adoption
For successful conversion and adoption, companies should adopt a carefully planned approach that includes the following elements:

- Top management must be sure about the commitment to the conversion and necessary requirements.
- Management must be sure about this involvement in the process and must be known to its cost, duration to complete the conversion and expected results.
- They should study their operations critically and decide the most critical parts.
- They should have the support and cooperation of the workers.
- Arrange necessary training programs to make JIT a success.

- The workers must be fully aware of why JIT is desirable and also about their job security.
- Once it is started, management should try to maintain the current system.
- They should identify and solve existing problems; find out and enlist potential workers.

JIT in Bangladesh

The development of the JIT system in Japan was mainly due to the scarcity of resources. The same situation prevails in Bangladesh as we have very limited natural resources, but comparatively greater human resources. Therefore, JIT could be a very effective system for a poor country like ours. But there are some constraints in this regard. These might be,

- The most important problem in implementing JIT in Bangladesh is the socio-cultural status. The people are not accustomed to such culture of being in time, which is a hindrance to JIT system. More over, the existence of uncertain variables in Bangladesh is many (i.e. hartals, traffic jams). So accomplishing tasks in time is not at all expectable.
- Raw materials from agricultural and seasonal products are not suitable for steady production in small lots.
- The infrastructure of Bangladesh is not developed enough to distribute or collect goods or raw materials in time according to their needs.
- To apply JIT, it requires strong discipline, reliable operating conditions, and support of the influential persons. The communication system is also not of higher technological. So, the necessary materials, equipment and others cannot arrive at the destination quite timely. The practice of getting compensation because of the supplier's delay is also not possible in Bangladesh.
- JIT becomes a failure story where a co-operative spirit between management and workers is absent or little, which is frequent in our industries.
- Buyers may not be willing to commit the resources necessary to help the suppliers adopt the JIT system. They may be uneasy about long term commitments to a seller.
- Suppliers may not be frequent in small deliveries because it will be difficult if they have other traditional buyers.
- The parties involved in this system need engineering and technological changes resulting from continuing JIT improvements required by the buyer as well as the suppliers.

People of Bangladesh are not accustomed to the culture of JIT, which is a constraint to the system.

Activity: Within the present global competitive market do you think Bangladesh as a developing economy needs to consider JIT seriously? Why or why not? Justify with good logic.

As Bangladesh passes through the above constraints, the rate of failure in applying JIT is high here. Despite some of the fertilizer companies use JIT to some extent, for example, they use natural gas from pipeline and use it only at times of production, switching it off after use. In the same manner, we can hope to see the implementation of JIT in other industries in the near future.