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POSSIBLE COST REDUCTION BY APPLYING MRP IN A TRANSFORMER MANUFACTURING COMPANY OF BANGLADESH

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ABSTRACT

Local manufacturing industries generally do not pay adequate attention towards applying the state-of-the-art operations management techniques in inventory control, scheduling, material requirements planning (MRP) etc. The main identifiable reasons are lack of exposure to the concurrent techniques and facilities, exorbitantly high price of commercially available software and inadequate indigenous support systems. Moreover, the lack of knowledge about the benefits of using MRP in various aspects hindered its wide spread diffusion. Most of the local firms assume that the procurement of raw materials either in huge quantity at a time or in small amount from period to period without adopting any mathematical approach would not have any remarkable effect on the total inventory cost. Practically the situation is different and it has been found that the procurement of material applying an established algorithm instead of current practice could significantly reduce the total incremental inventory costs. In this respect educational software was used. This paper highlights the salient features of MRP application in a local transformer manufacturing industry and makes a comparison of the total inventory costs determined by following the user-defined approach and the standard lot-sizing approaches.

KEYWORDS: MRP, Lot-size, Inventory

INTRODUCTION

MRP is a technique of managing production inventories that takes into account the specific timing of the material requirements. It is a schedule of material required in each period by the firm's production schedule and the schedule is determined by markets sales forecast. MRP that helps in maintaining the steady flow of materials through the plants is constituted of three principal elements named bill of material (BOM), master production schedule (MPS) and inventory data system. A typical structure of MRP is shown in Figure 1.The MRP process starts with the master production schedule (MPS) providing the quantity of each model or part required per period. The bill of material provides the MRP system with the part number and quantity of all parts required to build and to assemble the product [1]. The inventory control system supplies the MRP system with the projected on hand balance of all parts and materials listed on the BOM. The inputs from BOM and inventory control system must be timely and accurate for the formal MRP system to work. Updates of the inventory control system for changes in inventory due to part movement in manufacturing or purchasing must be continuous.

There are many reasons for the poor performance of MRP system in practice [2,3]. Some of these relate to the need for widespread education in MRP thinking and to the necessity for top management commitment to ensure success. In most MRP installation a high level of BOM accuracy is required, and even a higher level of location and count accuracy is necessary for specific parts in the inventory system [4]. The MPS must support the production strategies such as engineer to order (ETO), make to order (MTO), assembly to order (ATO) and make to stock

(MTS). The ETO and MTO strategies use similar processes in the MPS implementation and the ATO and MTS processes are quite different. A modified architecture for production management system [5] for MTO and ETO companies was proposed recently, where the output of customer order entry function entered at two different levels and the products were typically customized.

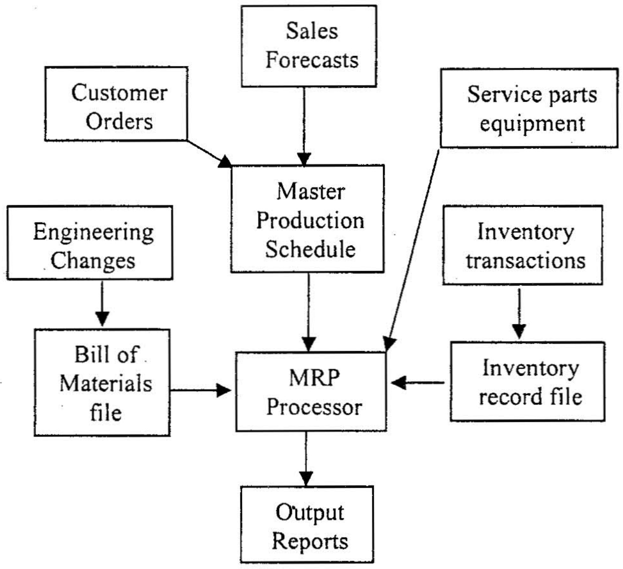

Figure 1. Structure of a material requirement planning system

The primary impact on the MPS for all of these production approaches is in the choice of units for the MPS. Turner and Hurst (1986) examined what the master schedule had to assume within the procedures of an organization to be effective [6]. This does not mean, however, that a good control system is not necessary. For medium term planning and control the MRP logic is useful and computer support for automated material requirements calculations is absolutely necessary [7]. Besides this, the classical MRP idea of restructuring the bill of material has to be added to the control concept.

In most MRP systems, the production drives the information systems. At each stage of production MRP evaluates the usage rate of raw materials and determines the necessary inventory level. If managers or designers want to alter the production line, they can use existing data and simulations to determine approximate inventory levels for the new production. Production management has to rely on mathematical models of queuing theory, economic inventory theory, and simulation to determine the best flow of production and the required supply of materials and labor [8]. By adaptation of all these models many companies achieved remarkable gains in terms of improved customer service, reduced inventories, and lower manufacturing cost.

3. LOT SIZING TECHNIQUES

The quantities and timing for planned orders are determined by MRP logic using the inventory position, the gross requirement data, and a specific procedure for determining the quantities the lot sizing procedure. A number of procedures have been developed for MRP systems, ranging from ordering as required (lot for lot), to simple decision rules, and finally to extensive optimizing procedures. A joint ordering policy instead of separate ordering policy was found to be superior [9].

Economic Order Quantity (EOQ)

EOQ is preferable when relatively constant independent demand exists, not when we know the demand. EOQ is a statistical technique using typically average demand for a year, whereas MRP assumes known demand. Operations managers should take advantage of demand information that is known. However EOQ is still used in many organizations.

In EOQ calculation,

$$q^* = \sqrt{2kr/h}$$

where, q = economic order quantity, k = ordering cost, r = average rate of demand and h = holding cost

Period Order Quantity (POQ)

The POQ uses the same type of economic reasoning as the EOQ, but determines the number of periods to be covered by each order rather than number of units to order. The total cost per period as a function of t, the cycle time in periods is given by

$$C(t)= k/t + h(rt)/2$$

It can be proven that just

$$t^* (t^* - 1) \leq 2k/hr$$

where, C (t) = total cost, k = ordering cost, h = holding cost, r = average rate of demand and t = the cycle time.

The largest value of t such that t (t-1) is less than or equal to 2k/hr

Lot-for-Lot

The simplest lot sizing technique is lot for lot. A lot is scheduled in each period in which a demand occurs for a quantity equal to the net requirement.

An MRP system should produce units only needed, with no safety stock and no anticipation of further order. When frequent orders are economical and just in time inventory technique implemented, lot for lot is very efficient. However when ordering cost is significant, management is unable to implement JIT lot-for-lot would be expensive.

Part Period Balancing (PPB)

It is a more dynamic approach to balance ordering and holding cost. PPB uses additional information by changing the lot size in the future. PPB attempts to balance ordering and holding cost for known demands. Part period balancing develops an economic part period (EPP), which is the ratio of ordering cost to holding cost.

Wagner -Whitin

The Wagner–Whitin procedure is a dynamic programming model that adds some complexity to the lot size computation. It assumes a finite time horizon beyond which there are no additional net requirements. The Wagner–Whitin algorithm [10], however, employs a mathematical optimization technique called dynamic programming and find almost optimum solution.

The algorithm first determine an optimal plan for period 1, then for 1 and 2, then for 1, 2 and 3 and so forth, until an optimal plan is obtained through the planning horizon. At each stage, the cost of previous optimal plans are used in determining the current optimal plan

Let $E_{i+1,j}$ = the cost of satisfying demands for periods i+1 through j using one order to be received at the beginning of period i+1

f_j = the minimum costs over periods 1 through j where the Inventory at the end of period j is zero.

$= \min \{f_i + e_{i+1,j}\}$ where $j = 1,\ldots,n$; $i = i_{j-1},\ldots, j-1$ & $f_0 = 0$

The equation depicted above to determine f_j , the minimum ordering and carrying cost through period j, a regeneration point, i , should be selected such that the sum of minimum cost through i plus the cost for one order after i would be a minimum. In searching for the proper value for i, it is need to look back no further than i_{j-1}, the regeneration point selected in determining f_j

4. DATA COLLECTION AND ANALYSIS

The data used in this study for the year 2001 were collected from a local transformer manufacturing company, which follow MTO and ETO strategies. It has mainly two divisions: transformer division and switchgear division [11]. Transformer division is one of the largest divisions of the company, contributing the bulk of its turnover. The transformer division comprises of both fabrication and assembly sections whereas switchgear division has only the assembly section. The company embodies the knowledge, experience and state-of-the-art technology in transformer engineering and practice

The company has recently obtained ISO 9001 certification. As a requirement of this certification it has become imperative for the company to have proper documentation. Necessary measures are being adopted to improve the current documentation process. It has been noticed that the company is concentrating on defined product structures and indented bill of materials for different transformers.

There are about thirty end items for transformers with which a BOM chart has been constructed as part of the study. Among them all of these items are neither equally costly nor ordered with same frequency. Items responsible for the significant portion of the annual cost for raw materials were searched. It was found that only eleven items would cost more than 90% of the total annual raw material cost. These items were taken into account for lot size determination, using five methods namely: Economic Order Quantity (EOQ), Period Order Quantity (POQ), Lot for Lot, Part Period Balancing (PPB) and, Wagner–Whitin.

Estimation of Various Inventory Costs

There are mainly three types of costs for operating inventory systems: - ordering, carrying (holding) and shortage costs. Some elements of these costs may be difficult to estimate and, therefore, do not appear in the accounting records. However, the total costs resulting from inventory decisions are relatively insensitive to reasonable errors in the estimation of costs and thus a great precision is not necessary. In the present study shortage cost was not considered and, therefore, costs that were estimated are holding and ordering costs.

Ordering cost is the cost that increases with the number of orders placed. The cost includes cost of supplies, forms, order processing, clerical support and so forth [10]. Ordering cost elements can be listed as Table 1

Holding costs are the cost associated with holding or "carrying" inventory over time. Therefore, holding costs include obsolescence and costs referred to storage, such as insurance, extra staffing and interest payment etc. These costs increase with the size of inventory. Usually most of this cost is a function of the value of inventory. Since in this study only the purchased items were considered, the holding cost would be valued at the purchase cost of the item. In Table 2 the purchase cost of relevant item are presented.

Table 1 Ordering cost elements

Ordering cost elements	Imported	Local
1. Preparation of purchase requisition	Tk. 250	Tk. 250
2. Preparation of purchase order	Tk 400	Tk 400
3. Mail	Tk 200	Tk 0
4. Expediting, (telephone & telegraph)	Tk 400	Tk 0
5. Transportation	Tk 16000	Tk 1000
6. Receiving	Tk 2000	Tk 300
7. Inspection	Tk 400	Tk 400
8. Put away	Tk 0	Tk 0
9. Updating inventory records	Tk 200	Tk 200
10. Paying invoice	Tk 1500	Tk 200
11. LC	Tk 4000	Tk 0
12. Customs	Tk 5000	Tk 0
Total	Tk 30350	Tk 2750

Considering the local conditions and consulting with the relevant involved persons in the company, the estimated holding cost elements are presented in Table 3. Thus the overall holding costs can be evaluated by summing up all the cost elements.

In general any inventory holding cost of less than 15% is susceptible, but annual holding cost often approaches 40% of the value of inventory [12].

Table 2 Purchase cost of the selected eleven raw materials (Taka/unit)

1. Tank RM	Tk 25 per Kg	7. Channel	Tk 10 per Kg
2. Radiator RM	Tk 28 per Kg	8. Conservator RM	Tk 27 per Kg
3. Silicon Steel RM	Tk 215 per Kg	9. Pr. Board	Tk 220 per Board
4. LT Wire	Tk 210 per Kg	10. Copper Rod	Tk 286 per Kg
5. HT Wire	Tk 200 per Kg	11. Nut Bolt	Tk 3.50 per piece
6. Transformer oil	Tk 50 per liter		

Table 3 Estimated holding cost element

Category	Cost as a percent of Inventory value
1. Housing costs such as building rent, depreciation, operating cost, taxes, insurance..............	3%
2. Mat. Handling costs including equipment, lease or depreciation, power, operating cost...	2%
3. Labor cost from extra handling	0.5%
4. Investment costs such as borrowing costs, taxes and insurance on inventory	15%
5. Pilferage, scrap and obsolescence.........	1.5%
Total	22%

The unit holding cost is, therefore, designated in Taka per unit-period as h. Thus

$h = fb$

where f = holding cost fraction and b = unit cost.

Sample calculation

The holding cost for inventory of silicon steel for which f = 0.22 per year, b = Taka 215 per Kg is evaluated as h = (0.22*215)/12 = Taka 3.94 per Kg-month. Table 4 illustrates the holding and ordering costs for the raw materials consumed in making transformer.

Table 4 Holding and ordering costs for different materials

Item	Holding Cost, (Tk per unit-month)	Ordering Cost, (Tk per order)
Tank Raw Material	Tk. 0.45 per kg month	Tk. 2,750
Radiator RM	Tk. 0.51 per kg month	Tk. 2,750
Silicon Steel	Tk. 3.94 per kg month	Tk. 30,350
LT wire	Tk. 3.85 per kg month	Tk. 30,350
HT wire	Tk. 3.66 per kg month	Tk. 2,750
Transformer oil	Tk. 0.91 per liter month	Tk. 30,350
Channel RM	Tk. 0.18 per kg month	Tk.2,750
Conservator RM	Tk. 0.49 per kg month	Tk. 2,750
Press Board RM	Tk. 4.03 per piece month	Tk. 2,750
Copper Rod RM	Tk. 5.24 per meter month	Tk. 30,350
Nut Bolt	Tk. 0.06 per piece month	Tk. 2,750

5 MRP LOT SIZING BY POM SOFTWARE

With the emergence of MRP systems, a need arose for the methods of determining lot sizes under conditions quite different from those assumed in the models used for independent demand inventories. The relevant conditions are (i) deterministic demand (ii) discrete demand (iii) variable demand (iv) no shortages and (v) holding (or carrying) cost based on end-of-period inventory. Different methods including a number of heuristic lot-sizing techniques are available which aim at providing near optimal lot sizes. Wagner-Whitin is an algorithm which employs a mathematical optimization technique known as dynamic programming and guarantees an optimal solution.

In POM software (Production and Operations Management, an educational version software) there are six options available to find the total inventory cost: Wagner–Whitin, EOQ, Lot for lot, POQ, Part Period Balancing and user-defined approach. In every method, period basis demand data are provided along with holding cost, ordering cost, lead time and initial inventory. The result sheet provides the total incremental inventory cost as the summation of the holding and ordering costs.

6. RESULTS AND DISCUSSION

As already mentioned there are about thirty end items of which eleven were initially chosen depending on the basis of cost. However, in view of the annual consumption only a few items are found responsible for the bulk of total cost. So identification of those significant items is necessary. Moreover, for a given level of effort devoted to controlling inventory, results can be improved if the amount of effort allocated to controlling an item according to its importance. This is particularly true in the majority of companies where a small percentage of the items in inventory account for a large part of the total monetary value. ABC analysis is the appropriate tool to categorize the items into: A-high value of annual use, B-medium value of annual use and C-low value of annual use.

ABC analysis to identify the significant items

The ABC analysis revealed that silicon steel was the most costly item responsible for about 61.2% of the total annual raw material cost. So silicon steel could be classified as item A. Similarly HT wire (13.3%), Transformer oil (10.4%) and LT wire (10.2%) could be termed as B item. The rest of the eleven items were considered as C items. The sum of A and B items constitute about 95% of total annual raw material costs. Figure 2 depicts the curve for ABC analysis.

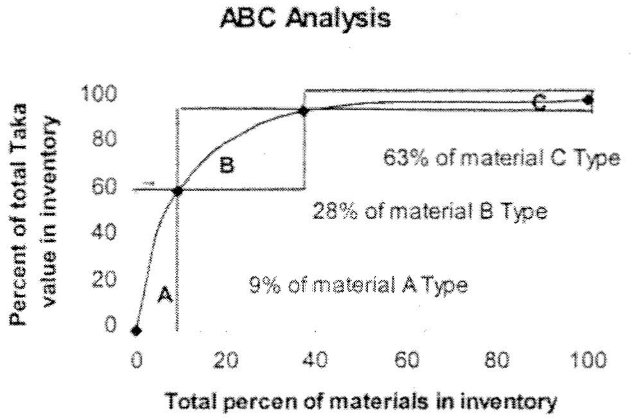

Figure 2: ABC analysis for the preliminarily chosen eleven items

Annual Inventory Cost for the four significant materials

The four significant items identified by the ABC analysis were considered for evaluating the annual inventory cost by using the POM software. The result sheet provided by the software is presented in Table 5.

Table 5 Annual inventory cost defined by 5 popular method and also the company's method

Material	W.Whitin	Lot for lot	EOQ	POQ	PPB	User defined
Silicon steel	454,544	1,601,442	1,908,730	1,601,442	481,748	1,795,691
LT wire	160,014	469,765	427,867	362,852	160,014	417,287
HT wire	48,682	105,500	127,668	94,982	50,506	174,096
Transformer oil	162,779	471,268	439,476	363,436	162,779	519,402

The cost-figures show that there is an immense scope of reducing inventory cost by choosing appropriate method for lot sizing. For example, the company places an order of 288 drum (equivalent to 60480 liter) of transformer oil at a time, resulting in annual inventory cost of Tk. 5,19,502. The amount is remarkably higher than the total inventory cost (Tk. 1,62,779) calculated according to the Wagner-Whitin method. Therefore, the percentage in possible cost reduction is about 69%. Similarly for silicon steel, LT wire, and HT wire possible cost reduction are respectively 74%, 61% and 72%. Among the various methods Wagner-Whitin appears to be the most attractive one. Table 6 depicts the probable relative cost savings by Wagner–Whitin algorithm over other approaches.

Table 6. Percentage cost savings by Wagner-Whitin method compared to other methods

Material	W. Whitin	Lot for lot	EOQ	POQ	PPB	User defined
Si steel	0	0.72	0.76	0.72	0.06	0.74
LT wire	0	0.66	0.63	0.56	-	0.61
HT wire	0	0.54	0.62	0.49	0.04	0.72
Transformer oil	0	0.65	0.63	0.55	-	0.69

Inventory cost plays a vital role in MRP. In this study Wagner-Whitin method ensures minimum inventory expenses. A comparative view of this method with the user-defined approach (currently adopted by the company) is presented in Figure 3 illustrating the inventory costs to be incurred.

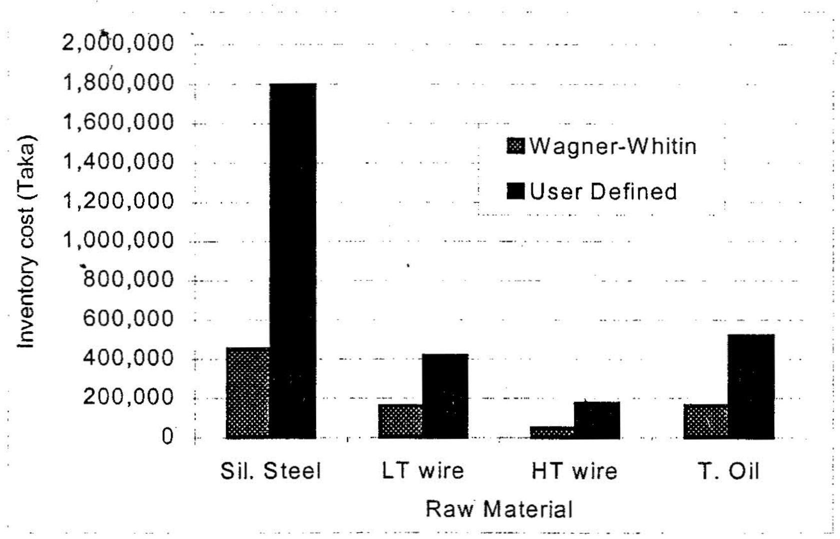

Figure 3: Item wise inventory cost followed by Wagner-Whitin and User defined method.

8. CONCLUSION

It is apparent from the study that there is a scope for the company to reduce the inventory cost significantly. Necessary steps may be taken to adapt the MRP system in the company. This would require to bring in change in many aspects, the important of which are the relationship with vendor, consistent quality of the raw materials, the documentation process, the reliable lead time etc.

Moreover, with globalization the local companies are destined to encounter fierce competition. To keep the price of the products in a competitive position, the local industries must make necessary endeavor. In this respect, among other issues the control of inventory costs through proper MRP can play a vital role.

In this study, the inventory cost was evaluated on the basis of individual item but in practice, order of multiple items is generally placed at a time. Inventory model handling with this kind of situation may be attempted.

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