**CHAPTER SIX–OTHER MAJOR CONCEPTS**

6.1 Inventory Management

6.2 Supply Chain Management

6.3 Systems in Operations Management

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## INVENTORY MANAGEMENT

The objective of inventory management has been to keep enough inventory to meet customer demand and also be cost effective. However, inventory has not always been perceived as an area to control cost. Traditionally, companies maintained “generous” inventory levels to meet long-term customer demand because there were fewer competitors and products in a generally sheltered market environment. In the current global business environment, with more competitors and highly diverse markets in which new products and new product features are rapidly and continually introduced, the cost of inventory has increased due in part to quicker product obsolescence. At the same time, companies are continuously seeking to lower costs so they can provide a better product at a “lower” price.

### The elements of inventory management

Inventory is a stock of items kept by an organization to meet internal or external customer demand. Virtually every type of organization maintains some form of inventory. Department stores and grocery stores carry inventories of all the retail products they sell; a nursery has inventories of different plants, trees, and flowers; a rental-car agency has inventories of cars; and a major league baseball team maintains an inventory of players on its minor league teams. Even a family household maintains inventories of items such as food, clothing, medical supplies, and personal hygiene products. Most people think of inventory as a final product waiting to be sold to a retail customer—a new car or a can of tomatoes. This is certainly one of its most important uses. However, especially in a manufacturing firm, inventory can take on forms besides finished goods, including:

* Raw materials
* Purchased parts and supplies
* Partially complete work in progress (WIP)
* Items being transported
* Tools, and equipment

Most organizations adopt one among the two most popular inventory classification systems in managing and organizing their inventory at warehouses. These inventory classification systems are – VED analysis and ABC analysis.

When an organization uses VED analysis for inventory classification, the primary objective is to classify inventory items into three categories based on the importance of each item in the operations process. The first category termed as *vital*, includes all vital and unavoidable items of the operations process which are to be stocked in inventory. Without these items the operations would not take place. The second category termed as *essential*, are also very much important to the operations. However, they are not that critical like the items in vital category. And the third category, desired, are those items which are desired but not important for the operations.

On the other hand, ABC analysis too classifies inventory items into three categories – A, B, and C. Nevertheless, this classification is based on monetary valuation of materials rather than the importance of the items. A category counts the most valuable while B moderate and C least valuable to the operations.

## Inventory costs

The purpose of inventory management is to determine the amount of inventory to keep in stock— how much to order and when to replenish, or order. In this chapter we describe several different inventory systems and techniques for making these determinations.

Three basic costs are associated with inventory: carrying, or holding, costs; ordering costs; and shortage costs.

Carrying costs are the costs of holding items in inventory. Annual inventory carrying costs in the United States are estimated to be over $300 billion. These costs vary with the level of inventory in stock and occasionally with the length of time an item is held. That is, the greater the level of inventory over a period of time, the higher the carrying costs. In general, any cost that grows linearly with the number of units in stock is a carrying cost. Carrying costs can include materials handling expenses, labor, rent, depreciation, power, record keeping, etc.

Ordering costs are the costs associated with replenishing the stock of inventory being held. These are normally expressed as a dollar amount per order and are independent of the order size. Annual ordering costs vary with the number of orders made—as the number of orders increases, the ordering cost increases. In general, any cost that increases linearly with the number of orders is an ordering cost. Costs incurred each time an order is made can include requisition and purchase orders, transportation and shipping, receiving, inspection, handling, and accounting and auditing costs.

Ordering costs react inversely to carrying costs. As the size of orders increases, fewer orders are required, reducing ordering costs. However, ordering larger amounts results in higher inventory levels and higher carrying costs. In general, as the order size increases, ordering costs decrease and carrying costs increase.

Shortage costs, also referred to as stockout costs, occur when customer demand cannot be met because of insufficient inventory. If these shortages result in a permanent loss of sales, shortage costs include the loss of profits. Shortages can also cause customer dissatisfaction and a loss of goodwill that can result in a permanent loss of customers and future sales. Some studies have shown that approximately 8% of shoppers will not find the product they want to purchase in stock, which will ultimately result in total lost sales of about 3%.

In some instances, the inability to meet customer demand or lateness in meeting demand results in penalties in the form of price discounts or rebates. When demand is internal, a shortage can cause work stoppages in the production process and create delays, resulting in downtime costs and the cost of lost production (including indirect and direct production costs).

Costs resulting from lost sales because demand cannot be met are more difficult to determine than carrying or ordering costs. Therefore, shortage costs are frequently subjective estimates and sometimes an educated guess.

### Inventory Control Systems

An inventory system controls the level of inventory by determining how much to order (the level of replenishment) and when to order. There are two basic types of inventory systems: a continuous (or fixed-order-quantity) system and a periodic (or fixed-time-period) system. In a continuous system, an order is placed for the same constant amount whenever the inventory on hand decreases to a certain level, whereas in a periodic system, an order is placed for a variable amount after specific regular intervals.

### 1. The Basic Economic Order Quantity Model

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. We will describe two model versions: the basic EOQ model and the production quantity model.

The basic EOQ model is a 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:

* Demand is known with certainty and is constant over time.
* No shortages are allowed.
* Lead time for the receipt of orders is constant.
* The order quantity is received all at once.

Hence, the Economic Ordering Quantity (EOQ) or Optimal order quantity (Qopt) can be computed as below:

|  |  |
| --- | --- |
|  | Qopt – Economic Ordering QuantityC0 – Ordering costCc – Carrying costD - Demand |

### 2. Reorder Point and Safety Stock

In our description of the EOQ model in the previous section, we addressed how much should be ordered. Now we will discuss the other aspect of inventory management, when to order. The determinant of when to order in a continuous inventory system is the reorder point, the inventory level at which a new order is placed.

The reorder point or reorder level for our basic EOQ model with constant demand and a constant lead time to receive an order is equal to the amount demanded during the lead time,

RL = dL

Where, **RL** is reorder level, **d** is daily demand and **L** is lead time in days.

In some cases, organizations would like to keep a buffer stock which is acting as a cushion in the events of contingencies. It implicate that the organization is not intended to reach zero stock at any time of an order cycle. If there is a specified safety stock, RL = dL + ss, where ss is safety stock.

## 3. Lean Production

Lean production means doing more with less—less inventory, fewer workers, less space. The term was coined by *James Womack and Daniel Jones* to describe the Toyota Production System, widely recognized as the most efficient manufacturing system in the world.

### The basic elements of Lean Production



### Smooth the Flow

### KANBANS

Kanban is the Japanese word for card. In the pull system, each kanban corresponds to a standard quantity of production or size of container. A kanban contains basic information such as part number, brief description, type of container, unit load (i.e., quantity per container), preceding station (where it came from), and subsequent station (where it goes to). Sometimes the kanban is color coded to indicate raw materials or other stages of manufacturing. The information on the kanban does not change during production. The same kanban can rotate back and forth between preceding and subsequent workstations.***Kanban is a card that corresponds to astandard quantity of production(usually a container size).***

### Small Lots

Small-lot production requires less space and capital investment than systems that incur large inventories. By producing small amounts at a time, processes can be physically moved closer together and transportation between stations can be simplified. In small-lot production, quality problems are easier to detect and workers show less tendency to let poor quality pass (as they might in a system that is producing huge amounts of an item anyway). Lower inventory levels make processes more dependent on each other. This is beneficial because it reveals errors and bottlenecks more quickly and gives workers an opportunity to solve them.

### Uniform production levels

The flow of production created by the pull system, kanbans, small lots, and quick setups can only be maintained if production is relatively steady. Lean production systems attempt to maintain uniform production levels by smoothing the production requirements on the final assembly line. Changes in final assembly often have dramatic effects on component production upstream. When this happens in a kanban system, kanbans for certain parts will circulate very quickly at some times and very slowly at others. Adjustments of plus or minus 10% in monthly demand can be absorbed by the kanban system, but wider demand fluctuations cannot be handled without substantially increasing inventory levels or scheduling large amounts of overtime.

### Continuous Improvement:

### Quality at the source

For lean systems to work well, quality has to be extremely high. There is no extra inventory to buffer against defective units. Producing poor-quality items and then having to rework or reject them is a waste that should be eliminated. Producing in smaller lots encourages better quality. Workers can observe quality problems more easily; when problems are detected, they can be traced to their source and remedied without reworking too many units. Also, by inspecting the first and the last unit in a small batch or by having a worker make a part and then use the part, virtually 100% inspection can be achieved.

### Visual control

Quality improves when problems are made visible and workers have clear expectations of performance. Production systems designed with quality in mind include visible instructions for worker or machine action, and direct feedback on the results of that action. This is known as visual control. Examples include kanbans, standard operation sheets, andons, process control charts, and tool boards. A factory with visual control will look different from other factories. You may find machines or stockpoints in each section painted different colors, material-handling routes marked clearly on the floor, demonstration stands and instructional photographs placed near machines, graphs of quality or performance data displayed at each workstation, and explanations and pictures of recent improvement efforts posted by work teams.

Visual control of quality often leads to what the Japanese call a poka-yoke. A poka-yoke is any foolproof device or mechanism that prevents defects from occurring. For example, a dial on which desired ranges are marked in different colors is an example of visual control. A dial that shuts off a machine whenever the instrument needle falls above or below the desired range is a poka-yoke. Machines set to stop after a certain amount of production are poka-yokes, as are sensors that prevent the addition of too many items into a package or the misalignment of components for an assembly.

### KAIZEN

Quality in lean systems is based on kaizen, the Japanese term for “change for the good of all” or continuous improvement. As a practical management system based on trial-and-error experiences in eliminating waste and simplifying operations, lean was created and is sustained through kaizen. Continuous improvement is not something that can be delegated to a department or a staff of experts. It is a monumental undertaking that requires the participation of every employee at every level. The essence of lean success is the willingness of workers to spot quality problems, halt operations when necessary, generate ideas for improvement, analyze processes, perform different functions, and adjust their working routines.

### JIDOKA

It was the idea that workers could identify quality problems at their source, solve them, and never pass on a defective item that led Ohno to believe in zero defects. To that end, Ohno was determined that the workers, not inspectors, should be responsible for product quality. To go along with this responsibility, he also gave workers the unprecedented authority of jidoka—the authority to stop the production line if quality problems were encountered.

To encourage jidoka, each worker is given access to a switch that can be used to activate call lights or to halt production. The call lights, called andons, flash above the workstation and at several andon boards throughout the plant. Green lights indicate normal operation, yellow lights show a call for help, and red lights indicate a line stoppage. Supervisors, maintenance personnel, and engineers are summoned to troubled workstations quickly by flashing lights on the andon board. At Toyota, the assembly line is stopped for an average of 20 minutes a day because of jidoka. Each jidoka drill is recorded on easels kept at the work area. A block of time is reserved at the end of the day for workers to go over the list and work on solving the problems raised. For example, an eight hour day might consist of seven hours of production and one hour of problem solving.

This concept of allocating extra time to a schedule for nonproductive tasks is called undercapacity scheduling. Another example of undercapacity scheduling is producing for two shifts each day and reserving the third shift for preventive maintenance activities. Making time to plan, train, solve problems, and maintain the work environment is an important part of lean’s success.

### Total productive maintenance

Machines cannot operate continuously without some attention. Maintenance activities can be performed when a machine breaks down to restore the machine to its original operating condition, or at different times during regular operation of the machine in an attempt to prevent a breakdown from occurring. The first type of activity is referred to as breakdown maintenance; the second is called preventive maintenance.

Total productive maintenance (TPM) combines the practice of preventive maintenance with the concepts of total quality—employee involvement, decisions based on data, zero defects, and a strategic focus. Machine operators maintain their own machines with daily care, periodic inspections, and preventive repair activities. They compile and interpret maintenance and operating data on their machines, identifying signs of deterioration prior to failure.6 They also scrupulously clean equipment, tools, and workspaces to make unusual occurrences more noticeable. Oil spots on a clean floor may indicate a machine problem, whereas oil spots on a dirty floor would go unnoticed. In Japan this is known as the 5 S’s—seiri, seiton, seiso, seiketsu, and shisuke—roughly translated as sort, set, shine, standardize, and sustain.

