APPLICATION OF MRP IN INDUSTRIES OF BANGLADESH : CASE OF AN ELECTRONICS APPLIANCE MANUFACTURING PLANT

by
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A thesis submitted to the Department of Industrial and Production Engineering, Bangladesh University of Engineering and Technology, Dhaka, in partial fulfillment of the requirements for the degree of Master of Engineering in Industrial and Production(IP) Engineering

December, 2002

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The thesis titled "application of MRP in industries of Bangladesh : case of an electronics appliance manufacturing plant" submitted by Md. Tanvir Hossain Roll No 9608003F, session - 1995-96-97 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Engineering in Industrial and Production Engineering (IP) on January 2003.

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It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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ACKNOWLEDGEMENT

The author is highly indebted to his project supervisor Dr. A. N. Mustafizul Karim, Professor, Department of Industrial and Production Engineering (IPE), Bangladesh University of Engineering and Technology (BUET), Dhaka for his advice, constant support, valuable guidance and encouragement from the inception to the completion stage of this project work.

The author owes his immense gratitude to Dr.Ing. M. Anwarul Azim, Professor, Department of Industrial and Production Engineering and Dr. Mohiuddin Ahmed, Professor & Head, Department of Industrial and Production Engineering for their agreement to act as examiners of the project thesis.

The production and operations management software (POM) that was one of the key facilities in the analysis. Dr. Hasan Imtiaz Chowdury, Assistant Professor, Department of Industrial and Production Engineering made it available and the author is thankful to him.

The author also expresses his deep sense of gratitude to Dr. K Siddique – e – Rabbani, Director, Grameen Bitek Ltd. who has given him the opportunity to work over there and permiting to use the data and other relevant information of Bitek in carrying out the project work.

Finally, the author would like to extend thanks and gratitude to his parents, wife, respected teachers of the department, classmates and friends especially Sikder Mainul Hasan and Mr. Shohel Anwarul Karim who helped him directly or indirectly in finishing the work.

Author

ABSTRACT

The present study was conducted on a local electronics applicance manufacturing company in the context of how the planning of material requirement is performed. The company is a fabrication/assembly organization where raw materials are procured, processed and assembled. It would not be unrealistic to say that the management of indizenous industries is not very keen to apply the operations management techniques such as inventory control, scheduling, material requirements planning (MRP) etc. This situation can be attributed to a number of failures. But main reason of the organization's reluctant attitude is identified as unawareness of the state-of-the-art techniquesand and benefits acrued out of utilizing of these techniques, a potential one of which is the MRP. A general perception that the procurement of raw materials either in huge quantity at a time or small quantity from period to period would not have any significant effect on the total cost still prevails in many local companies. But the situation is certainly different and healthier condition can be achieved by adopting and applying these techniques.

MRP is applied for planning of future activities of a company. Data on demand, of the products (MPS), lead times, set-up/ordering costs, holding or carrying costs etc. are required. However in this study previous data of the company for a period of six months from January to June, 2002 were used to analyse and make comparative study. It has been found that the procurement of materials applying an established algorithm (i.e. Wagner-Whitin approach) instead of current practice (user defined method) could reduce the total inventory cost quite remarkably. In the lot sizing analysis an educational version production and operation management software named POM was used. The outcome of the analysis revealed that the company could save as high as

67% of the inventory cost in case of the transformer only. Similar situation is expected to prevail for other items also.

Moreover, the incorporation of MRP could facilitate the company in many respects. There is a potential scope of improving the current situation through reduction in the total inventory cost, avoidance of reordering, shortfalls of materials, minimization of idle time, improvment of the efficiency of operations, delivery of product in a shorter period, improvment of customer service, increase in productivity, and reduction in the overall cost of products.

However, it would be required for the company to bring in change in many aspects to adapt the MRP system, the important of which are the relationship with vendor, consistent quality of the raw materials, the documentation process, recruitment of skilled manpower, estimating the reliable lead times etc. Situation could be improved further by applying the results of mathematical model for multiple items lot size and variable lot size taking into consideration of the real-life constraints such as store's space, available fund, transport facilities etc.

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LIST OF ABBREVIATIONS OF TECHNICAL TERMS

POM: Production and Operation Management

EOQ: Economic Order Quantity

POQ: Period Order Quantity

PPB: Part Period Balancing

MRP: Material Requirements Planning

MPS: Master Production Schedule

BOM: Bill of Material

WIP: Work in Process

MTO: Make to Order

JIT: Just in Time

OPT: Optimized Production Technology

BSTI: Bangladesh Standard Testing Institute

BUET: Bangladesh University of Engineering and Technology

APICS: American Production and Inventory Control Society

PAC: Production Activity Control

UPS: Uniterruptible Power Supply

IPS: Instant Power Supply

R&D: Research & Development

PCB: Printed Circuit Board

LC: License for Credit

CHAPTER ONE

INTRODUCTION

1.1 GENERAL BACKGROUND

The first steps towards a systematic, model-building, approach of production control problems were set by engineering scientists like Taylor, Gantt, Harris, Gigli etc. These authors based these models on a very practical viewpoint, which resulted in very simple models. However, their insight that explicit model-building has been a valuable contribution to solving production control problems. In fact it was a breakthrough in those days.

Thereafter the field of production control research has developed along two separate lines. The first line concentrates on solving models and hardly deals with the problems as they are encountered in practice. The second line of research development was much more in line with the initial practice-oriented systemizing steps. Based on a board practical experience, the entire field is characterized in categories and a number of models and techniques are given its place in this field.

Both of these lines did not lead to a comprehensive and complete scheme of categories, models and techniques for production control. The model-oriented line did not have enough roots in practice, and in the practice-oriented line developments were confused too much by the overwhelming complexity of the production control field. In fact (in the fifties sixties) theory and practice were living apart together.

From the early seventies on, however, this situation has drastically changed. Theory has developed to more normative models and the practitioners are becoming more and more professionals. This is similar to the development of the natural sciences, where we also can distinguish a phase during which science and practice became integrated. The alchemy and the searching for the "Philosopher's Stone" was a major element in this phase. The current state of affairs with respect to production control reminds us of the natural sciences. It is striking to see that the search is for one comprehensive principle as the basis for the solution to all production control problems. The three major developed production control principles are Material Requirements Planning (MRP), Just-In –Time (JIT), and Optimized Production Technology (OPT).

The widespread use of MRP is primarily due to the increasing availability of computing power and data capture capabilities. In the MRP approach, production control is primarily conceived as a registration and information-processing problem.

The American profession organization APICS (American Production and Inventory Control Society) has contributed substantially to the development of MRP. This resulted in the professionalisation of the field of production and inventory control. In this education, the MRP approach was presented as a standard. MRP was the basis for developing computer software for production and inventory control. MRP being a standard system, it was profitable to invest in the development of MRP software [1].

1.2 GROWTH OF MRP

Between the two world wars, early developments occurred in the application of the analytical methods in solving production / inventory problems. The economic order quantity was invented, followed by the order point and statistical safety stock. In the 1950s, companies were using order point – order quantity systems to generate production and purchase orders for product components and expediters to push completion of the most urgent orders In the 1950s, computers became commercially available, and companies started using them for processing bills of materials and materials requirements planning. APICS was founded and played a major role in making industry aware of this new potential.

The first company to have an MRP system running was American Bosch, in Springfield, Massachusetts, in 1959. Other companies early in the field were J.I.case, Black and Decker, and Twin Disc. A number of computer manufacturers produced, commercial software packages for MRP, the best known of which was the PICS package from IBM.

1.3 IMPORTANCE OF MRP

Computer-based production and inventory control embodies powerful new tools for more effective manufacturing management developed over the last two decades. The intense international competition in manufacturing has provided a strong incentive to management to seek new, more effective ways of managing production to maintain or achieve a competitive edge. As a result, thousands of companies have implemented computer-based production and inventory control systems. The most widely adopted systems are called material requirements planning and manufacturing resource planning. Many of these companies have achieved remarkable gains by implementing MRP in terms of improved customer service, reduced inventories, and lower manufacturing costs [2].

1.4 SCENARIO OF LOCAL INDUSTRIES IN THE CONTEXT OF MRP:

The overall scenario of local industries about adoption and implementation of MRP is not very encouraging. In the race of "technology management effort" to face the challenges of the fierce competition in the business world, Bangladesh falls far behind.

The primary target of most of the industries in Bangladesh is to get back quick return on investment. Long term business plan is absent in many cases. A significant number of enterprises including government organizations are reluctant to apply operations management techniques. The identifiable reasons are lack of exposure to the concurrent techniques and facilities, high price of relevant commercially available software's, inadequate and indigenous support system, scarcity of qualified manpower etc.

For most of the organizations, people at the top management, though experienced, are not to pay adequate attention in the context of applying the operations management techniques in inventory control, scheduling and material requirements planning (MRP). They are not interested to provide education and training to their employees. So the overall production level cannot be improved.

Computer hardwares and softwares are not very expensive now-a-days. So it is an opportunity for local manufacturing industries to take the advantage of computer-based production and inventory control. However, one of the main problems in implementing MRP in local industries is the lack of trained manpower. Some companies purchased the software in exchange of high price but could not run it due to the above-mentioned problem.

In Bangladesh, most of the organization does not follow any standard either national or international. Very few manufacturing organizations have so far implemented ISO standards. In this project study it has been noticed that the company under study does not apply the operations management techniques in inventory control, scheduling and material requirements planning (MRP).

1.5 OBJECTIVES OF THE STUDY/PROJECT WORK

The foregoing discussions amply demonstrate the gloomy picture of operation management system in industries of Bangladesh. Unless the industries implement appropriate measures to improve their operation management system as quickly as possible, it will be very difficult, if not impossible for them to stay in the business world. The present research study is an attempt to be conducted to critically examine the existing situation particularly the weaknesses and limitations. In this regard a typical organization has been selected as a model. The following objectives have been defined for the study:

- To study and investigate the scope of implementing the MRP concept in a local electronics appliance manufacturing industry.
- To estimate holding and set-up/ordering cost of individual materials
- To recommend appropriate measures to be adopted by the company in applying MRP and to identify the action plans for future work.
- To identify the scope of applying MRP software including MPS and MRP lot sizing for some major products.

CHAPTER TWO

BACKGROUND STUDY & LITERATURE SEARCH

2.1 INTRODUCTION

Material Requirements Planning (MRP) is based on several concepts that are independent versus dependent demand, manufacturing lead times and common use items. Independent demand means that demand for a product is not directly related to demand for other items. Independent demand is influenced by market conditions outside the control of operations; it is therefore independent of operations. Examples of independent demand are finished goods and spare parts in a manufacturing company that is used to satisfy final customer demand. Independent demand must usually be forecasted. Dependent demand means that demand for the item is related directly to the demand for some other product. Dependent demand is not independently determined by the market. Examples of dependent demand are raw materials and work-in-process inventories used in manufacturing companies to support the manufacturing process itself. MRP is based on the concept of dependent demand. By exploding the master schedule through the bill of materials (BOM), it is possible to derive demand for component parts and raw materials. The MRP system can then be used to plan and control capacity, and it can be extended to resource planning throughout a manufacmring firm.

The lead-time for a job is the time that must be allowed to complete the job from start to finish. There are two types of lead-times in MRP: ordering lead-times and manufacturing lead-times. An ordering lead-time for an item is the time required from initiation of the purchase requisition to the receipt of the item from the vendor. If the item is a raw material that is stocked by the vendor, the ordering lead-time should be relatively short, perhaps a few weeks. Manufacturing lead-time is the time required to fabricate a part. This lead-time may be substantial in cases it can be several months.

Common use items are raw materials and components that are used on more than one product. MRP collects these common use items from different products to effect economies in ordering the raw materials and producing the components [3,4].

2.2 MRP SYSTEM COMPONENTS

Fig 2 1 shows the basic components of an MRP system. Three major sources of information are mandatory in the MRP systems are: a master production schedule (MPS), an inventory status file, and a bill of materials (BOM) file. Using these three information sources, the MRP processing logic (computer program) provides three kinds of information output for each product component: order release requirements, order rescheduling, and planned orders.

Master production Schedule (MPS)· The MPS is initially developed from firm customer orders or from forecasts of demand before the MRP system begins to operate. The MPS is an input to the MRP system. Designed to meet market demand, the MPS identifies the quantity of each end product (end item) and when it needs to be produced during each future period in the production-planning horizon. Orders for replacement (service) components for customers are also entered as end items in the MPS Thus, the MPS provides the focal information for the MRP system: the MPS ultimately governs the MRP systems recommended actions on the timing of procuring materials and producing subcomponents, which are geared to meeting the MPS output schedule.

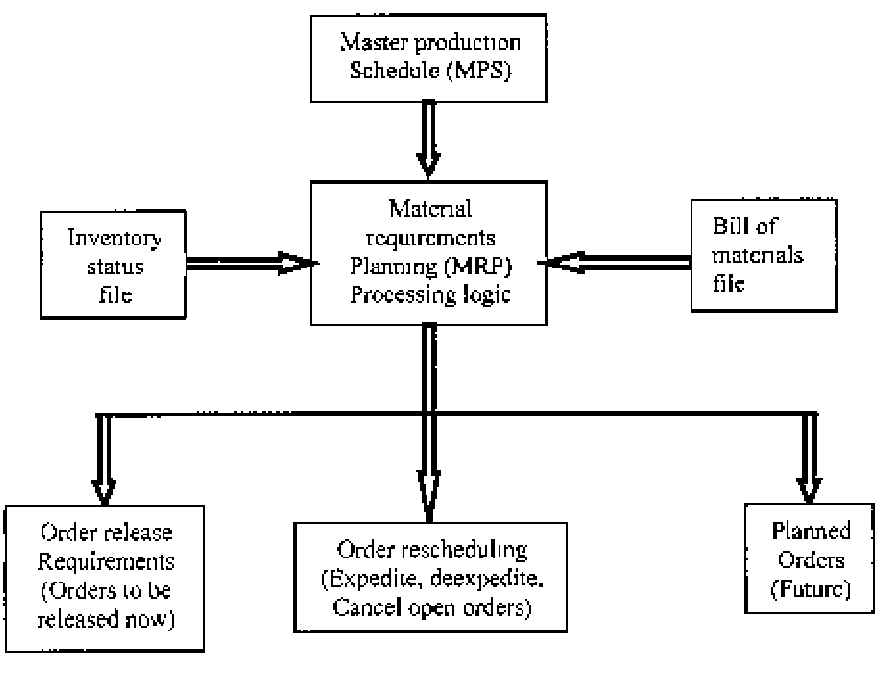

Figure 2.1 Material Requirements Planning System.

Bill of Materials (BOM)- The BOM identifies how each end product is manufactured, specifying all subcomponent items, their sequence of buildup, their quantity in each finished unit, and the work centers performing the buildup sequence. This information is obtained from product design documents, workflow analysis, and other standard manufacturing and industrial engineering documentation.

The primary information to MRP from the BOM is the product strucmre. Product strucmre is the levels of components to produce an end product. The end product is on level 0, components required for level 0 are on level 1, and so on.

Inventory Status File- the MRP system must retain an up-to-date file of the inventory status of each item in the product structure. This file provides accurate information about the availability of every item controlled by the MRP system which can then maintain an accurate accounting of all inventory transactions, both actual and planned. The inventory status file contains the identification number, quantity on hand, safety stock level, quantity disbursed (allocated), and procurement lead time of every item [5].

2.3 SCOPE FOR MRP

There are many reasons for the poor performance of some MRP systems in practice. Some of these relate to the need for widespread education in MRP thinking and to the necessity for top management to ensure success. Others are more technical in nature and include:

Lead- times: a MRP assumes production lead times to be known and fixed. Each product is given a pre-defined production lead-time. These times are estimates and unfortunately MRP users often treat these lead times as being very precise.

Design/Quality: The areas of production environment design and attention to quality issues are not addressed. MRP systems tend to assume that the environment exists as is and is not subject to change. This gives rise to the need for a production environment design element in the factory co-ordination subsystem.

Infinite Capacity: MRP assumes infinite capacity, i.e. when a master production schedule is derived, all resources being used in the plant can be assumed to offer at least sufficient capacity to fulfil that schedule. This is based on the premise that the plan has already been passed through rough cut capacity planning and therefore must be 'achievable'. Both JIT and OPT schedule production assuming a limited capacity

Batch sizing: Many implemented MRP systems tend to use the ideas of economic batch quantities after calculating the planned order quantities. Batches are larger than is necessary in order to offset the supposed costs of set up and inventory. JIT and OPT have overcome the batch size problem.

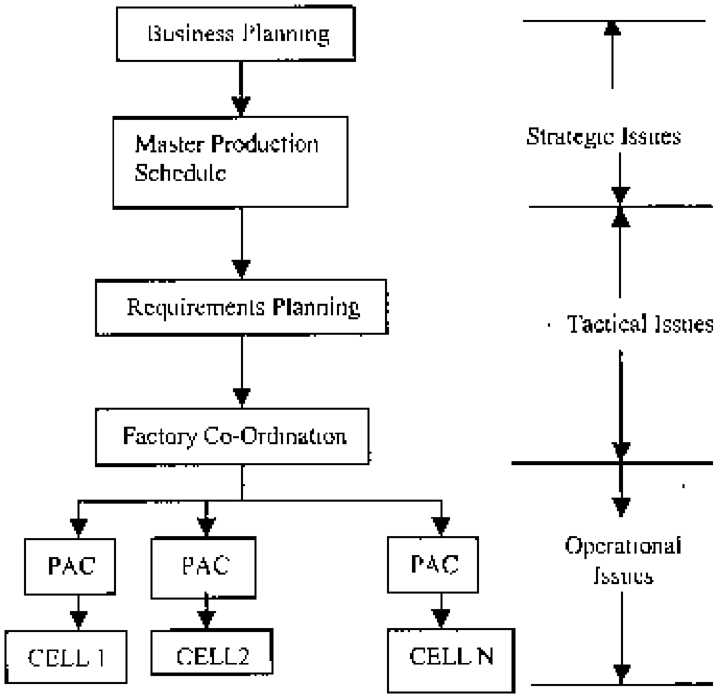

Figure 2.2. An architecture for production management systems.

2.4 MRP WITH ADAPTATION

The shortcomings discussed in section 2.3 however were tried by many to reduce or eliminate. Paul Higgins proposed a solution in 1992 in Figure 2.2 above. This architecture reflects a situation where a factory has been decomposed in so far as possible into a series of group technology based production cells, where each cell is responsible for a family of its products, components or processes and is controlled by a production activity control (PAC) system. Another possibility is that each group is actually geographically dispersed, that is there are a number of different focused factories. The factory co-ordination module ensures that the individual cells/factories interact to meet an overall production plan.

Strategic issues: Strategic production management issues relate to: the determination of the products to be manufactured; the matching of products to markets and customer's expectations; and the design of the manufacturing system.

Tactical issues: Tactical issues relate to the generation of detailed plans to meet the demands imposed by the long-range production plan. It involves the breakdown of the products in this plan into a feasible master production schedule.

Operational issues: Operational PMS issues essentially involve taking the output from the tactical planning phase, e.g. the planned orders from an MRP system and managing the manufacturing system in quasi real time to meet these requirements

Requirements planning is concerned with translating the master schedule items into component requirements for short term planning and purchasing. Factory co-ordination and production activity controls mainly deal with the operations associated with manufacturing the component items and assembling the finished product [6].

2.5 MRP AND MANAGEMENT

MRP increased status, however, has not been realized through a simple steady advance in its scope and application Indeed. the more ambitious MRP has become the more uncertain has been the outcome. Large complex systems have sometimes achieved wonders for companies and at other times have proved disastrous. Paradoxically, it is the suspect nature of the outcome, which has created its notoriety. The status of MRP has been enriched as much through its failure as through its success. Its appropriateness and effectiveness are a matter of contention.

MRP implies that managers have to treat everything formally. Once the MRP system has been taken on, all sorts of flexibilities in the business appear to have been lost. If they are to be recovered they have to be recovered in the same formal idiom as the MRP system itself. Safizadeh and Raafat (1986) examined this question as the fundamental pre-condition which managers must accept for MRP to work. Mehta (1980) examines how safety stock must be formally assessed within the MRP system. Civerolo (1980) studied ways of handling the overtime question to cope with an overloaded master schedule and suggested a formal rule where overtime also could be structured in relation to the MRP scheme. Turner and Hurst (1986) examined what the master schedule had to assume within the procedures of an organization to be effective [7,8].

2.6 DETERMINATION OF LOT SIZES

With the emergence of MRP a need arose for new method to determine the lot size under conditions quite different from that assumed under independent demand inventories. Specially the conditions are follows:

1. Deterministic demand - items controlled by MRP are materials or components used in making higher level items. Whereas the final products may have uncertain customer demand, once the production schedule has been decided. So, with some exception such as component with service demand is considered deterministic.
2. Discrete demand - rather than demand occurs continuously, demand occurs at discrete intervals at the beginning of planning period.
3. Variable demand - due to fluctuations in customer demand the size of demand can vary from period to period.
4. No shortage - as shortages would cause delay in production of higher level items and ultimately of final products, no shortages are allowed.
5. Carrying cost based on end of inventory - the objective is to minimize the sum of ordering and carrying costs with the constraint that all net requirements must be satisfied. The carrying cost is based on the available inventory at end of each planning period.

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 organization.

In EOQ calculation,

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

Where, q = economic order quantity

k = ordering cost

r = average rate of demand

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.

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

It can be proven that, $t^* (t^*-1) \leq 2k/hr$

Where, C(t) = total cost

k = ordering cost

h = holding cost

r = average rate of demand

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 produced 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 or management is unable to implement JIT lot for lot would be expensive.

Part Period Balancing (PPB)

PPB 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 set up 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, 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 one through j where the inventory at the end of period j is zero

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

The equation depicted above to determine f_j, the minimum ordering and carrying cost through period j, we should select a regeneration point, i, such that the sum of minimum cost through i plus the cost for one order after i will be a minimum. In searching for the proper value for i, its need looks back no further then i_{j-1}, the regeneration point selected in determining f_{j-1} [2].

CHAPTER 3

COMPANY PROFILE AND ITS PRODUCTION LINE

3.1 INTRODUCTION

The data used in this study were collected from a local electronics manufacturing company, Grameen Bitek Ltd. This manufacturing industry is primarily of electronic nature, arising out of a joint venture between Grameen Fund and a sister concern of internationally reputed Grameen Bank, and Bitek (Bangladesh Innovative Technology Group).

The Bitek group was founded in 1993 with a commitment to establish commercial manufacture locally innovated of electronic products. "Volt-Guard" was made as the first product, which is an abnormal voltage protection device.

As of date most of the power line problems encountered in developing countries like ours have been taken care of and different ranges and models of Volt-Guard and Stabiliser with Volt-Guard have been produced to protect different types of equipment and house-hold appliances under varying power line conditions. Today thousands of equipment and house-hold appliances in Bangladesh are under the protection of different models of Volt-Guard and Stabiliser with Volt-Guard with brilliant records of success even under extreme abnormal power line conditions.

Now, the company also produces UPS (Uninterruptible Power Supply) for computer and IPS (Instant Power Supply) for TV, Fan, and Tube Light which caters instant power back up for 2-3 hours of power shut-down.

The company has two sections: Stabiliser section and IPS section. In IPS section different ratings of IPS and UPS are manufactured.

With such a high technological standing of Bitek and the proven administrative and economic strength of Grameen establishments, the new joint venture Grameen Bitek Ltd. aspires to provide a pioneering lead in the technological arena of the country and be of service to the nation.

3.2 LAYOUT OF THE PLANT

The company's layout is the type of process layout where production system is arranged into groups according to general types of manufacturing process. The plant layout of Grameen Bitek Ltd. is shown in Figure 3.1. The operations carried out in making a typical product are PCB preparation, component preparation, PCB fabrication, hardware fixing to cabinet and testing. Department is categorized according to the operations. Testing department does the adjustment of low-cut voltage and high-cut voltage.

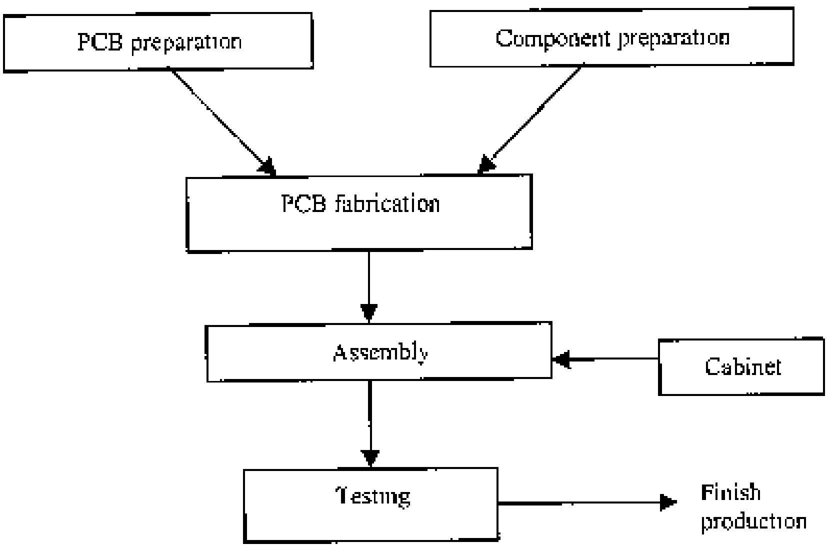

Figure 3.1 Simplified Plant Layout in Grameen Bitek Ltd.

3.3 STABILISER SECTION

Stabiliser section is the key section contributing the bulk of its turnover. The company's highly trained engineering and manufacturing team have been successfully manufacturing Volt-Guard and Stabiliser with Volt-Guard for the last one-decade.

Keeping pace with latest changes in technology, the company is making considerable investments in manufacturing and in-house R&D, which is an important consideration of Grameen Bitek. Continuous R&D has elevated the quality of Volt-Guard and Stabiliser with Volt-Guard to an enviable position and feedback from the market is always conveyed to the R&D section for technological improvements. It enhanced its product range to upgrade rating of input and output voltage.

The company is currently producing Volt-Guard of 2200VA, 3300VA, 4400VA & 5500VA and Stabiliser of 500VA, 550VA, 800VA, 1100VA, 1600VA, 2200VA, 3300VA. 4400VA, and 5500VA. The company shortly has started manufacturing of 3-phase Volt-Guard and Stabiliser.

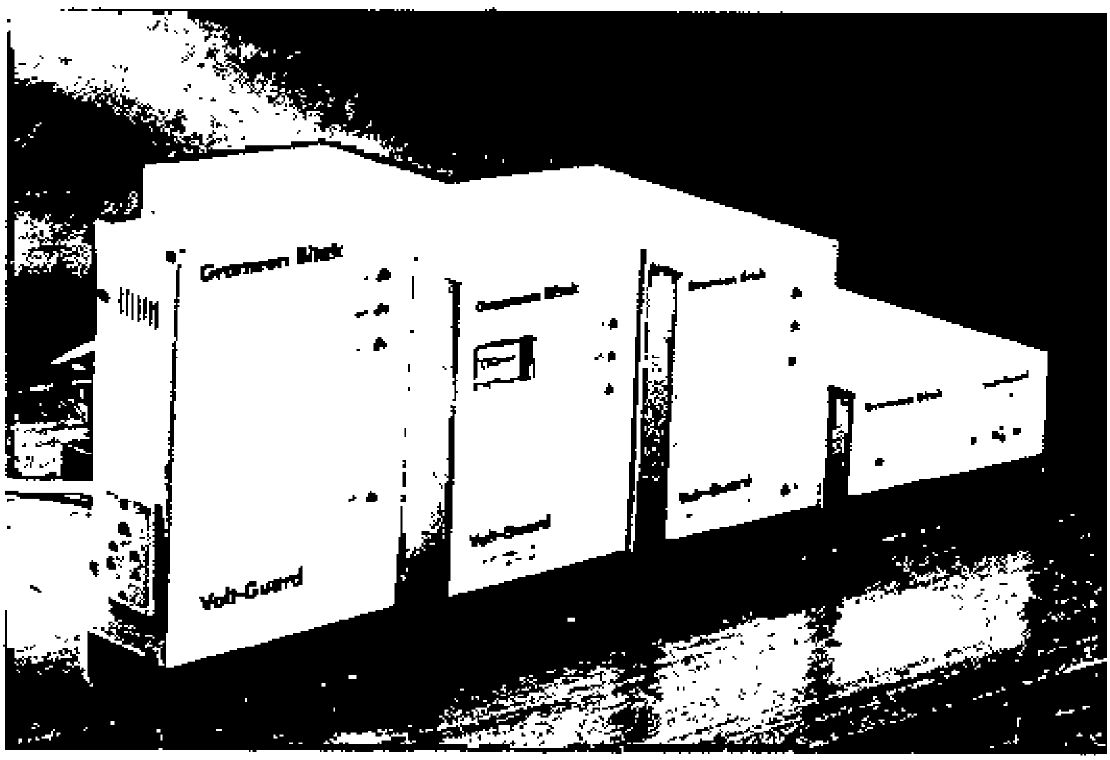

Exhibit 1: Volt-Guard and Volt-Guard with Stabiliser.

3.4 STABILISER FEATURE

The Stabilisers are designed according to the requirement of individual customer, conforming to recognized standard including BSTI and BUET.

DESIGN

The company boasts of modern design and production techniques. In-house R&D activities are continuously behind the development of quality products.

TESTS

Tests are carried out rigorously at every stage of assembly. Stabilisers are qualified for dispatch on successful completion of the following routine test.

- Electronic component test.
- Transformer test
- Plug, socket test (by taking samples), on procurement.
- Fuse holder and switch test.
  - Switch on repeated on/off (50 cycles) with load.
  - Warming on maximum rated current
- Cables & connecting wires test
  - Visual
  - Solderability.
- Cabinet check (100%), on procurement.
- Complete circuit test.
- Adjustment of input and output voltage settings.
- 440V test.

QUALITY

The company is committed to achieve excellence in the quality of products and the services. The quality policy not only adorns the walls of the company but also genuinely follows at every stage of manufacturing. Efforts are always made from procurement to processing to build and constantly adapt upgrading the technology to maintain the quality.

3.5 PROCESS FLOW CHART

The company has sales executive and dealer all over the country. On the basis of previous sales, customers direct order to dealer or at sales office and demand collected by sales executives of the marketing department a futuristic forecast of stabiliser requirement of production is made. The factory manager prepares the master production schedules, material requirement in consultates with stores. Figure 3.2 shows the process flow chart for showing the activities in manufacturing.

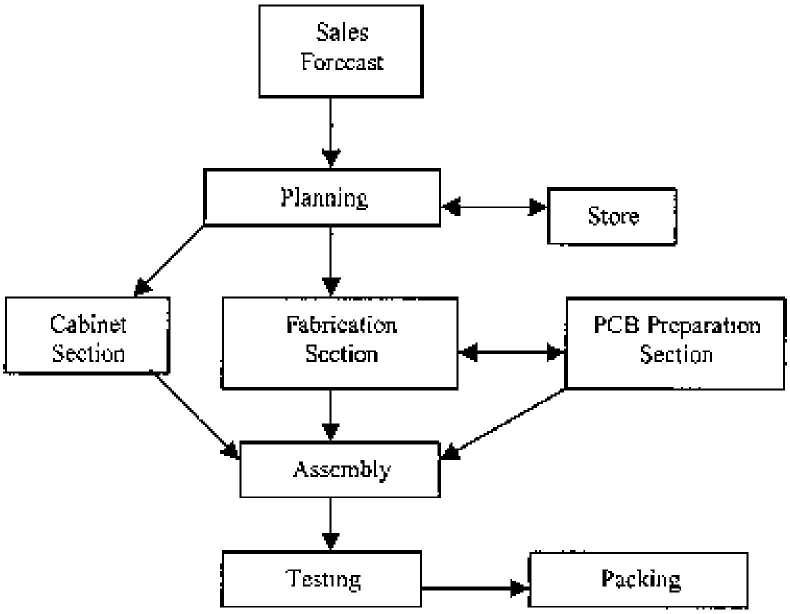

Figure 3.2 Process flow chart showing the activities in a manufacturing company.

For every type and specification of voltage stabiliser there is a distinct design. Store gives the information of the raw material on hand. Raw copper board is cut to size by manually operated cutting machine. PCB of stabiliser is fabricated in fabrication section where electric soldering irons are used. The complete PCB is delivered from fabrication section to Assembly section to make a final product. All fittings are done according to the design and in this regard a number of mechanical tools are used. After the assembly the stabiliser is tested and delivered to customer [9,10].

CHAPTER - 4

METHODOLOGY

4.1 INTRODUCTION

Since there are several categories of stabilisers being fabricated in the company, it is necessary to construct BOM for each category to make the final MRP for the whole production. In this chapter the steps followed in MRP have been discussed with a simple example. Moreover, the method of constructing the bill of materials, estimating the lead-time, holding cost, set-up or ordering cost, determining the lot-size is also briefly discussed.

4.2 WORKING PRINCIPLE OF MRP

The master production schedule is a listing of (i) what products are to be produced, (ii) how many of each product are to be produced, and (iii) when they are to be ready for shipment. The general format of the master schedule is shown in Figure 4.1. The master production schedule must be based on an accurate estimate of demand and a realistic assessment of the production capacity. In MRP, it is important to know not only the current level of inventory, but also the future changes that will occur against the inventory.

Week number	6	7	8	9	10
Product P1			50		75
Product P2		60	70	20	
Etc.					

Figure 4.1 Master Production Schedule for products P1 and P2 showing weekly delivery quantities.

The structure of an assembled product can be pictured as shown in Figure 4.2. This is a relatively simple product in which a group of individual components make up two subassemblies, which in turn make up the product. The product structure is in the form of a pyramid, with lower levels feeding into the levels above The dashed line shows the raw materials used to make the individual components. The items at each successively higher level are called the parents of the items in the level directly below. For example, subassembly S1 is the parent of components C1, C2 and C3. Product P1 is the parent of subassemblies S1 and S2. The product structure must also specify how many of each item is included in its parent.

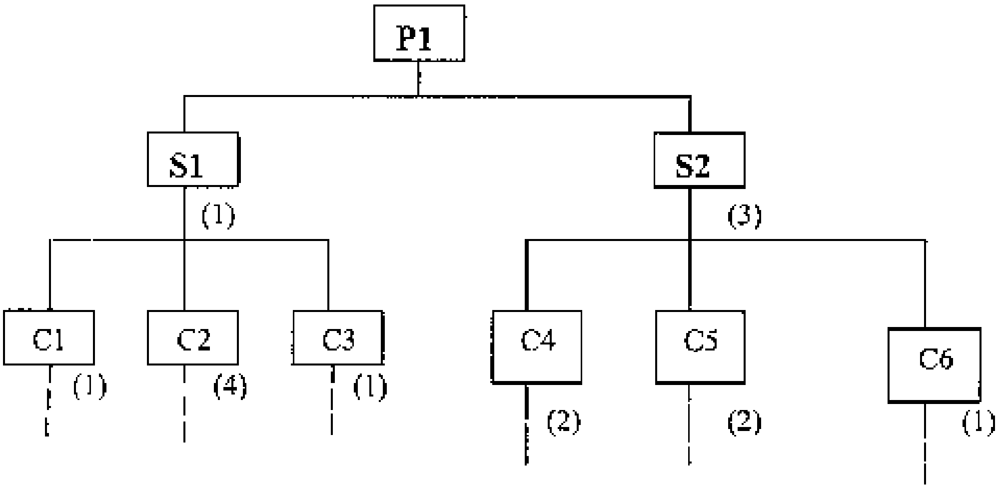

Figure 4.2 Product Structure for Product P1.

The master schedule specifies a period-by--period list of final products required. The BOM defines what materials and components are needed for each product. The MRP program computes how many of each component and raw materials are needed by "exploding" the end product requirements into successively lower levels in the product structure. Now referring to the product structure in Figure 4.2, 50 units of P1 explodes into 50 units of subassembly S1 and 150 units of S2, and the following numbers of units for the components: C1: 50 units,

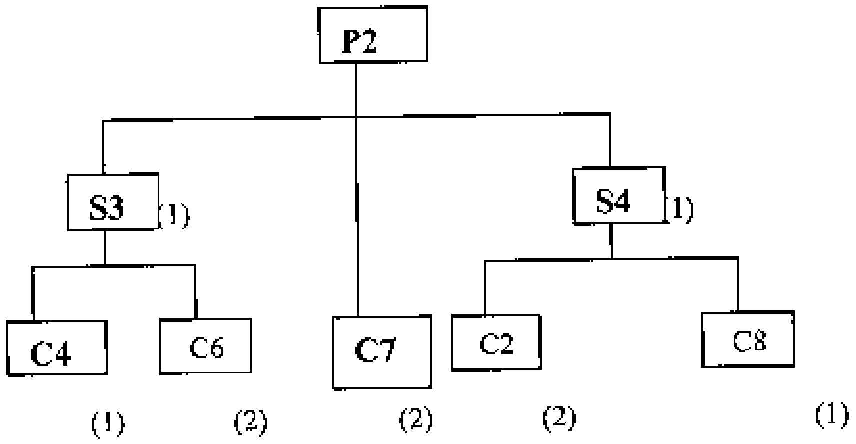

Figure 4.3 Product Structure for Product P2

C2: 200 units, C3: 50 units, C4: 300 units, C5: 300 units and C6: 150 units. The quantities of raw materials for these components are determined in a similar manner. Similarly for product P2 in Figure 4.3, the quantities of subassemblies and components can be determined.

Net Requirement

Most inventory systems also note the number of units in inventory that has been assigned to specific future production but not yet used or issued from the stockroom. Such items are often referred to as allocated item. Allocated items increase requirements and then should be included in an MRP planning sheet. The allocated quantity has the effect of increasing the requirement (or, alternatively reducing the quantity on hand). The net requirement MRP is:

Net Requirements

= [(Gross requirement) + (allocation)] - [(on hand) + (schedule receipts)]

= [Total requirements] - [available inventory]

Sample Calculation:

Let us consider component C4 is made out of raw material M4. The ordering and manufacturing lead times needed to make the MRP computations are as follows:

P1: assembly lead time = 1 week

P2: assembly lead time = 1 week

S2: assembly lead time = 1 week

S3. assembly lead time = 1 week

C4: manufacturing lead time = 2 weeks

M4: ordering lead time = 3 weeks

From the Table 4.1 to Table 4.6 (MRP solution) it would be clear to find material requirement and its timing (backward calculation). At table 4.6, on hand material is 30 and schedule received is 50 total 80 items is available at period 3 but gross requirement is only 60 therefore 20 items are access. On period 4 this 20 items would act as on hand item and gross requirement is 270 therefore its need 250 items only. These 250 items will be needed to order at period 1 and so on

Now MRP solution is as like this:

Period	1	2	3	4	5	6	7	8	9	10
Item Product P1								50		75
Gross Requirement										
Schedule Receipts.										
On Hand										
Net Requirement								50		75
Planned order Release							50		75	

Period	1	2	3	4	5	6	7	8	9	10
Item: Product P2							60	70	20	
Gross Requirement										
Schedule Receipts.										
On Hand										
Net Requirement							60	70	20	
Planned order Release						60	70	20		

Period	1	2	3	4	5	6	7	8	9	10
Item: Product S2							100		150	
Gross Requirement										
Schedule Receipts.										
On Hand										
Net Requirement							100		150	
Planned order Release						100		150		

Period	1	2	3	4	5	6	7	8	9	10
Item: Product S3						60	70	20		
Gross Requirement										
Schedule Receipts										
On Hand										
Net Requirement						60	70	20		
Planned order Release					60	70	20			

Period	1	2	3	4	5	6	7	8	9	10
Item: Product C4					60	270	20	300		
Gross Requirement										
Schedule Receipts.										
On Hand										
Net Requirement					60	270	20	300		
Planned order Release			60	270	20	300				

Period	1	2	3	4	5	6	7	8	9	10
Item: Product M4			60	270	20	300				
Gross Requirement										
Schedule Receipts.			50							
On Hand 30			80	20						
Net Requirement			-20	250	20	300				
Planned order Release	250	20	300							

Figure 4.4 MRP solution of the Sample Problem

4.3 CONSTRUCTION OF BILL OF MATERIAL (BOM)

The construction of bill of material in complete form for a practical product is undoubtedly a tedious work. In a stabiliser there are larger number of components or parts. To construct the BOM it is necessary to be familiar with all the stages of fabrication and steps adopted in assembly or subassembly. Considering the practical limitations, only the major items were taken into account in constructing the BOM. A typical BOM for a stabiliser of 550VA is presented in Figure 4.5.

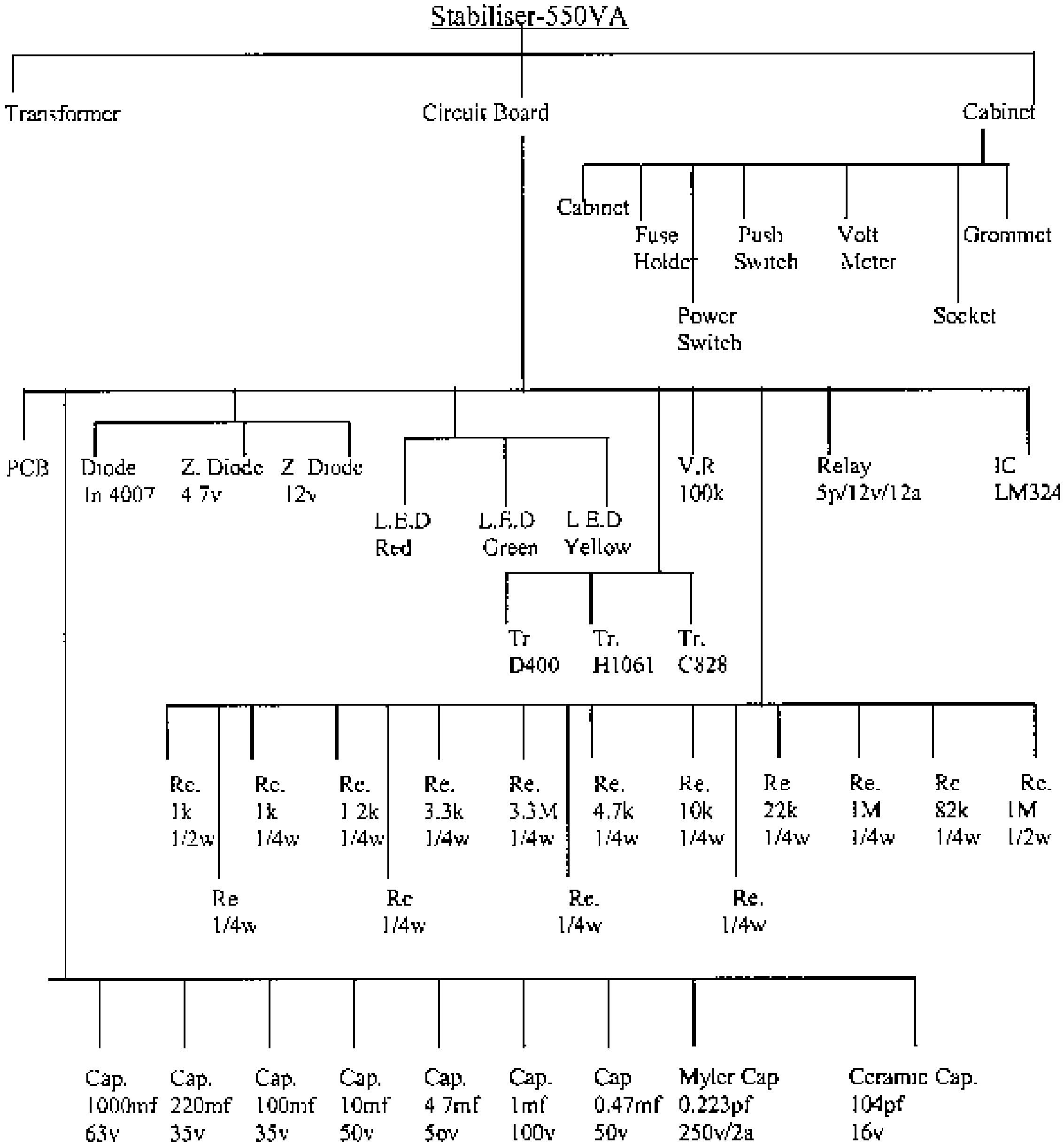

Figure 4.5 The Bill of Material (BOM) of 550VA Stabiliser.

4.4 ESTIMATION OF LEAD TIME

The lead-time for a job is the time that must be allowed to complete the job from start to finish. There are two types of lead times in MRP: ordering lead-time and manufacmring lead-time. An ordering lead- time for an item is the time required from initiation of purchase requisition to the receipt of the item from the vendor. If the item is the raw material that is stocked by the vendor, the ordering lead- time should be relatively short, perhaps a few weeks. If the item is fabricated, the lead -time may be substantial, perhaps several months.

In this case, data on manufacturing lead times were collected from the concern operators whereas ordering lead times were based on the recorded data in the store. In either case lead-time is taken on the basis of 'time needed most frequently'. Here it has been found manufacturing lead time and assembly lead - time are matters of days and ordering lead time is a matter of days, 1 week or 2 weeks for item purchased locally.

4.5 CALCULATION OF SET UP AND HOLDING COSTS

Set up cost is the cost to prepare a machine or process for manufacturing an order. It increases with the number of orders. Holding cost is the cost to keep or carry inventory in stock. This cost increases with the size of the inventory. Total cost is, therefore, the summation of

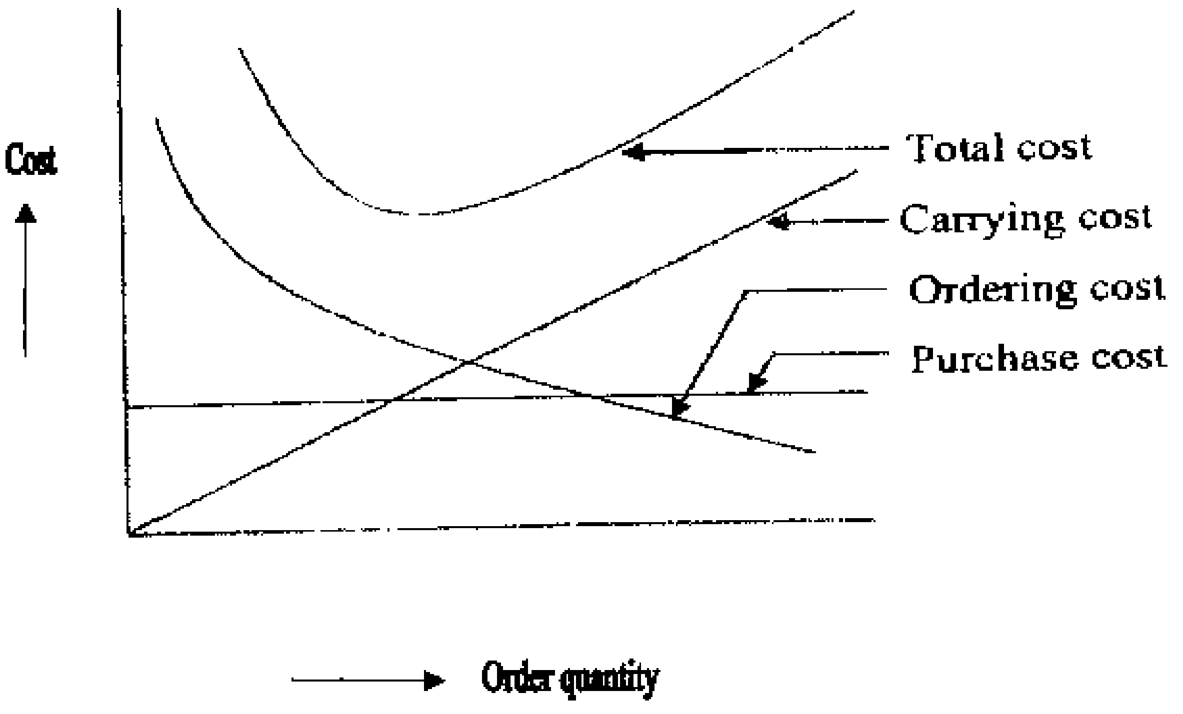

Figure 4.6 Cost elements showing the total inventory cost

holding cost, ordering cost and purchased cost. Figure 4.6 depicts the typical total inventory cost with order quantity. The cost elements relating to the set up and holding cost being enormous therefore its determination became quite difficult. Data were collected on the basis of procurement officer's buying experience. The data will not be exact due to guess and rough estimation. However, holding cost elements and its percentage value of inventory is shown in Table 4.1 and ordering cost (set up cost) in Table 4.2. It may be mentioned here the elements of ordering costs should not be expressed as percentage value of inventory

Table 4.1 Holding cost elements

1. Housing costs such as building rent, depreciation, operating cost, taxes, insurance. ... ..., ...	(3-10%)
2. Material handling costs including equipment, lease or depreciation, power, operating cost..................	(1-3.5%)
3. Labor cost from extra handling	(3-5%)
4. Investment costs such as borrowing costs, taxes and insurance on inventory	(6-24%)
5. Pilferage, scrap and obsolescence...	(2-5%)

Table 4.2 Ordering cost elements

1. Preparation of purchase requisition
2. Preparation of purchase order
3. Mail
4. Expediting, (telephone & telegraph)
5. Transportation
6. Receiving
7. Inspection
8. Put away
9. Updating inventory records
10. Paying invoice
11. LC
12. Customs

[2,3,11,12]

4.6 SELECTION OF PRINCIPAL ITEMS FOR EVALUATION

There are as many as 45 end items for stabiliser according to BOM chart But all these items are neither costly uor frequently ordering items. It is enourmous to take all the items for lot sizing determination. So ABC analysis is required for identifying significant items.

4.6.1 ABC ANALYSIS

Materials management involves thousands or even millions of individual trausactions each year To do their job effectively, materials managers must avoid the distraction of unimportant details and concentrate on significant maners. Inventory control procedures should isolate those items requiring precise control from other items that can be controlled with less precision. Selective inventory control can indicate where the manager should concentrate his efforts.

It is usually uneconomical to apply detailed inventory control analysis to all items carried in an inventory. Frequently, a small percentage of inventory items accounts for most of the total inventory value. It is usnally economical to purchase a large supply of low cost items and maintain little control over them. Conversely, small quantities of expensive items are purchased, and tight control is exercised over them. It is frequently advantageous to divide inventories into three classes according to the taka volume (the product of annual quantity and the unit purchase cost or production cost). This approach of categorizing the items in terms of 'vital', 'middle order' or 'trivial' is called ABC analysis.

Grameen Bitek utilizes 47 items for production of the 550VA stabiliser. In this analysis, 29 items were taken for determining annual usage of inventory. Because some items have the same price (purchase value) and same quantities needed for the stabiliser.

TABLE 4.3: Sample annual usage of inventory

Sl. No	Item Name	Annual Taka Usage	Percent of Total Taka Usage
1	Transformer	3,56,400	51.3
2	Cabinet	95,040	13 7
3	Relay	52,272	7.5
4	Volt Meter	30,888	4.4
5	Socket	29,700	4.3
6	V R-100K	17,820	2.6
7	Capacitor 1000mf/63v	15,444	2 2
8	Trangistor-H1061	14,256	2.1
9	Power Switch	11,286	1.6
10	Trangistor-D400	10,692	1.5
11	Integrated Circuit-LM324	10,098	1.5
12	Circuit Board	8,743	1.3
13	Fuse Holder	7,722	1 1
14	Zenar Diode 12v	6,415	0 92
15	Push Switch	5,346	0 77
16	Zenar Diode 4 7v	3,920	0 56
17	Ceramic Capacitor	3,801	0 55
18	Capacitor 220mf/35v	3,564	0 51
19	Capacitor 100mf/35v	2,613	0 38
20	Myler Capacitor	1,900	0.27
21	Trangistor-C828	1,544	0 22
22	Registor 100k/0 25w	1,283	0 18
23	Capacitor 10mf/50v	1,188	0 17
24	L E D	950	0 14
25	Registor 22k/0 25w	641	0 09
26	Diode in4007	534	0 08
27	Registor 1k/0 5w	475	0.07
28	Registor 3 3k/0 25w	427	0 06
29	Registor 1k/0 25w	213	0 03
		Total = 6,95,175	Total = 100

Table 4.4: Sample ABC classification of inventory

Classification	Item Serial Number	Annual Taka Usage	Percent of Total Taka Usage	Number of Items	Percent of Total Number of Items
A	1,2,3	5,03,712	72 5	3	10.3
B	4,5	60,588	8.7	2	6 9
C	Rest of Numbers	1,30,875	18 5	24	82.8
Total		6,95,175	100	29	100

The ABC analysis reveals that transformer, cabinet and relay were the most costly items responsible for about 72.5% of the total annual raw material cost, while representing only 10.3% of the inventory items. So transformer, cabinet and relay could be classified as item A. Similarly voltmeter (4.4%) and socket (4.3%) accounts for 8.7% of the value of the inventory, while representing only 6.9% of the inventory items. Voltmeter and Socket could

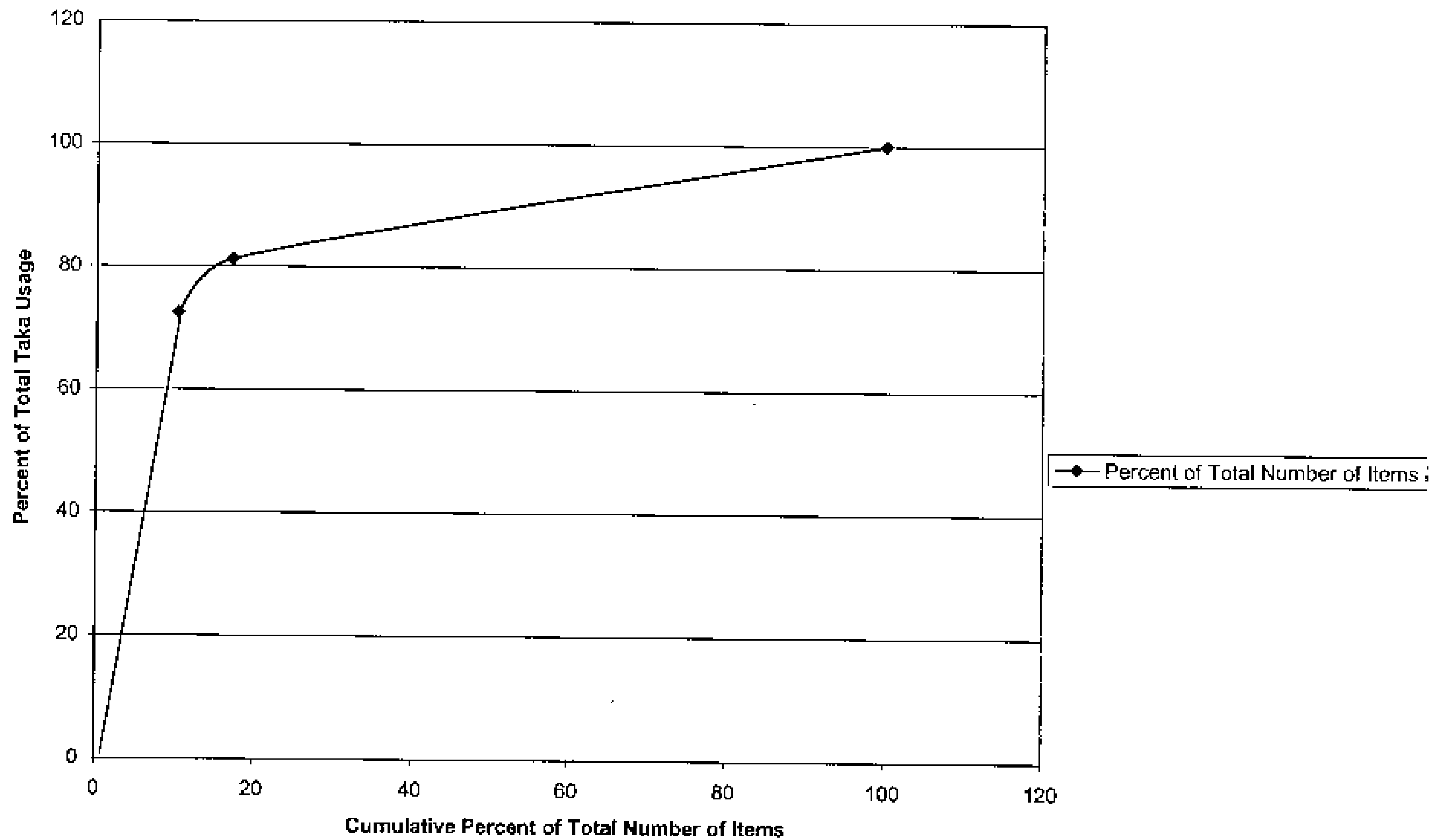

Figure 5.1: Typical ABC Inventory Analysis

be termed as B item. The rest of the items were considered as C items whose volume accounts for 18.8% of the inventory value but 82 8% of the inventory items. Figure 5.1 shows a typical ABC inventory classification. The class A items require the greatest attention, and the class C items need no special calculations, since they represent a low inventory investment. The major concern of an ABC classification is to direct attention to those inventory items that represent the largest annual expenditures. Tight control, sound operating and attention to security on A items would allow to control a large Taka volume with a reasonable amount of time and effort [5,13].

4.6.2 SELECTED PRINCIPAL ITEMS

Only eleven items were taken into account for lot sizing determination that is used in bulk quantity. The items were as follows:

1) Transformer
2) Cabinet
3) Relay 5p/12v
4) Voltmeter
5) Socket
6) Variable Registor 100K
7) Transistor D400
8) IC LM324
9) Electronic Capacitor 220mf/35V
10) Registor 100k/0.25W
11) Light emitting diode-red

4.7 POM SOFTWARE

The POM software, developed by Howard Weiss, is an educational version used to solve problems related to operations management. It has 20 modules such as Aggregate Planning, Assignment, Balancing Assembly Line, forecasting, Inventory, job Shop Scheduling, Linear Programming, Location, Lot Sizing, Material Requirements Planning, Project Management (PERT/CPM), Waiting Lines etc.

The module of material requirements planning (MRP) contains the columns named as Item name, Level, Lead time, Per parent, on hand inventory, Lot size and Minimum quantity The term 'level' indicates the level based on BOM product structure. This implies that the number inserted into this column will represent the level of the item in the BOM structure. 'Lead time' is the time elapsed from placing an order and the receipt. There are three types of lead times: assembly lead times, manufacturing lead times and ordering lead times respectively applied to assembly, manufacture a part and raw materials. 'Per parent'- tells the number or quantity required to make one unit of the product

The sample calculation is this section is for 550VA Stabiliser whose product structure comprises of three levels. The data obtained have been arranged in a tabular form from low level (0) item to high level (2) item starting with total requirement (TOT. REQ.); on hand inventory (ON HAND); schedule receipt (SCHE. REC.); net requirement (NET REQ.); planned receipt (PLAN REC.) and order release (ORD. REL.) against the period.

CHAPTER 5

DATA COLLECTION AND ANALYSIS

5.1 INTRODUCTION

The data and information collected were translated into usable formats and then analyzed. The analysis was carried out by an educational version of production and operations management (POM) software. This software is of very limited capacity with which it is not possible to handle a real life industrial problem having a large number of products over a wide horizon of time period. In the present study only the main items of products (stabiliser) were considered for a time-period of about six months to calculate the demand for the subsequent periods.

5.2 DATA COLLECTION

In manufacturing Stabiliser raw materials or parts are procured from local markets and from importers. Some of these items are used directly whereas majority pass through some tests and operations and then used. For the latter case, the lead-time for a job is the time required completing a job by performing the necessary operations & tests. For the former case, the lead-time for an item is the time required from initiation of purchase requisition to the receipt of the item from the vendor.

Data on lead times were collected from the concerned operators whereas ordering lead times were based on the recorded data in the store. In either case lead-time has been chosen on the basis of 'time needed most frequently'. It was noticed that manufacturing lead-time and assembly lead-time are matters of days and ordering lead-time is a matter of days or 1-2 weeks.

5.3 DETERMINATION OF SET UP AND HOLDING COSTS

The cost elements relating to set up and holding costs being enormons, therefore, its determination became quite difficult. The difficulty arose due to non-availability of data as formatted in the text. Therefore, information was gathered from the procurement officer's buying experience and relevant figures were estimated. So it is natural that the figures/data will not be exact due to guess and rough estimation

But POM does not facilitate of this aggregation And if it (aggregation) is done from manually done spreadsheet it would be time consuming and also there would be chance of errors. Therefore to avoid lot of data handling and errors and also to minimize the tedious effort, it is advantageous to calculate the quantities of raw materials requirement by Excel. It may be noted here that the results determined by Excel will be exactly the same as the data determined by manually prepared spreadsheet The result of material requirement planning (done manually) for 550VA stabiliser is shown from next page A sample calculation for determining ten, 550VA Stabiliser's is given from Table 5.1 to Table 5.5.

Table 5.1 Material Requirements Planning for 550VA Stabiliser

Item name	Level	Lead Time (days)	Per Parent	On Hand Inventory	Lot size	Min. quantity	Pd 1	Pd 2		Pd 9	Pd 10
Stabiliser	0	1	1	0							10
Transformer	1	3	1	0							
Ckt Board	1	1	1	0							
PCB	2	2	1	0							
Diode in4007	2	1	12	0							
Z. Diode 4 7v	2	1	3	0							
Z. Diode 12v	2	1	1	0							
L.F.D-Red	2	1	1	0							
L.E D-Green	2	1	1	0							
L.E.D-yellow	2	1	1	0							
Trangistor D400	2	1	2	0							
Trangistor H1061	2	1	1	0							
Trangistor C828	2	1	1	0							
V.R-100K	2	1	6	0							
Relay 5p/12v/12a	2	1	2	0							
IC LM324	2	1	1	0							
Registor 1k/0.5w	2	1	1	0							
Registor 1k/0.25w	2	1	1	0							
Registor 1.2k	2	1	1	0							
Registor 3.3k	2	1	2	0							
Registor 3.3M	2	1	1	0							
Registor 4 7k	2	1	2	0							
Registor 10k	2	1	2	0							

Table 5.1 Material Requirements Planning for 550VA Stabiliser (continue)

Registor 22k	2	1	3	0							
Registor 1M	2	1	1	0							
Registor 82k	2	1	2	0							
Registor 1M- 5w	2	1	1	0							
Registor 100k	2	1	6	0							
Registor 120k	2	1	3	0							
Registor 220k	2	1	3	0							
Registor 270k	2	1	1	0							
Cap 1000mf-63v	2	1	1	0							
Cap 220mf-35v	2	1	1	0							
Cap 100mf-35v	2	1	1	0							
Cap. 10mf-50v	2	1	1	0							
Cap 4.7mf-50v	2	1	1	0							
Cap 1mf-100v	2	1	1	0							
Cap 0 47mf-50v	2	1	1	0							
Myler cap 2a	2	1	2	0							
Ceramic Cap 16v	2	1	8	0							
Cabinet	1	1	1	0							
Cabinet	2	3	1	0							
Fuse holder	2	1	1	0							
Power switch	2	1	1	0							
Push switch	2	1	1	0							
Volt meter	2	1	1	0							
Socket	2	1	1	0							
Grommet	2	1	1	0							

Table 5.2 Indented Bill of Material of 550VA Stabiliser

Item ID			Lead Time	Number per Parent	On hand inventory	Lot size	Minimum Quantity
Stabilizer			1	1	0		
	Transformer		3	1	0		
	Circuit Board		1	1	0		
		PCB	2	1	0		
		Diode in 4007	1	12	0		
		Z Diode 4.7v	1	3	0		
		Z Diode 12v	1	1	0		
		LED -Red	1	1	0		
		LED- Yellow	1	1	0		
		LED- Green	1	1	0		
		Trangistor-D400	1	2	0		
		Trangistor- H1061	1	1	0		
		Trangistor- C828	1	1	0		
		VR-100k	1	6	0		
		Relay 5p/12v/12a	1	2	0		
		IC- LM324	1	1	0		
		Registor 1k/ 5w	1	1	0		
		Registor 1k/ 25w	1	1	0		
		Registor 1.2k/.25w	1	1	0		
		Registor 3 3k/.25w	1	2	0		
		Registor 3 3m/ 25w	1	1	0		
		Registor 4 7k/.25w	1	2	0		
		Registor 10k/.25w	1	2	0		
		Registor 22k/.25w	1	3	0		
		Registor 1m/ 25w	1	1	0		
		Registor 82k/ 25w	1	2	0		
		Registor 1m/ 5w	1	1	0		
		Registor 100k/.25w	1	6	0		
		Registor 120k/ 25w	1	3	0		
		Registor 220k/.25w	1	3	0		
		Registor 270k/.25w	1	1	0		
		Cap. 1000mf/63v	1	1	0		
		Cap 220mf/35v	1	1	0		
		Cap 100mf/35v	1	1	0		
		Cap 10mf/50v	1	1	0		
		Cap 4 7mf/50v	1	1	0		
		Cap. 1mf/100v	1	1	0		
		Cap 47mf/50v	1	1	0		
		Myler Cap. 2a	1	2	0		
		Ceremic Cap 16v	1	8	0		
	Cabinet		1	1	0		
		Cabinet	3	1	0		
		Fuse Holder	1	1	0		
		Power Switch	1	1	0		
		Push Switch	1	1	0		
		Volt Meter	1	1	0		
		Socket	1	1	0		
		Grommet	1	1	0		

0 1 2

Level ⟶

Demand for level 0 items i e. 550VA Stabiliser is assumed to be as follows:

Period	Demand
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	10

Table 5.3 Stabiliser (low level = 0)

Period	1	2	3	4	5	6	7	8	9	10	
Tot Req.										10	
On Hand											
Sche. Rec											
Net Req										10	
Plan Rec.										10	
Ord Rel.									10		

Table 5.4 Transformer (low level = 1)

Period	1	2	3	4	5	6	7	8	9	10	
Tot. Req									10		
On Hand											
Sche Rec											
Net Req.									10		
Plan Rec									10		
Ord. Rel						10					

And so on. But to arrange all this Tables create unnecessary occupation of space. Therefore, it is given in the Table 5.5 in a concise form.

Table 5.5 Concise MRP for 550VA Stabiliser (Requirement and period of requirement)

Item Name	Level	Tot. Req /Period	On Hand	Schedule receipt	Net req/Period	Plan rec/Period	Order Rel/ Period
Stabiliser	0	10/10			10/10	10/10	10/9
Transformer	1	10/9			10/9	10/9	10/6
Ckt. Board	1	10/9			10/9	10/9	10/8
PCB	2	10/8			10/8	10/8	10/6
Diode in4007	2	120/8			120/8	120/8	120/7
Z Diode 4 7v	2	30/8			30/8	30/8	30/7
Z Diode 12v	2	10/8			10/8	10/8	10/7
L.E.D-Red	2	10/8			10/8	10/8	10/7
L E D-Green	2	10/8			10/8	10/8	10/7
L E D-yellow	2	10/8			10/8	10/8	10/7
Trangistor D400	2	20/8			20/8	20/8	20/7
Trangistor H1061	2	10/8			10/8	10/8	10/7
Trangistor C828	2	10/8			10/8	10/8	10/7
V.R-100K	2	60/8			60/8	60/8	60/7
Relay 5p/12v/12a	2	20/8			20/8	20/8	20/7
IC LM324	2	10/8			10/8	10/8	10/7
Registor 1k/0 5w	2	10/8			10/8	10/8	10/7
Registor 1k/0 25w	2	10/8			10/8	10/8	10/7
Registor 1 2k	2	10/8			10/8	10/8	10/7
Registor 3.3k	2	20/8			20/8	20/8	20/7
Registor 3 3M	2	10/8			10/8	10/8	10/7
Registor 4.7k	2	20/8			20/8	20/8	20/7
Registor 10k	2	20/8			20/8	20/8	20/7
Registor 22k	2	30/8			30/8	30/8	30/7
Registor 1M	2	10/8			10/8	10/8	10/7
Registor 82k	2	20/8			20/8	20/8	20/7
Registor 1M-.5w	2	10/8			10/8	10/8	10/7
Registor 100k	2	60/8			60/8	60/8	60/7
Registor 120k	2	30/8			30/8	30/8	30/7
Registor 220k	2	30/8			30/8	30/8	30/7
Registor 270k	2	10/8			10/8	10/8	10/7
Cap 1000mf-63v	2	10/8			10/8	10/8	10/7
Cap 220mf-35v	2	10/8			10/8	10/8	10/7
Cap 100mf-35v	2	10/8			10/8	10/8	10/7
Cap. 10mf-50v	2	10/8			10/8	10/8	10/7
Cap 4 7mf-50v	2	10/8			10/8	10/8	10/7
Cap 1mf-100v	2	10/8			10/8	10/8	10/7
Cap 0 47mf-50v	2	10/8			10/8	10/8	10/7
Myler cap. 2a	2	20/8			20/8	20/8	20/7
Ceramic Cap. 16v	2	80/8			80/8	80/8	80/7
Cabinet	1	10/9			10/9	10/9	10/7
Cabinet	2	10/8			10/8	10/8	10/5
Fuse holder	2	10/8			10/8	10/8	10/7
Power switch	2	10/8			10/8	10/8	10/7
Push switch	2	10/8			10/8	10/8	10/7
Volt meter	2	10/8			10/8	10/8	10/7
Socket	2	10/8			10/8	10/8	10/7
Grommet	2	10/8			10/8	10/8	10/7

5.4 EVALUATION OF MATERIAL REQUIREMENTS BY EXCEL

The monthly master production schedule for 550VA Stabiliser ranging from 140V to 270V is presented in table 5.6 for six months starting from January 2002 to June 2002. Data on demand for the Stabiliser during January to June 2002 were available from the record of the factory.

It may be noted that the lead times for different raw materials or components are different. To facilitate the determination of time-phased requirements of materials having shorter lead times, the monthly MPS is broken down into day basis. It is necessary to mention that the present analysis has been restricted for the raw materials procured from outside of the factory and does not include the items fabricated within the premises of the factory. Out of 47 items, 11 items (raw materials) are procured from internal market, which need some processing's in the factory. According to the record, the lead times for procuring these materials can be less than a week.

The total requirements of the individual raw materials over the time horizon were calculated. Thus the cumulative amount of raw materials requirements determined on the basis of day.
For example to determine periodic demand of transformer it would require to multiply the transformer column of Table 5 7 with the columns of Table 5.6 the resnlts of which are presented in the Table 5.8.

Table 5.6

Day basis Master Production Schedule (MPS) of Stabiliser from January, 02 to June, 02

VA	First Forty Days	Second Forty Days	Third Forty Days	Fourth Forty Days	Last Twenty One Days
550	1	0	0	0	2
	0	6	5	1	0
	2	3	6	0	0
	0	1	2	4	4
	0	8	12	2	0
	1	0	14	6	4
	0	1	5	3	0

0	17	0	2	5
1	5	4	3	5
3	14	4	1	2
3	27	2	3	2
1	0	2	0	0
1	0	5	4	3
0	0	1	3	3
0	0	0	5	0
0	0	1	1	0
4	0	3	0	1
0	1	0	5	3
1	3	2	0	0
1	0	11	3	1
1	3	0	7	0
1	8	0	5	
2	3	8	8	
1	0	0	0	
0	3	1	6	
1	8	1	5	
2	1	10	4	
0	4	4	1	
4	2	0	7	
12	3	2	10	
0	6	5	0	
0	32	2	1	
1	3	12	2	
6	0	6	0	
22	2	0	7	
0	2	0	6	
16	3	3	3	
4	4	7	0	
0	0	3	3	
17	11	1	1	

Table 5.7

Raw material requirement for Stabiliser

	Transformer	Cabinet	Relay 5p/12 v/12a	Voltmeter	Socket	VR 100k	Transistor D400	IC LM324	Cap 220 mf	Registor 100k	LED-Red
Stabiliser	Piece	Piece	Piece	Piece	Piece	Piece	Piece	Piece	Piece	Piece	Piece
	1	1	2	1	1	6	2	1	1	6	1

Table 5.8

Periodic demand of transformer

VA	First Forty Days	Second Forty Days	Third Forty Days	Fourth Forty Days	Fifth Forty Days
550	1	0	0	0	2
	0	6	5	1	0
	2	3	6	0	0
	0	1	2	4	4
	0	8	12	2	0
	1	0	14	6	4
	0	1	5	3	0
	0	17	0	2	5
	1	5	4	3	5
	3	14	4	1	2
	3	27	2	3	2
	1	0	2	0	0
	1	0	5	4	3
	0	0	1	3	3
	0	0	0	5	0
	0	0	1	1	0
	4	0	3	0	1
	0	1	0	5	3
	1	3	2	0	0
	1	0	11	3	1
	1	3	0	7	0
	1	8	0	5	

	2	3	8	8	
	1	0	0	0	
	0	3	1	6	
	1	8	1	5	
	2	1	10	4	
	0	4	4	1	
	4	2	0	7	
	12	3	2	10	
	0	6	5	0	
	0	32	2	1	
	1	3	12	2	
	6	0	6	0	
	22	2	0	7	
	0	2	0	6	
	16	3	3	3	
	4	4	7	0	
	0	0	3	3	
	17	11	1	1	

5.5 MRP LOT SIZING

To ensure that all requirements will be satisfied, an order will be scheduled for completion at the beginning of the first period in which there is a positive net requirement. The size of the order may be just equal to the net requirement in the period in which it is due, or it may be larger to take advantage of economies of scale also covering net requirements in some subsequent periods. The process of deciding on the order quantity is called lot-sizing [2].

5.6 ESTIMATION OF RELEVANT INVENTORY COSTS

There are three main costs of 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 estimates of costs. So great precision is not necessary.

In the present study shortage cost was not considered. The costs that were estimate are holding and ordering costs. Holding costs are the cost associated with holding or "carrying" inventory over time. Therefore, holding costs include obsolescence and costs referred to shortage, such as insurance, extra staffing and interest payment. Considering the local conditions and consulting with the involved persons in the company the estemated holding cost elements are presented in Table 5.9

Table 5.9 Estimation of holding cost elements

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	3%
4 Investment costs such as borrowing costs, Taxes and insurance in inventory	6%
5. Pilferage, scarp and obsolescence....... .	2%
Total	16%

Thus the overall carrying costs can be evaluated by summing up all the cost elements. Any inventory holding cost of less than 15% is susceptible, but annual holding cost often approaches 40% of the value of inventory.

Ordering cost is the cost that increases with the number of orders placed. The cost include cost of supplies, forms, order processing, clerical support and so forth [10]. The estemated ordering cost elements for transformer, cabinet and components are presented in Tables 5.10 - 5 12.

Table 5.10 Ordering cost of Transformer

Heads	Estimated Cost
1. Preparation of purchase requisition	Tk.0
2. Preparation of purchase order	Tk.0
3. Mail	Tk 0
4. Expediting (telephone & telegraph)	Tk.3
5. Transportation	Tk.148
6. Receiving	Tk 50
7. Inspection	Tk.5
8. Put away	Tk.30
9. Updating inventory records	Tk.1 5
10. Paying invoice	Tk.0
11. LC	Tk.0
12. Customs	Tk 0
Total	Tk.237.5

Table 5.11 Ordering cost of Cabinet

Heads	Estimated Cost
1. Preparation of purchase requisition	Tk.0
2. Preparation of purchase order	Tk.0
3. Mail	Tk.0
4. Expediting (telephone & telegraph)	Tk.3
5. Transportation	Tk.212
6. Receiving	Tk.0
7. Inspection	Tk.0
8. Put away	Tk.25
9. Updating inventory records	Tk 1
10. Paying invoice	Tk 0
11. LC	Tk.0
12. Customs	Tk.0
Total	Tk.241

Table 5.12 Ordering cost of Components (Such as voltmeter, socket, relay, IC-LM 324 etc.)

Heads	Estimated Cost
1. Preparation of purchase requisition	Tk.38
2 Preparation of purchase order	Tk.0
3. Mail	Tk.0
4 Expediting (telephone & telegraph)	Tk 5
5 Transportation	Tk.200
6. Receiving	Tk.35
7. Inspection	Tk.125
8. Put away	Tk.25
9. Updating inventory records	Tk.16
10. Paying invoice	Tk.0
11. LC	Tk.0
12. Customs	Tk.0
	Total Tk.444

Calculation of Holding and Ordering Costs

Holding (or carrying) costs are those costs that 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 items. The purchase costs of the raw materials are presented in Table 5.13

Table 5.13 Cost of Raw Material

Items	Cost
1. Transformer	Tk.300 per piece
2. Cabinet	Tk.80 per piece
3. Relay 5p/12v/12a	Tk.22 per piece
4. Voltmeter	Tk. 26 per piece
5. Socket	Tk. 25 per piece

6. Variable Registor(VR)-100K Tk.2.50 per piece
7. Trangistor D400 Tk 4.50 per piece
8 Integrated Circuit(IC)-LM324 Tk.8.50 per piece
9 Capacitor 220mf/35v/63v Tk.3 per piece
10. Registor 100k/0 25w Tk.0.18 per piece
11. L.E.D-Red Tk.0 80 per piece

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

h = fb

Where f = holding cost fraction and

b = Unit cost (The value of b are assigned in Table 5 13)

Sample Calculation

The holding cost for inventory of Cabinet for which f = 0.16 per year, b = Taka 80 per piece is evaluated as h = (0 16 * 80)/12 = Taka 1.07 per piece-month. In Table 5.12, the holding and ordering costs for the different raw materials consumed in stabiliser are presented

Table 5.14 Holding and Ordering Costs for different materials

Item	Holding Cost (Tk Per unit-day)	Ordering Cost (Tk. Per order)
Transformer	0 13	237.5
Cabinet	0.036	241
Relay 5p/12v/12a	0.01	444
Voltmeter	0.35	444
Socket	0 01	444
Variable Registor(VR) 100K	0.001	444
Trangistor D400	0.002	444
Integrated Circuit(IC)-LM324	0.004	444
Capacitor 220mf/35v/63v	0.001	444
Registor 100k/0.25w	0.0001	444
L.E.D-Red	0.0004	444

5.7 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 there are five options finding total cost: Wagner-Whitin, EOQ, Lot for Lot, POQ and Part Period Balancing. 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 cost. In the subsequent Tables 5.15-5.45, the required data for Transformer were provided followed by the results obtained through application of the methods such Wagner-Whitin, EOQ, Lot-for-Lot, POQ and Part Period Balancing respectively.

Table 5.15

Problem title: Lot size determination of Transformer

Period	Demand (Piece)	Parameter	Value
1	1	Holding Cost	0 130
2	0	Setup Cost	237 5
3	2	Initial Inventory	3
4	0	Lead Time	3
5	0		
6	1		
7	0		
8	0		
9	1		
10	3		
11	3		
12	1		
13	1		
14	0		
15	0		
16	0		
17	4		
18	0		
19	1		
20	1		
21	1		
22	1		
23	2		
24	1		
25	0		
26	1		
27	2		
28	0		
29	4		
30	12		
31	0		
32	0		
33	1		
34	6		
35	22		
36	0		
37	16		
38	4		
39	0		
40	17		

Results:

Table 5.16

Transformer, Method: Wagner-Whitin (first fourty days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			3		
1	1		2	0.26	
2	0		2	0.26	
3	2		0		
4	0		0		
5	0		0		
6	1	24	23	2.99	237.5
7	0		23	2.99	
8	0		23	2.99	
9	1		22	2.86	
10	3		19	2.47	
11	3		16	2.08	
12	1		15	1.95	
13	1		14	1.82	
14	0		14	1.82	
15	0		14	1.82	
16	0		14	1.82	
17	4		10	1.3	
18	0		10	1.3	
19	1		9	1.17	
20	1		8	1.04	
21	1		7	0.91	
22	1		6	0.78	
23	2		4	0.52	
24	1		3	0.39	
25	0		3	0.39	
26	1		2	0.26	
27	2		0		
28	0		0		
29	4	82	78	10.14	237.5
30	12		66	8.58	
31	0		66	8.58	
32	0		66	8.58	
33	1		65	8.45	
34	6		59	7.67	
35	22		37	4.81	
36	0		37	4.81	
37	16		21	2.73	
38	4		17	2.21	
39	0		17	2.21	
40	17		0		
Totals	109	106	792	102.96	475
Ave demand	2.725				
Total Cost	577.96				

Table 5.17

Transformer, Method: Lot for lot (First Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			3		
1	1		2	0 26	
2	0		2	0 26	
3	2	1	1	0 13	237.5
4	0		1	0 13	
5	0		1	0 13	
6	1	1	1	0 13	237.5
7	0	3	4	0.52	237 5
8	0	3	7	0.91	237 5
9	1	1	7	0.91	237.5
10	3	1	5	0.65	237 5
11	3		2	0.26	
12	1		1	0.13	
13	1		0		
14	0	4	4	0.52	237.5
15	0		4	0 52	
16	0	1	5	0 65	237.5
17	4	1	2	0 26	237.5
18	0	1	3	0 39	237.5
19	1	1	3	0 39	237.5
20	1	2	4	0.52	237.5
21	1	1	4	0 52	237.5
22	1		3	0 39	
23	2	1	2	0.26	237 5
24	1	2	3	0.39	237.5
25	0		3	0 39	
26	1	4	6	0 78	237.5
27	2	12	16	2 08	237.5
28	0		16	2.08	
29	4		12	1.56	
30	12	1	1	0.13	237 5
31	0	6	7	0.91	237.5
32	0	22	29	3 77	237 5
33	1		28	3.64	
34	6	16	38	4.94	237 5
35	22	4	20	2.6	237.5
36	0		20	2.6	
37	16	17	21	2.73	237.5
38	4		17	2 21	
39	0		17	2.21	
40	17		0		
Totals	109	106	322	41 86	5462.5
Ave demand	2 725				
Total Cost	5504 36				

Table 5.18
Transformer, Method: Economic Order Quantity (First Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			3		
1	1		2	0.26	
2	0		2	0.26	
3	2	100	100	13	237.5
4	0		100	13	
5	0		100	13	
6	1		99	12.87	
7	0		99	12.87	
8	0		99	12.87	
9	1		98	12.74	
10	3		95	12.35	
11	3		92	11.96	
12	1		91	11.83	
13	1		90	11.7	
14	0		90	11.7	
15	0		90	11.7	
16	0		90	11.7	
17	4		86	11.18	
18	0		86	11.18	
19	1		85	11.05	
20	1		84	10.92	
21	1		83	10.79	
22	1		82	10.66	
23	2		80	10.4	
24	1		79	10.27	
25	0		79	10.27	
26	1		78	10.14	
27	2		76	9.88	
28	0		76	9.88	
29	4		72	9.36	
30	12		60	7.8	
31	0		60	7.8	
32	0		60	7.8	
33	1		59	7.67	
34	6		53	6.89	
35	22		31	4.03	
36	0		31	4.03	
37	16	100	115	14.95	237.5
38	4		111	14.43	
39	0		111	14.43	
40	17		94	12.22	
Totals	109	200	3168	411.8399	475
Ave demand	2.725		EOQ	100	
Total Cost	886.84				

Table 5.19
Transformer, Method: Period Order Quantity (First Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			3		
1	1		2	0.26	
2	0		2	0 26	
3	2	106	106	13.78	237.5
4	0		106	13 78	
5	0		106	13.78	
6	1		105	13.65	
7	0		105	13.65	
8	0		105	13 65	
9	1		104	13.52	
10	3		101	13 13	
11	3		98	12.74	
12	1		97	12 61	
13	1		96	12 48	
14	0		96	12 48	
15	0		96	12.48	
16	0		96	12.48	
17	4		92	11.96	
18	0		92	11 96	
19	1		91	11 83	
20	1		90	11.7	
21	1		89	11.57	
22	1		88	11 44	
23	2		86	11 18	
24	1		85	11.05	
25	0		85	11.05	
26	1		84	10 92	
27	2		82	10.66	
28	0		82	10 66	
29	4		78	10.14	
30	12		66	8 58	
31	0		66	8 58	
32	0		66	8.58	
33	1		65	8 45	
34	6		59	7.67	
35	22		37	4 81	
36	0		37	4.81	
37	16		21	2.73	
38	4		17	2 21	
39	0		17	2 21	
40	17		0		
Totals	109	106	2996	389 4799	237.5
Ave demand	2 725		EOQ	100	
Total Cost	626 98		POQ	37	

Table 5.20
Transformer, Method: Part Period Balancing (First Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			3		
1	1		2	0.26	
2	0		2	0 26	
3	2		0		
4	0		0		
5	0		0		
6	1	85	84	10 92	237 5
7	0		84	10.92	
8	0		84	10 92	
9	1		83	10 79	
10	3		80	10 4	
11	3		77	10.01	
12	1		76	9.88	
13	1		75	9.75	
14	0		75	9.75	
15	0		75	9.75	
16	0		75	9.75	
17	4		71	9.23	
18	0		71	9.23	
19	1		70	9.1	
20	1		69	8.97	
21	1		68	8 84	
22	1		67	8 71	
23	2		65	8.45	
24	1		64	8 32	
25	0		64	8 32	
26	1		63	8.19	
27	2		61	7.93	
28	0		61	7.93	
29	4		57	7.41	
30	12		45	5 85	
31	0		45	5.85	
32	0		45	5.85	
33	1		44	5.72	
34	6		38	4 94	
35	22		16	2 08	
36	0		16	2.08	
37	16		0		
38	4	21	17	2 21	237 5
39	0		17	2 21	
40	17		0		
Totals	109	106	2006	260 78	475
Ave demand	2 725				
Total Cost	735.78				

Table 5.21
Transformer, Method. User defined approach (First Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			3		
1	1		2	0.26	
2	0		2	0.26	
3	2	25	25	3.25	237.5
4	0		25	3.25	
5	0		25	3.25	
6	1		24	3.12	
7	0		24	3.12	
8	0	20	44	5.72	237.5
9	1		43	5.59	
10	3		40	5.2	
11	3		37	4.81	
12	1	10	46	5.98	237.5
13	1		45	5.85	
14	0		45	5.85	
15	0		45	5.85	
16	0	15	60	7.8	237.5
17	4		56	7.28	
18	0		56	7.28	
19	1		55	7.15	
20	1		54	7.02	
21	1	25	78	10.14	237.5
22	1		77	10.01	
23	2		75	9.75	
24	1		74	9.62	
25	0		74	9.62	
26	1	14	87	11.31	237.5
27	2		85	11.05	
28	0		85	11.05	
29	4		81	10.53	
30	12		69	8.97	
31	0		69	8.97	
32	0		69	8.97	
33	1		68	8.84	
34	6		62	8.06	
35	22		40	5.2	
36	0		40	5.2	
37	16		24	3.12	
38	4		20	2.6	
39	0		20	2.6	
40	17		3	0.39	
Totals	109	109	1953	253.89	1425
Ave demand	2.725				
Total Cost	1678.89				

Table 5.22

Transformer, Method. Wagner-Whitin (Second fourty days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			9		
1	0		9	1.17	
2	6		3	0.39	
3	3		0		
4	1	175	174	22 62	237 5
5	8		166	21.58	
6	0		166	21.58	
7	1		164	21.45	
8	17		148	19 24	
9	5		143	18.59	
10	14		129	16 77	
11	27		102	13 26	
12	0		102	13.26	
13	0		102	13.26	
14	0		102	13 26	
15	0		102	13 26	
16	0		102	13.26	
17	0		102	13.26	
18	1		101	13 13	
19	3		98	12 74	
20	0		98	12.74	
21	3		95	12.35	
22	8		87	11 31	
23	3		84	10.92	
24	0		84	10.92	
25	3		81	10 53	
26	8		73	9 49	
27	1		72	9.36	
28	4		68	8.84	
29	2		66	8.58	
30	3		63	8 19	
31	6		57	7.41	
32	32		25	3 25	
33	3		22	2 86	
34	0		22	2.86	
35	2		20	2.6	
36	2		18	2.34	
37	3		15	1.95	
38	4		11	1.43	
39	0		11	1.43	
40	11		0		
Totals	184	175	3088	401 439	237 5
Ave demand	4.6				
Total Cost	638 939				

Table 5.23

Transformer, Method: Lot for lot (Second Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			9		
1	0	1	10	1.3	237.5
2	6	8	12	1.56	237.5
3	3		9	1.17	
4	1	1	9	1.17	237.5
5	8	17	18	2.34	237.5
6	0	5	23	2.99	237.5
7	1	14	36	4.68	237.5
8	17	27	46	5.98	237.5
9	5		41	5.33	
10	14		27	3.51	
11	27		0		
12	0		0		
13	0		0		
14	0		0		
15	0	1	1	0.13	237.5
16	0	3	4	0.52	237.5
17	0		4	0.52	
18	1	3	6	0.78	237.5
19	3	8	11	1.43	237.5
20	0	3	14	1.82	237.5
21	3		11	1.43	237.5
22	8	3	6	0.78	
23	3	8	11	1.43	237.5
24	0	1	12	1.56	237.5
25	3	4	13	1.69	237.5
26	8	2	7	0.91	237.5
27	1	3	9	1.17	237.5
28	4	6	11	1.43	237.5
29	2	32	41	5.33	237.5
30	3	3	41	5.33	237.5
31	6		35	4.55	
32	32	2	5	0.65	237.5
33	3	2	4	0.52	237.5
34	0	3	7	0.91	237.5
35	2	4	9	1.17	237.5
36	2		7	0.91	
37	3	11	15	1.95	237.5
38	4		11	1.43	
39	0		11	1.43	
40	11		0		
Totals	184	175	537	69.81	6175
Ave demand	4.6				
Total Cost	6244.81				

Table 5.24
Transformer, Method: Economic Order Quantity (Second Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			9		
1	0	130	139	18 07	237.5
2	6		133	17 29	
3	3		130	16 9	
4	1		129	16.77	
5	8		121	15.73	
6	0		121	15.73	
7	1		120	15.6	
8	17		103	13.39	
9	5		98	12.74	
10	14		84	10.92	
11	27		57	7.41	
12	0		57	7.41	
13	0		57	7.41	
14	0		57	7.41	
15	0		57	7.41	
16	0		57	7 41	
17	0		57	7 41	
18	1		56	7 28	
19	3		53	6 89	
20	0		53	6 89	
21	3		50	6.5	
22	8		42	5.46	
23	3		39	5 07	
24	0		39	5 07	
25	3		36	4 68	
26	8		28	3 64	
27	1		27	3 51	
28	4		23	2 99	
29	2	130	151	19 63	237 5
30	3		148	19.24	
31	6		142	18 46	
32	32		110	14.3	
33	3		107	13 91	
34	0		107	13 91	
35	2		105	13.65	
36	2		103	13.39	
37	3		100	13	
38	4		96	12 48	
39	0		96	12 48	
40	11		85	11 05	
Totals	184	260	3373	438 49	475
Ave demand	4.6		EOQ	130	
Total Cost	913 49				

Table 5.25
Transformer, Method: Period Order Quantity (Second Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			9		
1	0	118	127	16.51	237.5
2	6		121	15 73	
3	3		118	15.34	
4	1		117	15.21	
5	8		109	14.17	
6	0		109	14.17	
7	1		108	14 04	
8	17		91	11.83	
9	5		86	11.18	
10	14		72	9 36	
11	27		45	5 85	
12	0		45	5.85	
13	0		45	5.85	
14	0		45	5 85	
15	0		45	5 85	
16	0		45	5 85	
17	0		45	5.85	
18	1		44	5.72	
19	3		41	5 33	
20	0		41	5 33	
21	3		38	4.94	
22	8		30	3 9	
23	3		27	3 51	
24	0		27	3 51	
25	3		24	3.12	
26	8		16	2 08	
27	1		15	1.95	
28	4		11	1.43	
29	2	57	66	8 58	237 5
30	3		63	8.19	
31	6		57	7.41	
32	32		25	3.25	
33	3		22	2 86	
34	0		22	2.86	
35	2		20	2.6	
36	2		18	2.34	
37	3		15	1.95	
38	4		11	1.43	
39	0		11	1.43	
40	11		0		
Totals	184	175	2017	262 21	475
Ave demand	4 6		EOQ	130	
Total Cost	737 21		POQ	28	

Table 5.26

Transformer, Method: Part Period Balancing (Second Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			9		
1	0		9	1.17	
2	6		3	0 39	
3	3		0		
4	1	150	149	19 37	237.5
5	8		141	18 33	
6	0		141	18.33	
7	1		140	18 2	
8	17		123	15.99	
9	5		118	15 34	
10	14		104	13 52	
11	27		77	10.01	
12	0		77	10.01	
13	0		77	10.01	
14	0		77	10 01	
15	0		77	10 01	
16	0		77	10.01	
17	0		77	10 01	
18	1		76	9.88	
19	3		73	9.49	
20	0		73	9.49	
21	3		70	9.10	
22	8		62	8 06	
23	3		59	7 67	
24	0		59	7 67	
25	3		56	7 28	
26	8		48	6.24	
27	1		47	6 11	
28	4		43	5 59	
29	2		41	5.33	
30	3		38	4.94	
31	6		32	4.16	
32	32		0		
33	3	25	22	2.86	237 5
34	0		22	2.86	
35	2		20	2.6	
36	2		18	2.34	
37	3		15	1 95	
38	4		11	1.43	
39	0		11	1 43	
40	11		0		
Totals	184	175	2363	307.19	475
Ave demand	4 6				
Total Cost	782 19				

Table 5.27

Transformer, Method. User defined approach (Second Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			12		
1	0		12	1.17	
2	6	34	40	4 81	237.5
3	3		37	4 42	
4	1		36	4.29	
5	8		28	3.25	
6	0		28	3.25	
7	1	25	52	6 37	237 5
8	17		35	4.16	
9	5		30	3 51	
10	14		16	1 69	
11	27	20	9	0.78	237 5
12	0		9	0.78	
13	0		9	0.78	
14	0	10	19	2 08	237.5
15	0		19	2.08	
16	0		19	2.08	
17	0	25	44	5 33	237 5
18	1		43	5 2	
19	3		40	4 81	
20	0		40	4.81	
21	3		37	4 42	
22	8		29	3.38	
23	3	20	46	5.59	237 5
24	0		46	5.59	
25	3		43	5.2	
26	8		35	4 16	
27	1	25	59	7 28	237.5
28	4		55	6.76	
29	2		53	6 5	
30	3		50	6.11	
31	6	25	69	8 58	237.5
32	32		37	4.42	
33	3		34	4.03	
34	0		34	4.03	
35	2		32	3.77	
36	2		30	3 51	
37	3		27	3 12	
38	4		23	2 6	
39	0		23	2 6	
40	11		12	1.17	
Totals	184	184	1219	158.47	1900
Ave demand	4 6				
Total Cost					

Table 5.28

Transformer, Method: Wagner-Whitin (Third fourty days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			11		
1	0		11	1 43	
2	5		6	0 78	
3	6		0		
4	2	133	131	17.03	237 5
5	12		119	15 47	
6	14		105	13 65	
7	5		100	13	
8	0		100	13	
9	4		96	12.48	
10	4		92	11.96	
11	2		90	11.7	
12	2		88	11 44	
13	5		83	10 79	
14	1		82	10.66	
15	0		82	10 66	
16	1		81	10 53	
17	3		78	10 14	
18	0		78	10.14	
19	2		76	9.88	
20	11		65	8.45	
21	0		65	8.45	
22	0		65	8.45	
23	8		57	7.41	
24	0		57	7.41	
25	1		56	7.28	
26	1		55	7.15	
27	10		45	5 85	
28	4		41	5 33	
29	0		41	5.33	
30	2		39	5 07	
31	5		34	4 42	
32	2		32	4 16	
33	12		20	2 6	
34	6		14	1.82	
35	0		14	1.82	
36	0		14	1 82	
37	3		11	1.43	
38	7		4	0.52	
39	3		1	0.13	
40	1		0		
Totals	144	133	2228	289.64	237.5
Ave demand	3 6				
Total Cost	527.14				

Table 5.29

Transformer, Method: Lot for lot (Third Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			11		
1	0	2	13	1.69	237.5
2	5	12	20	2.6	237.5
3	6	14	28	3.64	237.5
4	2	5	31	4.03	237.5
5	12		19	2.47	
6	14	4	9	1.17	237.5
7	5	4	8	1.04	237.5
8	0	2	10	1.3	237.5
9	4	2	8	1.04	237.5
10	4	5	9	1.17	237.5
11	2	1	8	1.04	237.5
12	2	3	6	0.78	
13	5	1	2	0.26	237.5
14	1	3	4	0.52	237.5
15	0		4	0.52	
16	1	2	5	0.65	237.5
17	3	11	13	1.69	237.5
18	0		13	1.69	
19	2		11	1.43	
20	11	8	8	1.04	237.5
21	0		8	1.04	
22	0	1	9	1.17	237.5
23	8	1	2	0.26	237.5
24	0	10	12	1.56	237.5
25	1	4	15	1.95	237.5
26	1		14	1.82	
27	10	2	6	0.78	237.5
28	4	5	7	0.91	237.5
29	0	2	9	1.17	237.5
30	2	12	19	2.47	237.5
31	5	6	20	2.6	237.5
32	2		18	2.34	
33	12		6	0.78	
34	6	3	3	0.39	237.5
35	0	7	10	1.3	237.5
36	0	3	13	1.69	237.5
37	3	1	11	1.43	237.5
38	7		4	0.52	
39	3		1	0.13	
40	1		0		
Totals	144	133	416	54.08	6650
Ave demand	3.6				
Total Cost	6704.08				

Table 5.30

Transformer, Method: Economic Order Quantity (Third Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			11		
1	0	115	126	16 38	237.5
2	5		121	15.73	
3	6		115	14 95	
4	2		113	14.69	
5	12		101	13.13	
6	14		87	11.31	
7	5		82	10 66	
8	0		82	10.66	
9	4		78	10 14	
10	4		74	9 62	
11	2		72	9 36	
12	2		70	9 1	
13	5		65	8 45	
14	1		64	8 32	
15	0		64	8 32	
16	1		63	8 19	
17	3		60	7 8	
18	0		60	7.8	
19	2		58	7.54	
20	11		47	6 11	
21	0		47	6.11	
22	0		47	6.11	
23	8		39	5 07	
24	0		39	5 07	
25	1		38	4 94	
26	1		37	4 81	
27	10		27	3.51	
28	4		23	2.99	
29	0		23	2.99	
30	2		21	2.73	
31	5	115	131	17.03	237.5
32	2		129	16 77	
33	12		117	15 21	
34	6		111	14.43	
35	0		111	14 43	
36	0		111	14.43	
37	3		108	14.04	
38	7		101	13.13	
39	3		98	12 74	
40	1		97	12.61	
Totals	144	230	3057	397.41	475
Ave demand	3 6		EOQ	115	
Total Cost	872 41				

Table 5.31
Transformer, Method: Period Order Quantity (Third Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			11		
1	0	119	130	16.9	237.5
2	5		125	16.25	
3	6		119	15.47	
4	2		117	15.21	
5	12		105	13.65	
6	14		91	11.83	
7	5		86	11.18	
8	0		86	11.18	
9	4		82	10.66	
10	4		78	10.14	
11	2		76	9.88	
12	2		74	9.62	
13	5		69	8.97	
14	1		68	8.84	
15	0		68	8.84	
16	1		67	8.71	
17	3		64	8.32	
18	0		64	8.32	
19	2		62	8.06	
20	11		51	6.63	
21	0		51	6.63	
22	0		51	6.63	
23	8		43	5.59	
24	0		43	5.59	
25	1		42	5.46	
26	1		41	5.33	
27	10		31	4.03	
28	4		27	3.51	
29	0		27	3.51	
30	2		25	3.25	
31	5		20	2.6	
32	2		18	2.34	
33	12		6	0.78	
34	6	14	14	1.82	237.5
35	0		14	1.82	
36	0		14	1.82	
37	3		11	1.43	
38	7		4	0.52	
39	3		1	0.13	
40	1		0		
Totals	144	133	2165	281.45	475
Ave demand	3.6		EOQ	115	
Total Cost	756.45		POQ	32	

Table 5.32
Transformer, Method: Part Period Balancing (Third Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			11		
1	0		11	1 43	
2	5		6	0.78	
3	6		0		
4	2	122	120	15 6	237.5
5	12		108	14 04	
6	14		94	12.22	
7	5		89	11.57	
8	0		89	11.57	
9	4		85	11.05	
10	4		81	10.53	
11	2		79	10.27	
12	2		79	10.01	
13	5		72	9 36	
14	1		71	9.23	
15	0		71	9 23	
16	1		70	9.1	
17	3		67	8 71	
18	0		67	8 71	
19	2		65	8 45	
20	11		54	7 02	
21	0		54	7 02	
22	0		54	7.02	
23	8		46	5.98	
24	0		46	5 98	
25	1		45	5.72	
26	1		44	4 42	
27	10		34	3 9	
28	4		30	3.9	
29	0		30	3 64	
30	2		28	2 99	
31	5		23	2.73	
32	2		21	1 17	
33	12		9	0 39	
34	6		3	0.39	
35	0		3	0 39	
36	0		3		
37	3		0	0 52	
38	7	11	4	0 13	237 5
39	3		1		
40	1		0		
Totals	144	133	1854	241 02	475
Ave demand	3 6				
Total Cost	716 02				

Table 5.33
Transformer, Method. User defined approach (Third Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			23		
1	0		23	2.99	
2	5	25	43	5.59	237.5
3	6		37	4.81	
4	2		35	4.55	
5	12		23	2.99	
6	14	20	29	3.77	237.5
7	5		24	3.12	
8	0		24	3 12	
9	4		20	2.6	
10	4		16	2.08	
11	2		14	1.82	
12	2	25	37	4 81	237 5
13	5		32	4 16	
14	1		31	4 03	
15	0		31	4 03	
16	1		30	3.9	
17	3	15	42	5.46	237 5
18	0		42	5 46	
19	2		40	5 2	
20	11		29	3.77	
21	0		29	3.77	
22	0		29	3.77	
23	8		21	2 73	
24	0	25	46	5 98	237.5
25	1		45	5.85	
26	1		44	5 72	
27	10		34	4 42	
28	4	25	55	7 15	237.5
29	0		55	7 15	
30	2		53	6 89	
31	5		48	6 24	
32	2	9	55	7.15	237.5
33	12		43	5.59	
34	6		37	4.81	
35	0		37	4 81	
36	0		37	4.81	
37	3		34	4 42	
38	7		27	3 51	
39	3		24	3 12	
40	1		23	2 99	
Totals	144	144	1378	179.14	1662 5
Ave demand	3 6				
Total Cost	1841.64				

Table 5.34

Transformer, Method: Wagner-Whitin (Fourth fourty days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			1		
1	0		1	0.13	
2	1		0		
3	0		0		
4	4	121	117	15.21	237 5
5	2		115	14 95	
6	6		109	14.17	
7	3		106	13 78	
8	2		104	13.52	
9	3		101	13.13	
10	1		100	13	
11	3		97	12.61	
12	0		97	12.61	
13	4		93	12.09	
14	3		90	11.7	
15	5		85	11 05	
16	1		84	10 92	
17	0		84	10 92	
18	5		79	10 27	
19	0		79	10.27	
20	3		76	9.88	
21	7		69	8.97	
22	5		64	8 32	
23	8		56	7 28	
24	0		56	7 28	
25	6		50	6 5	
26	5		45	5 85	
27	4		41	5.33	
28	1		40	5.2	
29	7		32	4 29	
30	10		23	2.99	
31	0		23	2.99	
32	1		22	2.86	
33	2		20	2 6	
34	0		20	2.6	
35	7		13	1 69	
36	6		7	0 91	
37	3		4	0.52	
38	0		4	0 52	
39	3		1	0.13	
40	1		0		
Totals	122	121	2208	287.04	237 5
Ave demand	3 05				
Total Cost	524 54				

Table 5.35

Transformer, Method: Lot for lot (Fourth Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			1		
1	0	4	5	0 65	237 5
2	1	2	6	0 78	237 5
3	0	6	12	1.56	237.5
4	4	3	11	1 43	237.5
5	2	2	11	1.43	237.5
6	6	3	8	1.04	237 5
7	3	1	6	0 78	237.5
8	2	3	7	0 91	237 5
9	3		4	0 52	
10	1	4	7	0.91	237.5
11	3	3	7	0 91	237.5
12	0	5	12	1.56	237.5
13	4	1	9	1.17	237 5
14	3		6	0 78	
15	5	5	6	0 78	237.5
16	1		5	0 65	
17	0	3	8	1.04	237 5
18	5	7	10	1.3	237 5
19	0	5	15	1 95	237.5
20	3	8	20	2 6	237 5
21	7		13	1.69	
22	5	6	14	1 82	237 5
23	8	5	11	1 43	237.5
24	0	4	15	1 95	237.5
25	6	1	10	1 3	237.5
26	5	7	12	1.56	237 5
27	4	10	18	2 34	237 5
28	1		17	2 21	
29	7	1	11	1 43	237.5
30	10	2	3	0.39	237 5
31	0		3	0.39	
32	1	7	9	1.17	237.5
33	2	6	13	1.69	237.5
34	0	3	16	2.08	237.5
35	7		9	1.17	
36	6	3	6	0.78	237 5
37	3	1	4	0 52	237 5
38	0		4	0.52	
39	3		1	0.13	
40	1		0		
Totals	122	121	364	47 32	7125
Ave demand	3 05				
Total Cost					

Table 5.36

Transformer, Method: Economic Order Quantity (Fourth Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			1		
1	0	106	107	13 91	237 5
2	1		106	13 78	
3	0		106	13 78	
4	4		102	13 26	
5	2		100	13	
6	6		94	12.22	
7	3		91	11 83	
8	2		89	11.57	
9	3		86	11.18	
10	1		85	11.05	
11	3		82	10.66	
12	0		82	10.66	
13	4		78	10 14	
14	3		75	9 75	
15	5		70	9 1	
16	1		69	8.97	
17	0		69	8.97	
18	5		64	8 32	
19	0		64	8 32	
20	3		61	7.93	
21	7		54	7.02	
22	5		49	6.37	
23	8		41	5.33	
24	0		41	5.33	
25	6		35	4 55	
26	5		30	3 9	
27	4		26	3 38	
28	1		25	3 25	
29	7		18	2 34	
30	10		8	1.04	
31	0		8	1.04	
32	1	106	113	14.69	237.5
33	2		111	14.43	
34	0		111	14.43	
35	7		104	13.52	
36	6		98	12 74	
37	3		95	12 35	
38	0		95	12.35	
39	3		92	11 96	
40	1		91	11 83	
Totals	122	212	2925	380 25	475
Ave demand	3 05				
Total Cost	855.25				

Table 5.37
Transformer, Method, Period Order Quantity (Fourth Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			1		
1	0	117	118	15.34	237.5
2	1		117	15.21	
3	0		117	15.21	
4	4		113	14.69	
5	2		111	14.43	
6	6		105	13 65	
7	3		102	13 26	
8	2		100	13	
9	3		97	12 61	
10	1		96	12 48	
11	3		93	12.09	
12	0		93	12 09	
13	4		89	11 57	
14	3		86	11.18	
15	5		81	10 53	
16	1		80	10 4	
17	0		80	10.4	
18	5		75	9 75	
19	0		75	9.75	
20	3		72	9.36	
21	7		65	8 45	
22	5		60	7 8	
23	8		52	6 76	
24	0		52	6.76	
25	6		46	5 98	
26	5		41	5 33	
27	4		37	4.81	
28	1		36	4.68	
29	7		29	3.77	
30	10		19	2.47	
31	0		19	2.47	
32	1		18	2.34	
33	2		16	2 08	
34	0		16	2 08	
35	7		9	1 17	
36	6	4	7	0 91	237 5
37	3		4	0 52	
38	0		4	0 52	
39	3		1	0 13	
40	1		0		
Totals	122	121	2431	316.03	475
Ave demand	3.05		EOQ	106	
Total Cost	791 03		POQ	35	

Table 5.38

Transformer, Method: Part Period Balancing (Fourth Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			1		
1	0		1	0 13	
2	1		0		
3	0		0		
4	4	108	104	13 52	237.5
5	2		102	13 26	
6	6		96	12 48	
7	3		93	12 09	
8	2		91	11 83	
9	3		88	11.44	
10	1		87	11 31	
11	3		84	10 92	
12	0		84	10.92	
13	4		80	10 4	
14	3		77	10.01	
15	5		72	9.36	
16	1		71	9.23	
17	0		71	9 23	
18	5		66	8 58	
19	0		66	8.58	
20	3		63	8 19	
21	7		56	7 28	
22	5		51	6.63	
23	8		43	5 95	
24	0		43	5.95	
25	6		37	4.81	
26	5		32	4 16	
27	4		28	3 64	
28	1		27	3 51	
29	7		20	2.6	
30	10		10	1 3	
31	0		10	1 3	
32	1		9	1.17	
33	2		7	0 91	
34	0		7	0 91	
35	7		0		
36	6	13	7	0.91	237.5
37	3		4	0 52	
38	0		4	0.52	
39	3		1	0.13	
40	1		0		
Totals	122	121	1792	232 96	475
Ave demand	3.05				
Total Cost	707.96				

Table 5.39

Transformer, Method: User defined approach (Fourth Forty Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			24		
1	0		24	3 12	
2	1	10	33	4 29	237 5
3	0		33	4.29	
4	4		29	3.77	
5	2		27	3.51	
6	6		21	2.73	
7	3	15	33	4 29	237.5
8	2		31	4 03	
9	3		28	3 64	
10	1		27	3 51	
11	3		24	3.12	
12	0	25	49	6 37	237.5
13	4		45	5.85	
14	3		42	5.46	
15	5		37	4 81	
16	1	25	61	7 93	237.5
17	0		61	7.93	
18	5		56	7.28	
19	0		56	7 28	
20	3		53	6 89	
21	7		46	5 98	
22	5	20	61	7.93	237.5
23	8		53	6.89	
24	0		53	6 89	
25	6		47	6.11	
26	5		42	5.46	
27	4	20	58	7.54	237 5
28	1		57	7.41	
29	7		50	6 5	
30	10		40	5 2	
31	0	7	47	6.11	237 5
32	1		46	5.98	
33	2		44	5.72	
34	0		44	5 72	
35	7		37	4.81	
36	6		31	4.03	
37	3		28	3 64	
38	0		28	3 64	
39	3		25	3 25	
40	1		24	3.12	
Totals	122	122	1631	212 03	1662.5
Ave demand	3 05				
Total Cost	1874.53				

Table 5.40

Transformer, Method: Wagner-Whitin (Last Twenty One Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			2		
1	2		0		
2	0		0		
3	0		0		
4	4	33	29	3.77	237.5
5	0		29	3.77	
6	4		25	3.25	
7	0		25	3.25	
8	5		20	2.6	
9	5		15	1.95	
10	2		13	1.69	
11	2		11	1.43	
12	0		11	1.43	
13	3		8	1.04	
14	3		5	0.65	
15	0		5	0.65	
16	0		5	0.65	
17	1		4	0.52	
18	3		1	0.13	
19	0		1	0.13	
20	1		0		
21	0		0		
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
Totals	35	33	207	26.91	237.5
Ave demand	0.875				
Total Cost	264.41				

Table 5.41

Transformer, Method: Lot for lot (Last Twenty One Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			2		
1	2	4	4	0 52	237.5
2	0		4	0 52	
3	0	4	8	1.04	237 5
4	4		4	0 52	
5	0	5	9	1 17	237 5
6	4	5	10	1 3	237 5
7	0	2	12	1.56	237.5
8	5	2	9	1.17	237.5
9	5		4	0.52	
10	2	3	5	0.65	237.5
11	2	3	6	0.78	237.5
12	0		6	0.78	
13	3		3	0 39	
14	3	1	1	0 13	237.5
15	0	3	4	0 52	237.5
16	0		4	0.52	
17	1	1	4	0.52	237.5
18	3		1	0.13	
19	0		1	0.13	
20	1		0		
21	0		0		
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
Totals	35	33	99	12.87	2612 5
Ave demand	0 875				
Total Cost	2625 37				

Table 5.42
Transformer, Method Economic Order Quantity (Last Twenty One Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv			2		
1	2	57	57	7.41	237.5
2	0		57	7.41	
3	0		57	7.41	
4	4		53	6.89	
5	0		53	6.89	
6	4		49	6.37	
7	0		49	6.37	
8	5		44	5.72	
9	5		39	5.07	
10	2		37	4.81	
11	2		35	4.55	
12	0		35	4.55	
13	3		32	4.16	
14	3		29	3.77	
15	0		29	3.77	
16	0		29	3.77	
17	1		28	3.64	
18	3		25	3.25	
19	0		25	3.25	
20	1		24	3.12	
21	0		24	3.12	
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
Totals	35	57	1266	164.58	237.5
Ave demand	0.875		EOQ	57	
Total Cost	402.08				

Table 5.43
Transformer, Method: Period Order Quantity (Last Twenty One Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			2		
1	2	33	33	4 29	237.5
2	0		33	4 29	
3	0		33	4 29	
4	4		29	3 77	
5	0		29	3.77	
6	4		25	3 25	
7	0		25	3 25	
8	5		20	2.6	
9	5		15	1.95	
10	2		13	1.69	
11	2		11	1 43	
12	0		11	1 43	
13	3		8	1 04	
14	3		5	0 65	
15	0		5	0.65	
16	0		5	0.65	
17	1		4	0 52	
18	3		1	0 13	
19	0		1	0 13	
20	1		0		
21	0		0		
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
Totals	35	33	306	39 78	237 5
Ave demand	0.875		EOQ	57	
Total Cost	277 28		POQ	65	

Table 5.44

Transformer, Method: Part Period Balancing (Last Twenty One Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			2		
1	2		0		
2	0		0		
3	0		0		
4	4	33	29	3.77	237.5
5	0		29	3.77	
6	4		25	3.25	
7	0		25	3.25	
8	5		20	2.6	
9	5		15	1.95	
10	2		13	1.69	
11	2		11	1.43	
12	0		11	1.43	
13	3		8	1.04	
14	3		5	0.65	
15	0		5	0.65	
16	0		5	0.65	
17	1		4	0.52	
18	3		1	0.13	
19	0		1		
20	1		0		
21	0		0		
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
Totals	35	33	207	26.91	237.5
Ave demand	0.875				
Total Cost	264.41				

Table 5.45
Transformer, Method: User defined approach (Last Twenty One Days)

Period	Demand	Produce	Inventory	Holding Cost Taka	Setup Cost Taka
Initial Inv.			26		
1	2		24	3 12	
2	0		24	3 12	
3	0		24	3 12	
4	4		20	2 6	
5	0		20	2 6	
6	4		16	2 08	
7	0	9	25	3 25	237.5
8	5		20	2.6	
9	5		15	1 95	
10	2		13	1 69	
11	2		11	1 43	
12	0		11	1.43	
13	3		8	1.04	
14	3		5	0.65	
15	0		5	0.65	
16	0		5	0.65	
17	1		4	0.52	
18	3		1	0.13	
19	0		1	0.13	
20	1		0		
21	0		0		
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					
32					
33					
34					
35					
36					
37					
38					
39					
40					
Totals	35	9	252	32 76	237.5
Ave demand	0.875				
Total Cost	270 26				

The final result of transformer is:

Material	W Whitin	Lot for lot	EOQ	POQ	PPB	User defined
Transformer	2532	28250	3930	3188	3206	7723

A summarizes result of all the raw material is shown on the Table 5.44 given below.

Table 5.44

Total cost for the individual items stipulated period (not annual)

Material	W. Whitin	Lot for lot	EOQ	POQ	PPB	User defined
Transformer	2532	28250	3930	3188	3206	7723
Cabinet	1579	28500	2212	1641	1579	7224
Relay 5p/12v/12a	2451	55067	3390	2463	2451	12888
Voltmeter	2335	55061	3094	2341	2335	12921
Socket	2335	55061	3094	2341	2335	12921
V R-100K	2289	55059	2917	2292	2289	
Trangistor D400	2266	55058	2799	2268	2266	
IC-LM324	2266	55058	2799	2268	2266	
Capacitor 220mf/35v	2231	55056	2521	2232	2231	
Registor 100k/ 25w	2226	55056	2455	2227	2226	
LED-Red	2224	55056	2413	2224	2224	

CHAPTER 6

RESULTS AND DISCUSSION

6.1 INTRODUCTION

Application of MRP requires a master production schedule (MPS) stating the end items a company plans to produce by quantity and period. The MPS, thus, schedules production plans and purchases orders, acts as principal input to the MRP system, forms the foundation for determining the resource requirements and provides the basis for making delivery promises to customers. Grameen Bitek Ltd. usually follows the make-to-order policy. The company generally prioritizes the orders depending on the dead lines of orders. The MPS is not strictly based on production plan, demand data arising out of sales forecast, safety stocks, anticipation inventories etc This chapter incorporates the discussion on effects of lot-sizing method on inventory costs, summary of MRP results, comparison of lot-sizing performed by various methods, present scenario of the company, application of MRP and the related issues and benefits.

6.2 INFLUENCE OF LOT-SIZING METHODS ON INVENTORY COSTS

The total incremental inventory cost is dependent on how much the lot-size is and how frequently the order is being placed. The five methods available with the POM software were tried and the incremental inventory costs for different materials were evaluated. In Table 6.1 the inventory costs against each of the eleven materials are presented in the corresponding column of the five methods adopted. Total annual inventory cost as shown at the bottom of each column helps to compare the methods in terms of cost savings.

Table 6.1 annual inventory costs (Taka) of different materials using different techniques.

Material	W Whitin	Lot for lot	EOQ	POQ	PPB	User defined
Transformer	5065	56501	7860	6377	6412	15447
Cabinet	3159	57001	4424	3282	3159	14449
Relay 5p/12v/12a	4902	110135	6781	4926	4902	25777
Voltmeter	4671	110123	6188	4684	4671	25843
Socket	4671	110123	6188	4684	4671	25843
V.R-100K	4578	110119	5834	4585	4578	
Trangistor D400	4532	110116	5598	4537	4532	
IC-LM324	4532	110116	5598	4537	4532	
Capacitor 220mf/35v	4463	110113	5042	4464	4463	
Registor 100k/.25w	4453	110112	4910	4454	4453	
LED-Red	4449	110112	4826	4449	4449	
Total	49560	1104577	63254	50980	50826	

In this study the five methods such as Wagner-Whitin, EOQ, Lot for lot, POQ and PPB were applied to determine lot-size Presently the intuitive approach adopted in the company appears to be close to an attempt of EOQ technique. It has been observed during this investigation that the factors relating to the estimation of holding and ordering costs are not properly recorded. Moreover, the values of the components of inventory costs such as the ordering and holding costs are assumed without following the standard procedure. So it is apparent that the practice made by the company may have considerable deviations from the results obtained by applying EOQ in true sense

For example, in case of transformer the company places orders of 594 pieces at a time. Considering the holding, ordering costs and the demand over the periods, the annual inventory cost is calculated and the amount appears to be more than Taka 15,000, which is higher than the amount determined by EOQ method.

Similar trend may be observed for some other raw materials. From cross-examination of Table 6.1 it is apparent that the company's current intuitive approach is always superior to EOQ approach.

It is also apparent from Table 6.1 Wagner-Whitin method appears to be the most attractive in determining the size of order. Part Period Balancing is the next choice whereas the position of

EOQ would be in the 4th place among the five standard lot-sizing approaches. Therefore, it can be very easily understood how much the company would gain should they shift from present intuitive approach to Wagner-Whitin approach to determine the order quantity. In each case, the percent of cost that could be saved had Wagner-Whitin method were used. For example the inventory cost required by the Lot- for- lot method the cost is estameed to be Tk 56501 where as for the same transformer, the cost could be brought down Tk 5065 using Wagner-Whitin method. So savings of cost would be =(56501-5065)/56501=0.91. Table 6.2 indicates the percentage of cost saving should the Wagner-Whitin method was used instead of Lot for lot, EOQ, POQ and PPB. Compared to EOQ, Wagner-Whitin method can ensure significant amount of savings in case of Transformer (saving of 36%), Cabinet (saving of 29%), Relay (saving of 28%) Voltmeter (saving of 25%) and Socket (saving of 25%).

Table 6.2 Percentage of cost saving compared to Wagner-Whitin method

Material	W Whitin %	Lot for lot	EOQ	POQ	PPB	User defined
Transformer	0	0.91	0 36	0.21	0.21	0.67
Cabinet	0	0.94	0.29	0.04	0	0.78
Relay 5p/12v/12a	0	0.95	0.28	0.004	0	0 81
Voltmeter	0	0.96	0.25	0.002	0	0.82
Socket	0	0.96	0.25	0.002	0	0.82
V.R-100K	0	0.96	0.22	0.001	0	-
Transistor D400	0	0.96	0.19	0.001	0	-
IC-LM324	0	0 96	0 19	0.001	0	-
Capacitor 220mf/35v	0	0.96	0 11	0.0001	0	-
Resistor 100k/.25w	0	0.96	0.09	0	0	-
LED-Red	0	0.96	0.08	0	0	-
Total	0	0.96	0.22	0.03	0 02	-

It is noticeable that proper lot sizing of the transformer, cabinet, relay, voltmeter and socket can be highly advantageous in the context of cost savings. While for the other items, the scenario is not same and the percentage of cost savings are relatively lower compared to transformer, cabinet, relay, voltmeter and socket.

6.3 COMPREHENSIVE SUMMERY OF MRP RESULTS

Ordering lot-sizes calculated using the Wagner-Whitin method for the three items such as transformer, cabinet and relay are presented in Table 6.3. These are actually the most expensive items used in Stabiliser manufacturing. Transformer being the most expensive item is required to be ordered in small quantities. This is attributed to the fact that costly items if ordered in large quantities lead higher holding costs.

Table 6.3 Lot-size result of Transformer, Cabinet and Relay determined by Wagner-Whitin method

Period (181 days)	Transformer	Cabinet	Relay
Totals Demand	594	594	1188
Ave demand	3 28	3.28	6 56
Total Inventory Cost	2532	1579	2451

It is apparent from the Table 6.3 above, that transformer being the most expensive item, should be ordered frequently. The less costly items in contrast should be ordered in large quantities leading to infrequent orders. The Transformer, Cabinet and Relay are therefore, ordered in every one to two months. Low-cost items such as voltmeter, socket and components for circuit board are ordered in bulk and therefore the frequency of order is less as depicted in Table 6.4.

Period (181 days)	Voltmeter	Socket	V.R-100K	Trangist or D400	IC LM324	Capacit or 220mf	Registor 100k	LED-Red
Totals Demand	594	594	3564	1188	594	594	3564	594
Ave Demand	3.28	3 28	19 7	6 56	3.28	3.28	19 7	3.28
Total Inventory Cost	2335	2335	2289	2266	2266	2231	2226	2224

6.4 COMPARING LOT-SIZES DETERMINED BY VARIOUS METHODS

A number of methods have been developed for determining the lot-size for MRP system. But in the study five standard methods were applied in calculating the lot-size as the POM software supports these methods The user defined for major items was also evaluated by POM software but remind it that it is not standard lot sizing approach rather it is intuitive approach.

There are several problems in using the economic lot size. The requirements are not equal from period to period, as is often the case of MRP, fixed EOQ lot sizes result in a mismatch between the order quantities and the requirements values. This mean excess inventory must be carried forward from day to day. The use of average daily requirement ignores a considerable amount of other information contained in the requirement schedule.

One way of reducing high inventory carrying cost associated with fixed lot size is to use the EOQ formula to compute an economic time interval between replenishment orders. POQ compared to EOQ (Table 5.44 material: Cabinet, method: EOQ and POQ) reduces total inventory cost by 25%. Although the POQ procedure improves the inventory cost performance by allowing the lot size to vary, it also ignores much of the information contained in the requirements schedule.

Despite Part Period Balancing (PPB) utilizes all of the information available, it will not always yield the minimum cost-ordering plan. Although this procedure can produce low cost ordering plan, it may miss the minimum cost plan, since it does not evaluate all of the possibilities for ordering material to satisfy the demand in each week of the requirements schedule.

In terms of inventory costs, PPB and Wagner-Whitin methods are very close. But since the later calculate lot size by dynamic programming it gives near about optimum lot size. The total inventory cost determined by Wagner-Whitin method is reduced by Taka 673, in comparison with the ordering plan produced by the PPB procedure (Table 5.44, material : Transformer, method PPB & Wagner-Whitin).

Lot for lot ordering results in a zero inventory but involves many orders. Lot for lot provides a steadier flow of work than other lot sizing technique. It is applicable in such cases where ordering cost is too low and holding cost is too high. As ordering cost for raw materials consumed in the company is high, there is no scope to adopt lot for lot method to determine lot size.

6.5 PRESENT SCENARIO OF THE COMPANY

The company is quite well-known in the country for voltage Stabiliser manufacturing for household appliances such as fridge, computer etc in the private sector. The company has obtained BUET and BSTI 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 situation. Three principal elements of MRP such as MPS, BOM and inventory records are getting adequate attention. During the present study it has been noticed that the company is exerting adeqnate efforts in defining the product structures and indented bill of materials for different stabilisers.

Currently instead of having a complete BOM, there is a chart for material requirement maintained in individual sections of fabrication and assembly. The chart contains the information concerning the specific requirements of a particular material in terms of units (kilogram or number of pieces) for manufacturing a particular Stabiliser. The Factory-In-Charge directly received new order and send it to the store officer for evaluating the quantity required for that order and fills the requisition form. As presently there is no product structure or BOM, it is not uncommon to make mistakes in calculating the requirement of materials. In such cases they have to reorder the item(s) which were short or to sustain with excess materials Both the shortage and the excess in materials are undesirable in the context of inventory.

Regarding master production schedule, the approach of the company is like a Make To Order (MTO) company. The prioritize on the basis of deadline i.e. the closer the deadline the higher the level of attention. It is true that MTO company where no finished goods inventories generally exist, all products are built on the basis of customer order. In this case development of MPS is difficult. In general the company remains busy with production over a period of a number of months to meet the orders placed. It may be mentioned here that the production volume for various categories of Stabilisers is not same. Orders for the stabilisers with the rating of 140v – 270v and 550VA are quite consistent. In addition to this, there are orders for other categories of Stabilisers. As a result the company remains occupied with fabrication/assembly work for a significant period of time with which it can adept the process of MPS making frequent adjustments.

The benefit of accurate inventory ensures reliable manufacturing schedule. From financial viewpoint, inventory accuracy means correctly stated inventory cost reports, less costly material expediting, and reduced losses due to obsolete and excessive inventory in stockrooms If the inventory values are not accurate enough, the MRP and other manufacturing planning and control software modules fail to function. The importance given in the company in updating the inventory records. Presently the company keeps the records of the quantity of incoming raw material, damaged raw material, production line raw material, repair purpose raw material and finished product.

6.6 APPLICATION OF MRP

Usually MRP can be adopted in an enterprise in three approaches mainly depending on its size. These are the manual MRP, computer-assisted MRP and manual to computer-assisted MRP. manual MRP can be applied usually in case of a small-scale industry and for a large-scale industry usually computer-assisted MRP is preferred whereas small to medium industries manual to computer assisted MRP approach can be adopted.

Different Phases of MRP Implementation

A product structure may be large or small depending on the number of levels, subassembly or parts. In case of riding lawn mower, automobile, videocassette recorder, or computer the product structures are quite large. These kinds of product often have over 30 levels in the bill, hundreds of different parts and subassemblies, each requiring an MRP record and thousand of individual items. In addition there are usually multiple models of the final assembly, which share common parts and subassemblies. As a result the MRP records for these common items have gross requirements coming from different sources that must be combined before the final production plan is completed. As an added burden, the MRP plan is never static; gross requirements, lead time and on hand balance change frequently. It is obvious that MRP calculations on final assemblies of this size are enormous and manual handling become extremely difficult. As a result, computer software is used.

However, there are exceptions for some few companies like Dataram and Ethan Allen Furniture Company which have been able to achieve many of the benefits by using MRP approaches in manual system. It has been proven by these companies that after manual system MRP adaptation computerization of the system became easier and more cost-effective. In fact, the significant cost in this regard, is that of converting company operations over to an MRP based approach, not the cost of computer [14].

The company is dealing with products having structures of only about three levels. As the number of level is less, attempt can be made to implement the manual MRP. However, in practice, a single item may vary extensively in its thickness, lengths, grades etc. If this factor is taken into account the number of items, depending on specifications, become very large. In such case manual MRP approach considering the variation in specification will not be easily executable. Therefore, it would be advisable for the company to treat the manual MRP as an intermediate step in the conversion process from the current stage to a compnter assisted MRP system.

It can be safely said that local industries, in general, are not very aware about the benefits of MRP application. However, few companies are now gradually paying attention on inventory management by using MRP. Initiatives are being taken to locally develop some inventory management software of limited capacity. Commercial version of MRP software is very expensive and may not be readily available in the local market. Procuring of such software is not enough in implementing the MRP concept in the company, rather it needs human resources with adequate knowledge and experience. Moreover, significant changes in organization structure and attitudes of employees are necessary towards successful implementation of MRP.

Necessary Preparation for Applying MRP

The implementation process of MRP requires a highly structured approach that involves every employee, with a minimum of 90 percent of the work forced trained, including management. The process used in successful implementation is called the proven path.

Education is the first step in the process and continues throughout the implementation. Top management commitment and involvement in the MRP program is critical. Management must understand the MRP process and comprehend the cost and effort required to install and to operate the process fully. In addition management must know how MRP will affect every department and the benefits that will result from successful implementation.

The installation process is divided into four phases: initial, preparation, implementation and operation. After the initial phase, the project team is in place with full time project director, and work on problem analysis begins. It is not uncommon for the project team to identify between 50 to 500 problems that must be addressed before the system is installed. Problems are divided into functional area and prioritized, then team of employees from the areas start working on solution. For example, the inventory group could be assigned to work on inventory count accuracy and damaged goods problem. Full MRP implementation can take 18 months in a medium sized company, with first 8 to 12 months used to get the current manufacturing system in proper order for the implementation of hardware and software.

The cost of implementation is directly proportional to size and type of company. The costs are usually divided into four categories: (1) consulting (10%), (2) education and problem analysis (40%), (3) hardware (20%) and (4) software (30%). The cost of the software is a function of compnter hardware. For example, costing base and scheduling software for a job shop operation that runs on a microcomputer is in the range of $20,000 to $30,000. MRP software for a microcomputer based system would be less than $50,000 while software for a mini or main frame computer is usually over $100,000.

Critical Aspects in using MRP System

In this section the critical aspects of using the MRP system are discussed to ensure that MRP system records are exactly synchronized with the physical flow of the material.

The MRP Planner

The persons must directly involved with the MRP system outputs are planners. The planners have the responsibility for making the detailed decisions that keep the material moving through the plant to achieve the shipment of final products. Their range of discretion is carefully limited (i.e. withont higher authorization, they cannot change plans for end items that are destined for customers). It is, however their actions that are reflected in the MRP records. Therefore high quality well-trained MRP planners are essential to effective use of the

MRP systems. In the company the chief of purchase, being an experienced person, may act as a planner after he/she is provided with relevant background and training.

Computerized MRP system produces a set of coordinated MRP time-phased records for each part number. As a consequence, planners are generally organized around logical grouping of parts such as metal parts, electronic parts etc.

The primary actions taken by an MRP planner should be:

1. Release orders (i.e. launch purchase or ship order when indicated by the system)
2. Reschedule the due dates of exiting open orders when desirable.
3. Analyze and update system-planning factors for the part numbers under his control. This would involve such things as changing lot size, lead times, scrap allowances or safety stock.
4. Reconcile errors or inconsistencies and try to eliminate root causes of these errors.
5. Find key problem areas that require action now to prevent future crises.
6. Use the system to solve critical material shortage so that the action can be captured in the records for the next processing. This means the planner works within the formal MRP rules, not by informal method.
7. Indicate where further system enhancements (outputs, diagnostics, etc.) that would make the planner's job easier.

Order Launching

The orders indicated by MRP as ready for launching are a function of lot sizing procedures and safety stock, as well as timing. When an order is launched, it is some times necessary to include a shrinkage allowance for scrap and other process yield situations. The typical approach is to allow some percentage for yield losses that will increase the shop order quantity above the net amount required. To effect good control over open orders, the total amount, and the schedule receipt should be reduced as actual yield losses occur during production.

Allocation and Availability Checking

Availability checking is to check whether sufficient components are available for the final product. If one order is created, then the system allocates the necessary quantities to the particular shop order (the computer assigns shop orders, in numerical sequence). The allocation means that this amount is mortgaged to the particular shop order and is therefore, not available for any other shop orders. Thus availability and allocation checking are a type of double entry bookkeeping. The result is that the quantity physically on hand should match what the records indicate is available plus what is allocated. If not, corrective action must be taken. The resulting accuracy facilitates inventory counting and other procedures for maintaining data integrity.

Bottom Up Replanning

Bottom up replanning is the process of using the pegging data to solve material shortage problems. However peggiug and bottom up replanning will provide warning in advance of shortage problem so that customer can take appropriate actions [15].

6.7 BENEFITS FROM MRP

The primary benefits of MRP is that solutions to problems in manufacturing due to disturbances in the production system are solved early when a greater number of alternatives are available to the planner. The secondary substantial benefits from implementation of MRP results from the preparation for the installation. Preparation of accurate bill of material (BOM) and a cycle count process can guarantee reliable inventory. The self-study used to improve the BOM and inventory tracking uncovers other operations that do not add value to the product. The correction of this problem and the improvement in BOM and inventory adds substantially to the profitability and quality to the products. Business organizations like Grameen Bitek Ltd can have productivity gains through the use of new and better technology. But productivity gains may not be automatic; technology must be managed to overcome many problems. It is important to identify the actual needs and find a matching technology [16]. The following list of improvements in the operation of enterprise is frequently attributed to implementing MRP.

- Improve customer service
- Improve vendor relationship
- Reduction in past due orders
- Better understanding of capacity constraint
- Significant increase in productivity

- Reduction in lead time
- Reduction in the inventory of finished goods, raw materials, component parts, and safety stock.
- Reduction in work in process (WIP)
- Elimination of annual inventory
- Precise cost figures
- Significant drops in annual accounting adjustment for inventory problems
- Usually, a doubling of inventory turns.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

The study was undertaken to make an overview of the present status of MRP application in a local eletronics appliance manufacturing company and to identify the relevant problems and issues and to suggest the action plans in the successful implementation of MRP concept. The company produces voltage stabiliser by assembling components/parts from various sources and can be seen as a representative organization of the country. The analysis, comments, suggestions, action plans etc. are, therefore, based on data and informarion gathered from this company. The aims and objectives of the study included the investigation of bottlenecks in applying MRP concept, estimation of relevant inventory costs required for running an academic version MRP software for limited items and recommendation of appropriate measures to pave the ways of applying MRP in future. The impact of free market economy and that of globalization and liberalization of trade has been significant on the industrial sectors in general. It would not be unrealistic to say that the overall scenario in local industries in terms of applying operations management techniques is not expected to be very encouraging.

7.2 CONCLUSIONS

The concluding remarks outlined below are based on the findings of the study:

i. In the context of applying the concept of MRP, it can be said that the position of the company under investigation is in a very primary stage. No formal production plan, MPS, BOM and MRP are maintained. Recording of data and information regarding on-hand inventory, WIP inventory, lead times, various inventory costs is not properly classified and stored.

ii. Since the company is in the primary stage in respect of MRP application, there is a potential scope of improving the current situation through implementation of MRP. Even an approach with manual MRP at this stage can be of remarkable advantages.

iii. The study reveals that the company currently procures raw materials on the basis of thumb rule instead of following any formal methods used for calculating of the lot sizing.

iv. Compared to present practice of determining the lot-size, MRP approach by using the most appropriate and optimum lot-sizing method (Wagner-Whitin) can significantly reduce the total inventory costs.

v. Due to the lack in understanding of the benefits acrued from MRP application, the top management is less aware and committed in implementing MRP concept.

vi. However, scarcity of skilled manpower needed for MRP implementation is also a common feature.

vii. Documentation and recording system are poor in most of the organizations.

Anticipated Contribution of MRP for the company

Through the application of MRP, the company can benefit from better management and reduction in cost of products.

Contribution in Operations and Management

i. Quick decision-making is possible because of availability of the structured information about products and production facilities.

ii. Accurate decision can be taken with reliable and up-to-date information. Proper MRP application demands reliable and up-to-date data and information.

iii. MRP is an information system that enables managers to improve the efficiency of operations.

iv. As MRP maintains tight schedule from procurement of raw materials to delivery of final products, it is necessary to monitor the work in process and take necessary steps if needed. This certainly helps in reducing past due orders.

v. There is a scope of improved customer service, as MRP ensures timely delivery of products. In addition, customer lead times are typically shorter than total lead times, and in such cases, companies using MRP can better manage to meet the customer's urgent need by adjusting with the situation and taking necessary measures.

vi. Significant increase in productivity is possible as MRP formulates the work in a very scientific and structured way.

vii. A product delivery lead-time is the summation of raw material ordering lead-time, manufacturing lead-time and assembly lead-time. MRP optimizes all these lead-times and can deliver product in a shorter period.

viii. MRP estimates material on capacity basis and orders raw materials after economic analysis of the future demand. As a result there is reduced level of work-in-process (WIP) and overall inventory.

Contribution in cost saving

- Ordering cost is a significant cost, which can be curbed only through mathematical determination of lot size and number of order(s) for a certain period. MRP lot sizing is based on reduced set-up or ordering and product changeover costs.
- MRP always updates the holding cost and ordering cost elements and determines total inventory cost which would facilitate annual accounting adjustment. Thus there is a possibility of significant drops in annual accounting adjustment for inventory problem.
- In MRP application, there is increased sales and reduction in sales price.
- With the same inventory level the throughput can be double if MRP is implemented properly.

7.3 RECOMMENDATIONS

Future action plan of the company

During the present study it has been learnt that there is no record product structure or BOM. Due to the absence of product structure, it is quite natural to make mistakes in calculating the requirements of various materials. As a result the company requiers to reorder the item(s) in short or to sustain with excess materials. A proper inventory record based on BOM is also essential for accurate calculation of material requirements. The following measures, therefore, are recommended for the company to ensure superior planning condition.

Recommended action plans for accurate data recording

i. Defined product structure diagram of each product has to be constructed. In a typical firm there may be many products and a particular product may have different grades or ratings. Therefore, construction of product structures is required to get a clear picture of product's manufacturing and assembling order.

ii. Indented bill of materials for different stabilisers needs to be constructed. Though the product structure diagram and the indented bill of material contains the same information, the representation of the later is much easier to capture in manufacturing planning and control software

iii. A formal MPS (end product) can be determined by combining the number of orders already placed and predicted future demand by using suitable forecasting methods.

iv. Responsibility should be assigned to a single department for the maintenance of the bill.

v. Engineering change should also be assigned to an expert group and the change should be infrequent and accurate.

vi. A single image of all product data and BOM information are necessary to be maintained in the central database system. It would facilitate in editing inaccurate data if necessary.

vii. To ensure accurate inventory, physical counting of all of the parts is required.

Recommended action plans for changes in management

i. At the initial stage manual MRP should be adopted, keeping in mind the long-term plan for computer assisted MRP implementation. Through manual MRP the involved persons will learn to perform necessary works especially material planning in a formal and structured way.

ii In today's manufacturing environment competitiveness is often measured on the basis of delivery times and other performance criteria. Top management needs to develop the firm's manufacturing strategy reflecting the needs of the market in terms of price, quality, delivery lead times and flexibility.

iii In ordering quantity of most inventory value items, careful attention is necessary to determine the lot size by some formal methods. Accuracy in lot size determination of least inventory value items is not very urgent.

iv. It is necessary to recognize that MRP is a disciplined way of conducting business of the company, and to learn the concept and technology firsthand. Top management must be sufficiently patient and firmly determined to implement a long-term project on MRP.

v Necessary resources are to be provided by assigning full time people to MRP and making MRP a top priority for all managers. Cooperation is essential in such an environment and the directives from the top management to all managers would excel the overall implementation process.

vi. A formal implementation plan is required to develop covering about two year's time into the future before actual work starts. The time will cover education, justification, enterprise analysis, software and system selection and implementation, and finally evaluation.

vii. It is necessary to make sure that all involved receive an education on what MRP can do and their role in it

viii. Marketing, finance manufacturing and personnel from all divisions should jointly engage in the implementation process. For closed-loop MRP implementation, integration of all the departments is necessary.

ix. MRP implementation needs considerable patience. Some results may be expected during the initial time before the system is completely implemented.

x. It is necessary that the managers actually understand the form of their operation prior to the adoption of MRP. This is a key managerial requirement of MRP.

xi. ABC analysis is necessary to find out the most important items. All items do not need to pay same attention. Some items are intrinsic items and they are in need to pay sufficient attention. In the company transformer, cabinet, relay, voltmeter and socket are the examples of intrinsic items.

Recommended action plan for MRP software

i. In procuring MRP software, price and compatibility are extremely important. The software must match the company's requirement and be reasonable in price.

ii. In case of unavailability of compatible software within affordable price attempts may be made to develop software locally. At present there is a good number of skilled software developer. If they were provided with proper feedback on MRP it is anticipated that they will be able to develop relevant software. Local development of software will benefit the organizations in technical supporting of MRP implementation.

7.4 LIMITATIONS OF THE PRESENT STUDY

In estimating various cost parameters, some assumptions were made which in reality may not be strictly valid.

- In reality a number of items are usually ordered at a time for procurement. So analysis on the basis of single item may lead to some deviation from the realistic situations.
- Fixed lead times were considered, which is not strictly true.
- Ordering cost was considered to be independent of the lot-size. In real life the situation may different.
- Uncertainty was not taken into account. Probabilistic methods could be better option to handle this kind of situation.

7.5 SCOPE OF FUTURE WORK

A successful MRP system requires (1) adequate computer support, (2) accurate data, (3) management support, and (4) user knowledge All manufacturing and service companies can benefit from MRP if it is properly installed and operated. The scenario of local companies in respect of MRP application is not expected to be very different from what has been observed in the study. So there is a potential scope of applying this technique and thus help improve the productivity of profit margin of the local companies.

Since MRP software is very much case oriented; attempt can, therefore, be made to develop this kind of software using indigenous resources.

In order to carry out more realistic analysis, following steps may be recommended for adoption:

- Development of the mathematical model for determining lot-size considering multiple items to be ordered at a time.
- Development of the model for variable lot-size incorporating the constraints of fund, stores, transport facilities etc.
- Development of appropriate software on MRP considering local conditions
- Development of the forecasting models for Make-To-Order (MTO) situation
- Providing adequate facilities for inspection and testing in the process.
- Emphasizing in the training and education program.
- Ensuring the procurement of quality raw materials.
- Adapting state-of-the-art technology in manufacturing.
- Viewing the total company system as a whole unit utilizing the data from all departments.
- There is no consideration for safety stock in the models considered. An approach to determine the optimum safety stock can be an area of future work.

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