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Research Article

Evaluation of Multilevel Inventory System for Moderating Cost Value - A Case Study

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Abstract

The purpose of this paper is to investigate how a model for controlling a multi-level inventory system can be used to calculate the optimize inventory value of a steel strip in a steel plant. Furthermore, the paper will, by simulation in every inventory method so could be reduced if a coordinated inventory control method is implemented, instead of the uncoordinated control system used today. In this study, the goods flow chosen is the simplest possible multi-level case.

Keywords: *Inventory control, EOQ, MRP, POQ, LTC*

1. Introduction

Inventory control means, making the desired items of required quality and in required quantity, available to various departments when needed. But it requires optimization of inventory. Too much inventory creates a problem of their storage, huge investment and the maintenance of stored items. But low inventory leads to chances of stoppage of production, increases the overheads and disturb the production programs. So, inventory must be properly controlled so that right item is available in right quantity, of right quality and that too with economy. Modern Industrialization has in its wake highlighted a number of management problems, an important one of which is cost reduction and cost control. Since the cost of material accounts for nearly more than 50% of the total cost in production and construction industries, materials are produced and stocked in the shape of inventories. It is, basically, necessary to hold inventories such as a raw material, work-in-progress, spares and equipments, finished goods to act as a cushion between supply and demand, both of which will normally fluctuate to facilitate steady and efficient plant operation and enable the firm to meet orders promptly and to keep the production cycles going smooth with least interruption. The Inventory management in its broadest perspective is to keep the most economical amount of one kind of asset in order to facilitate an increase in the total value of all assets of the organization.

L.V. Fine (Industrial Purchasing) gives the most outstanding idea about the inventory control: Inventory control may be defined as the planning, ordering and scheduling of material used in the manufacturing process. It is impossible to exercise control over the three types inventories recognized by accountant as raw materials, work in progress and finished good. Inventory systems have received extensive attention since the first half of the twentieth century. Effective management of inventory using operations Research tools has been a major concern both in the literature and the industry. Basic, yet crucial questions such as when to replenish and how much to replenish have been the focus of inventory management. Since inventory costs constitute a significant portion of the costs a firms faces, the objective of inventory management has been ensuring a high level of customer service by holding the minimum possible amount of inventory. Although the depth of the focus of inventory management has extended from single locations to multiple locations (multi-echelon theory) and from a single product to customized products (product differentiation), in most cases demand from multiple sources is handled in a uniform way. However, just as different customers may require different product specifications, they may also require different service levels. Particularly, for a single product, different customers may have different stockout costs and/or different minimum service level requirements or different customers may simply be of different importance to the supplier by similar measures.

The computer is used to calculate, share and provide this information. This method of inventory management is called Material Requirement Planning (MRP) The MRP system is a practical inventory control method development around 1960 to handle large amount of record keeping, material requirement data, inventory status of material and their cost, interlinking the production with procurement of materials,

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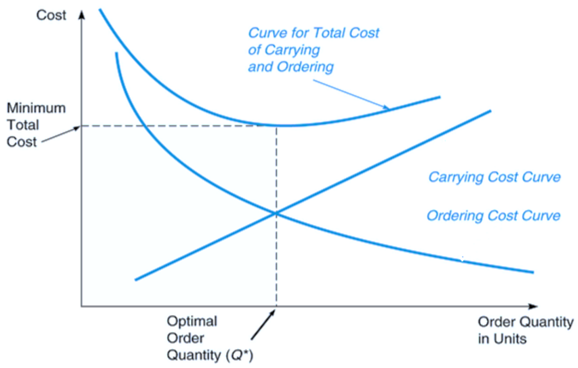
controlling the stock and deliveries. It controls the manufacturing resources and flow of material much more efficiently and accurately. In MRP system lot sizing is required for fulfilling end product demand which is independent. The demand for subassemblies, component parts and raw material stock is derived from planned production level of end products and is dependent on end item demand. Such a multilevel production/inventory situation involves production and procurement of various materials as per bill of material of various final products according to master production schedule. The level 0 represents the end product and its demand is fixed by customer order and forecasted as per market needs. The single level lot sizing technique would be applied to level-1 .The level 0 is fixed and level 1 is controlled by some lot sizing rule. The multilevel lot sizing problem is to determine the production of lower level.

2. Literature Review

Wang, Cohen *et al*, (2002) first study a single location system and derive expressions for the inventory level distribution and random customer delay. As a result, an expected yet crucial observation is made: the service level of customers with positive demand lead times is higher than service level for customers with zero demand lead time as long as there is a positive probability that the replenishment order corresponding to a customer with positive demand lead time arrives before its demand due date is made. After deriving the steady state performance metrics for the single location system, the model is extended to a two echelon system. By following an approach similar to the well-known METRIC, the multi-echelon network is decomposed into single location subsystems. After the analysis of the two-echelon setting, an optimization study is conducted to see the effects of the introduction of a non-emergency service class. As a result it is seen that the system with two service classes results in significant cost savings in terms of inventory as a result of the non-zero demand lead-time. The objective of the model is to minimize total cost, assuming continuous review, a known, constant demand, and a known, constant lead time. As shown in Figure, the minimum cost is incurred when the cost of holding stock is balanced with the cost of ordering stock. The EOQ is given by Q= $\sqrt{(2D.C_o/C_h)}$, where D is the fixed ordering cost, C0 is the average annual demand, and Ch is the holding cost per unit per year. The reorder point is given by the demand per period multiplied by the lead time (in number of periods).

In the system we consider, the customers with positive demand lead times constitute the non-critical demand class, while the customers with zero demand lead times constitute the critical demand class. Therefore, it is imperative that we use a policy that could provide a higher service level to the demand class with zero demand lead times. Rationing is such a policy. In the standard policy, whenever on-hand inventories drop below a certain level - usually called critical level, rationing level or threshold level of the associated customer class- the demands of the lower priority classes are not satisfied with the expectation of future high priority class customer demands.



The literature about rationing begins with Veinott who was the first to consider the problem of several demand classes in inventory systems. He analyzed a periodic review inventory model with n demand classes and zero lead-time with limited ordering, and introduced the notion of a critical level policy.

Topkis *et al*, (1968) proved the optimality of this policy both for the case of backordering and for the case of lost sales. The problem was analyzed by breaking down the period until the next ordering opportunity into a finite number of subintervals. In any given interval the optimal rationing policy is such that demand from a given class is satisfied from existing stock as long as there remains no unsatisfied demand from a higher class and the stock level does not drop below a certain critical level for that class. The critical levels are generally decreasing with the remaining time until the next ordering opportunity.

Hariharan *et al*, (1995) then coined the name demand lead-time to describe inventory distribution systems where customers do not require immediate delivery of orders and allow for a fixed delay. The key observation of both papers is that a demand lead-time works just as the opposite of supply lead-time reducing the inventory required for achieving a required service level. Obviously this fact also applies to the system we consider but the existence of the two service classes makes the system more complex requiring a different analysis.

Frank *et.al*, 2005 considered a periodic review inventory system with two priority demand classes, one deterministic and the other stochastic. The deterministic demand must be supplied immediately while stochastic demand not satisfied is lost. Thus at each decision epoch, one has to decide how much demand to fill from the stochastic source along with the usual replenishment decisions. They first characterize the optimal policy and show that it has a complex state dependent structure. Therefore they proposed a simpler policy, called (s; k; S) policy, k being the static critical level determining how much stochastic demand to satisfy, and provided a numerical study which shows that this simpler policy works very well.

Zhang *et al*, (1997) presents a discrete time multi-item inventory system where end items are assembled from different sets of components. The author assumes that component inventories are maintained using periodic-review order-up-to policies and the demand for the different types of end-items occurs according to a multivariate normal distribution. Manufacturing inventories consist of raw material and finished components, subassemblies and finished component in stock and in process. In order to establish these manufacturing inventories providing accurate information about the requirement of material, time at which it is required, quantity of material on hand i.e. inventory and work in process and quantity of requirement to be ordered of manufacturing. The computer is used to calculate, share and provide this information. This method of inventory management is called material requirement planning (MRP)

3. Objectives of Inventory Control

- Protection against fluctuations in demand.
- Better use of Men, machine & material.
- Protection against fluctuation in output.
- Better service to customer.
- Control of stock volume.
- Control of stock distribution.

4. Material Requirement Planning (MRP)

MRP system is a practical inventory control method development around 1960 to handle large amount of record keeping, material requirement data, inventory status of material and their cost, interlinking the production with procurement of materials, controlling the stock and deliveries. It controls the manufacturing resources and flow of material much more efficiently and accurately. In MRP system lot sizing is required for fulfilling end product demand which is independent. The demand for subassemblies, component parts and raw material stock is derived from planned production level of end products and is dependent on end item demand. Such a multilevel production/inventory situation involves production and procurement of various materials as per bill of material of various final products according to master production schedule. The level O represents the end product and its demand is fixed by customer order and forecasted as per market needs. The single level lot sizing technique would be applied to level-1 .The level O is fixed and level 1 is controlled by some lot sizing rule. The multilevel lot sizing problem is to determine the production of lower level items (level 2, 3 etc.) economically.

5. MRP Procedure

MRP computations are carried out in the following steps.

Step 1 Explosion: The end product products are exploded into their components and the gross requirement of component worked out. It starts with the time when the product is required and proceeds backwards. It uses the information from the MPS and the bill of materials to generate the sequence followed to produce the end product.

Step 2 Netting: The gross requirement are now converted to net requirement based on the quantities on hand or quantities on order expected to be delivered during the period being considered.

Step 3 Offsetting: The system next determines when orders must be released either to procure the materials or to manufacture it in house. This is based on the lead times required for each item.

Step 4 Consolidation: The next step is to consolidate the requirement of a particular item for all the end product in which it is used.

6. Model formulation

If there is no interaction between the different items, and if we are not calculating the economic order quantity jointly (in terms of rupees) for the multiple items as one group, then it is difficult to fulfill the inventory requirement as desired by system. The model formulation is quite general, allowing organization to handle a variety of multi item decision, such as determining order quantities. In production environment, there may be limited workspace for manufacturing different product families. EOQs for the individual items will be calculated by the usual EOQ formula.

$EOQ = \sqrt{2\, C_o .\, A / C_c}$

Ordering cost = C_o

Carrying cost = C_c

Annual requirement = A

Table 1 The net requirements for a steel strips coil from an MRP schedule are

Month	1	2	3	4	5	6	7	8
Demand	100	120	140	120	160	180	120	160

Cost per unit is Rs. 20.00

Set up cost is Rs. 100.00

Carrying cost in 0.05 per unit per month

Figure 1 Inventory of steel strip coil in a steel plant

Determine the Most Economical Method for Inventory Control of steel strips coil.

Lot for Lot:

In this method only the quantity required is ordered or produced. No inventories are formed. The method does not take up set up costs into account.

Month	Demand	Quantity ordered	Set up cost	Inventory carrying cost	Total cost
1	100	100	100	0	100
2	120	120	100	0	100
3	140	140	100	0	100
4	120	120	100	0	100
5	160	160	100	0	100
6	180	180	100	0	100
7	120	120	100	0	100
8	160	160	100	0	100
				TOTAL	800

The Total cost will be Rs. 800.00

Economic Order Quantity

Economic order quantity (EOQ) is that size of the order which gives maximum economy in purchasing any material and ultimately contributes towards maintaining the materials at the optimum level and at the minimum cost.

In other words, the ***economic order quantity (EOQ)*** is the amount of inventory to be ordered at one time for purposes of minimizing annual inventory cost.

Formula of Economic Order Quantity (EOQ)

The different formulas have been developed for the calculation of economic order quantity (EOQ). The following formula is usually used for the calculation of EOQ.

$$\sqrt{2.A.C_P/C_H}$$

- A = Demand for the year
- C_p = Cost to place a single order
- C_h = Cost to hold one unit inventory for a year

Underlying Assumptions of Economic Order Quantity

1. The ordering cost is constant.
2. The rate of demand is constant.
3. The lead time is fixed.
4. The purchase price of the item is constant i.e. no discount is available.

The replenishment is made instantaneously the whole batch is delivered at once.

In this method, EOQ **is** the lot size and is ordered whenever needed. The annual demand for the item based on the eight month data =1100×12/8= 1650 unit

$$EOQ = \sqrt{2 \times 1650 \times 100/.60}$$
$$= 741 \text{ UNITS}$$

Month	Demand	Cumulative demand	Quantity ordered	Set up cost	Inventory carrying cost	Total cost
1	100	100	741	100	32.05	132.05
2	120	220			26.05	26.05
3	140	360			19.05	19.05
4	120	480			13.05	13.05
5	160	640			5.05	5.05
6	180	820	741	100	33.1	133.1
7	120	940			26.1	26.1
8	160	1100			19.1	19.1
					TOTAL	373.55

The Total cost of ordering EOQ quantity is Rs 373.55. The closing inventory at the end of eight month is 328 units.

Least Total Cost (LTC): In this method is almost akin to the EOQ method. We attempt to find the least total cost for a lot which will occur when the set up cost and the inventory carrying cost are nearly the same.

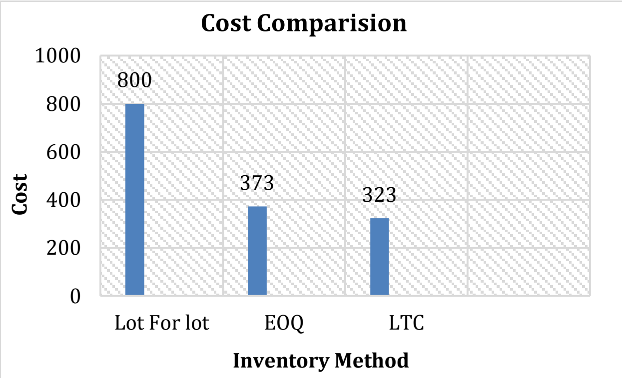
Month	Cumulative demand	Quantity ordered	Set up cost	Inventory carrying cost	Total cost	Unit cost
1	100	100	100	0.00	100	1.00
1-2	220	220	100	6.00	106	0.48
1-3	360	360	100	20.00	120	0.33
1-4	480	480	100	38.00	138	0.29
1-5	640	640	100	70.00	170	0.27
1-6	820	820	100	115.00	215	0.26 **Least Cost**
1-7	940	940	100	151.00	251	0.27
1-8	1100	1100	100	207.00	307	0.28
7	120	120	100	0.00	100	0.83
7-8	280	280	100	8.00	108	0.39

Similarly, for the seventh and eighth month, the lot size for seventh month is 280 and the cost will be Rs 108. The total cost will be Rs 423.

Month	Demand	Cumulative demand	Quantity ordered	Set up cost	Inventory carrying cost	Total cost
1	100	100	820	100	36	136
2	120	220			30	30
3	140	360			23	23
4	120	480			17	17
5	160	640			09	09
6	180	820			00	00
7	120	940	280	100	08	108
8	160	1100			00	00
					TOTAL	323

Conclusions

We presented results which lead to the determination of the optimal inventory policy and the minimum total cost. Product structure can be any type; each item in the system can have external demands and the cost parameter (carrying cost & changeover cost). In addition, the proposed precise model can help inventory decision maker to obtain solution closer to global optimum. The promising result motivates the need for further research on the inventory problem with Least Total Cost (LTC) method. Table above shows the cost comparison and it is found that in case for Least Total Cost (LTC) method the cost in Minimum. Table: Cost Comparison Table



So, the best lot size can now be selected. As may seen the least Total cost method cost of Rs 323 which is lower than the EOQ Method cost of Rs 373 and the Lot for lot method cost of Rs 800 so we select the Least Total Cost (LTC) Method.

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