APPLICATION OF MRP IN A MANUFACTURING COMPANY OF BANGLADESH

by

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The thesis titled "application of MRP in a manufacturing company of Bangladesh" submitted by Sikder Mainul Hasan Roll No 040008008 (F) session April, 2000 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 August 2002.

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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.

4.04.02

SIKDER MAINUL HASAN

DEDICATION

In loving memory of my parents

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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
MRP II: Manufacturing Resource Planning
MPS: Master Production Schedule
BOM: Bill of Material
RM: Raw Material
ETO: Engineer to Order
MTO: Make to Order
MTS: Make to Stock
ATO: Assembly to Order
BPDB: Bangladesh Power Development Board
REB: Rural Electrification Board
MVA: Mega Voltage Amperage
KVA: Kilo Voltage Amperage
JIT: Jnst in Time
OPT: Optimized Production Technology

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Sikder Mainul Hasan

ABSTRACT

The present study was conducted on a local transformer manufacturing company. This is a fabrication/assembly organization where raw materials are procured and processed. The scenario observed in the study is not very different from other local industries. Local firms in many cases are very reluctant or pay less attention in incorporating and utilizing operations management techniques such as inventory control, scheduling, material requirements planning (MRP) etc. The main reason of the organization's unenthusiastic attitude is identified as unawareness of the benefits from technology utilization. The lack of knowledge about the benefits of using MRP in various aspects hindered its wide spread diffusion.

A general perception that the procurement of raw materials either in huge quantity at a time or in small quantity from period to period without adopting any mathematical approach would not have any significant effect on the total cost still prevails in the local firms. Practically the situation is different. It has been found that the procurement of materials applying an established algorithm (i.e Wagner-Whitin approach) instead of current practice (intuitive approach) could reduce the inventory costs remarkably. In this respect (lot sizing) an educational version production and operation management software named POM was used. The study revealed that the company could save as high as 70% inventory cost such as silicon steel. Similar is the situation for other materials also.

Besides this, the incorporation of MRP facilitates the company in many ways especially in better management such as avoidance reordering, shortfalls of materials, idle time minimization, timely delivery of products etc. It is 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, the reliable lead time etc. Situation could be improved further if mathematical model for multiple items lot size and variable lot size could be developed considering the constraint of stores, fund, transport facility etc.

CHAPTER 1
INTRODUCTION

1.0 BACKGROUND

Material Requirements Planning (MRP) is a very familiar name in the text of Industrial Engineering. Manufacturing requires various resources- one of which is raw materials. It also requires products to be tracked through entire production process to shipment. There are many ways to organize and monitor a production line. Hence there are many ways to build information system to support production. One of the oldest production management methods focuses on inventory management. The objective was to maintain sufficient raw material to keep the line running yet hold cost down by keeping inventories as small as possible.

Many manufacturing companies base their information system on the manufacturing line. A popular system was based on the operation management concepts of material requirement planning (MRP). In most MRP systems, the production drives the information systems. At each stage of production MRP evaluates the usage rate of raw material and determines the necessary inventory level If managers or designers want to alter the production line, they can use existing data and simulations to determine approximate inventory levels for the new production [1]. Production management has to rely on mathematical models of queuing theory, economic inventory theory, and simulation to determine the best flow of production and the required supply of materials and labor. By adaptation all these models many companies achieved remarkable gains in terms of improved customer service, reduced inventories, and lower manufacturing cost.

1.1 HISTORY AND TREND IN PRODUCTION FIELD

There is no well document of production history but it is believed that it started from very ancient time when man started cultivation. In course of time man learnt about his needs, surroundings nature and environment and started formal production. Production at that time was domestic production, handicraft production, or cottage industry. Domestic production was within the home and was consumed by home members. Handicraft production was in or outside the home, and the product was sold to local consumers. In cottage industry, a middleman provided the materials to the handicrafts workers, bought their output, and marketed it. The industrial revolution occurred in between 1770 and the early 1800s and soon spread from central Europe to America and later to East Asia. Production was organized in factories where many men & machines were employed and production was in larger volumes than that was possible with previous manual system.

Later, factories expanded in size, utilized more machinery, increased production rate and became more complex in operation. Observing the conditions and wanting to improve upon them, Frederick W Taylor embarked upon a series of experiments in the Midvale steel corporation in Philadelphia in the years 1878 – 1890. The results of these experiments formed the basis of the "scientific management" which revolutionized factory management. In 1915, Ford W. Harris, an engineer at Westinghouse Corporation, developed a formula for *economic order quantity* (EOQ), the quantity to produce per order that would minimize the sum of ordering and holding costs. EOQ was the first analytical method to solve inventory management. From then until about 1930, the traditional view prevailed, and many techniques we still use today were developed [2].

The 1940s saw the coming of World War II and the massive changeover of American industry from the production of civilian goods to war material. Rather than efficiency meeting the delivery schedules was of prime importance. Companies started to use tabulating machines and punch cards for such functions as exploding bill of materials and preparing shop orders. During the war there was remarkable success in solving the problem of military operations using scientific method called operations research. The approach involved analysis of a particular problem, formulation of mathematical model and solving that optimize the measure of effectiveness. After the war, operations researchers turned their attention to business problems and got success in forecasting demand, controlling inventory, and scheduling production.

In the late 1950s postwar, customers demanded more rapid delivery. Many companies then were forced from 'make to order' to 'make to stock'. Exponential smoothing technique was then used to forecast demand. Master schedule was not yet feasible since it had to be continuously adjusted and manual method could no longer keep up. In these circumstances the concept of *order point* aroused. As soon as the inventory level fell to the order point an order was issued. In the late 1950s the concept of CPM and in 1957 the concept of PERT was developed. The first was by Catalytic Construction Company and the second was by U.S Navy. Both the concepts are virtually same and determine the longest time for the completion of a project [3].

The first commercially available computer appeared in 1951. IBM introduced the IBM 701 in 1953 and IBM 650 in 1954. The early application of computer was mainly to keep accounting. But later computer started to dominate both in *Automation* and in *CIM*. Throughout the successive involvement of computer technology in industry the MRP concept came to the frontline.

1.2. COMPUTER AND THE EVOLUTION OF COMMERCIAL MRP

Computer in its early days was limited on the use of bill of material (BOM) processors and material requirements planning (MRP). MRP uses BOM to explode the master schedule for products to determine when & what quantity to be ordered. Leading American companies developed their own programs & successfully implemented the program. The first company that implemented MRP was American Bosch, in Springfield, Massachuetts in 1959. Other such companies are J. I. Case, Black & Decker, and Twin Disc. During the 1960s, many companies introduced commercial computer software of MRP; the best known was PICS by IBM. Subsequently many companies introduced MRP and it becomes obvious that it is a little of the total system. Therefore, in 1980s to meet the clients' demand MRP II was developed which in addition to MRP provides production planning, master scheduling, capacity planning, and shop floor controlling [3].

The intense international competition in manufacturing has provided a strong incentive to management to seek new, more effective ways of managing production. As a result thousands of companies have implemented computer-based production and inventory control. The most widely adopted systems are called material requirements planning & manufacturing resource planning. Many companies, having achieved success with MRP II, continued their effort in research & development of flexible automation and computer integrated manufacturing.

1.3. TYPICAL MANUFACTURING SYSTEM

To operate properly, MRP contains several data files. The files serve as inputs to MRP processor. They are master production schedule, bill of materials file, and inventory record file. Figure 1.1 depicts the flow of MRP processor and its conversion into useful output reports. The *master production schedule* tells what, when and how many to be produced. What means, what is the end product when means, the time horizon when it will be ready for shipment and how many means, the quantity that will be produced. The master production schedule must be based on an accurate estimate of demand and a realistic of its production capacity. The *inventory record file* is referred to as item master file in a computerized inventory system. The file is divided into three segments. The first segment provides item's

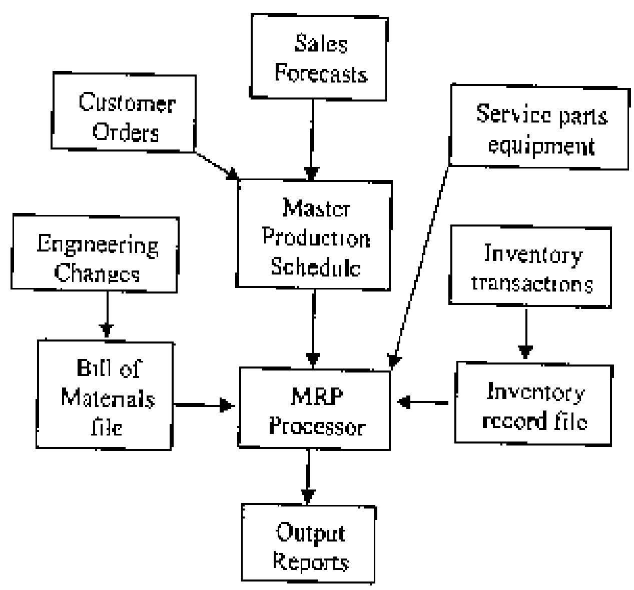


Figure 1.1 Structure of a material requirement planning system

identification (part number); the second gives a time phase record of inventory status. In MRP it is not only recorded the current inventory status but also the future changes that will occur against the inventory. Therefore the inventory status segment lists the gross requirements for the item, schedule receipts, on hand status, and planned order releases. The third file segment provides subsidiary data such as purchase orders, scraps or rejects, and engineering changes [4].

The bill of material provides the MRP system with the part number and quantity of all parts required to build and to assemble the product. The inventory control systems supplies the MRP system with the projected on hand balance of all parts and materials listed on the BOM. The inputs from BOM and inventory control system must be timely and accurate for the formal MRP system to work. Updates of the inventory control system for changes in inventory due to part movement in manufacturing or purchasing must be continuous.

In most MRP installation a BOM accuracy of 95 percent or better is required, and a location and count accuracy of 98 percent is necessary for specific parts in the inventory system. The MPS must support the production strategies such as engineer to order (ETO), make to order (MTO), assembly to order (ATO) and make to stock (MTO). The ETO and MTO strategies use similar process in the MPS implementation and the ATO and MTS processes are quite different. The primary impact on the MPS for all of these production approaches is in the choice of units for the MPS.

Product demand may be of three types: first, the customer orders for specific products usually promised by sales department to the clients. The second is the forecasted demand based on statistical technique applied to previous demand. The forecast may constimte the major portion of the master schedule. The third is the demands for individual component parts usually repair parts. This category usually is excluded from master production schedule since it does not represent the end product. It is evident from the Figure 1.1 above and directly added to the MRP processor.

1.4. MRP IN LOCAL INDUSTRIES

In general local manufacturing industries do not pay adequate attention in the context of state-of-the art operations management techniques such as inventory, scheduling, material requirement planning (MRP) etc. The identifiable reasons are lack of exposure to the concurrent techniques and facilities, exorbitantly high price of commercial software, inadequate indigenous support system, scarcity of qualified manpower etc.

On the other hand, manufacturing industries in the developed nations are taking the advantage by applying relevant software and techniques and thus dominating the world trade & business. Computer hardware and software are now cheap enough, so it is an opportunity for local manufacturing industries to take the advantage of computer integrated manufacturing (CIM). The main identifiable problem in implementing MRP in local industries is the lack of skilled manpower. Some companies purchased the software in exchange of high price but could not run it due to above-mentioned problem. Again some companies hired people from abroad to implement the software and they took time even more than two years. It may be mentioned that though the concept is straightforward but complicity arises in the application of the technique because a package may not be applicable to all industries.

The implementation of MRP can lead to disaster when it is used without careful analysis of the specific requirements of the concerned company [5]. Therefore, its appropriateness and effectiveness depend upon the extent of its customization. Again every manufacturing firm wants to maximize profit by reducing inventory. Once inventory management was treat as a clerical job and not proper attention was paid on it But in course of time when management found that inventory claims almost one-third of total investment then they became conscious to curb the cost in inventory. As local manufacturing industries have to face extreme competition due to globalization and in many cases their production cost is extensively high so they are in required to take the advantage of utilization the concept of MRP and its implementation.

1.5 OBJECTIVES OF THE PRESENT STUDY

The present study was aimed at identifying the present status of MRP application in local industries. In this regard a typical local fabrication/assembly organization was selected as a model. It was understood that there were problems and prospects in implementation of MRP in local industries and that's why with the following aims and objectives the present study was conducted:

(i) To study and investigate the bottlenecks in applying the MRP concept in a local transformer manufacturing industry

(ii) To estimate the holding and set up cost of individual materials

(iii) To implement the MRP software including MPS and MRP lot sizing for certain products

(iv) To recommend appropriate measures for local industries in applying MRP and to identify the action plans for future work.

CHAPTER 2
BACKGROUND STUDY

2.0 COMMON TERMS IN MRP

Material Requirements Planning is based on several concepts. Concept of dependent & independent demand is fundamental in MRP. *Independent demand* means the demand for a product is not directly related to the demand for other items. End products and spare parts are examples of items whose demand is independent. For an automobile car, the car itself is an example of independent demand. *Dependent demand* means the demand for the item is related directly to the demand for some other products. Not only component part but also raw materials and subassemblies are examples of dependent demand. Four doors and four tires are examples of dependent demand.

The lead time is the time needed to complete a job from start to finish. There are three lead times: assembly lead time, ordering lead time and manufacturing lead time. Assembly lead time is the time required to assemble a product or part. The ordering lead time is the time required from initiation of purchase requisition to the receipt of the item from the vendor. Manufacturing lead time is the time required to fabricate a part. Usually assembly lead time is relatively short and may be matter of even a day only, ordering lead time depends upon the source and types of the raw material. In case of purchasing it from foreign countries the ordering lead time is much larger compared to purchasing it from local market.

Common use items are raw materials and components that are used on more than one product. MRP collects these common items and calculate it in its lot sizing. MRP is a powerful technique in the planning and control of manufacturing inventories. The quantities of dependent demand items can be determined very efficiently by MRP. The items constitute raw material, work in process, component parts, and subassemblies.

2.1 DEBATES ON MRP/MRP II

There are many reasons advanced for the poor performance of MRP system in practice [6 & 7]. Some of these relate to the need for widespread education in

MRP thinking and to the necessity for top management commitment to ensure success. Now let it be discussed the shortcomings in different area of MRP.

Lead times: 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. But in practice lead time is not too 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 production environment design element in the factory coordination 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 fulfill that schedule. This is based on the premise that the plan has already been passed through cut capacity planning and therefore must be 'achievable'. Both JIT and OPT schedule production assuming a limited capacity. In JIT the Kanban card is used to control the capacity and in OPT bottleneck is used.

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 cost of set up and inventory. JIT and OPT have overcome the batch size problem.

MRP's 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 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. It's appropriate and effectiveness is a matter of contention [8].

MRP implies that managers have to treat everything formally. Once the MRP system has been taken on, all sorts of flexibility in the business appear to have been lost if they are to be recovered in the same formal idiom as the MRP system itself. Safizadeh and Raafat (1986) examined this question as the fundamental precondition 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 overload master schedule and suggested a formal rule where overtime also could be structured in relation to the MRP scheme Turner and Hurst (1986) examined that the master schedule had to assume within the procedures of an organization to be effective.

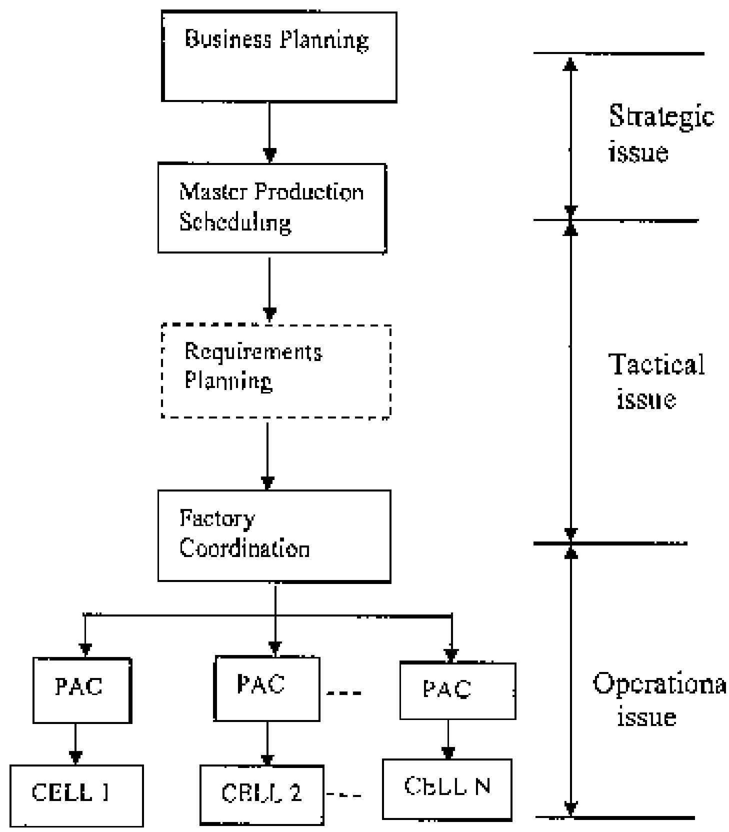


Figure 2.1: Architecture for PMS in hybrid environments.

2.2 MRP WITH MODIFICATION/ ADAPTATION

The shortcomings discussed in section 2.1 however tried many one to reduce or eliminate. A solution was proposed by Paul Higgins in 1992 depicted in Figure 2.1 above named as Architecture for PMS in hybrid environment [9]. The 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 product, components or process 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 coordination module ensures that the individual cells/ factories interact to meet an overall production plan [10, 11 & 12]. Strategic issues mean to the determination of the products to be manufactured, the matching of products to markets and customer's expectations and to design the manufacturing system. Tactical issues relate to the generation of detailed plans to meet the demands imposed by the long-range production plan. And operational issues essentially involve taking the output from the tactical planning phase and managing the manufacturing system in quasi real-time to meet these requirement.

The implementation of MRP can lead to disaster when it is used without careful analyses of the specific requirements of the company concerned. This does not mean, however, that a good control system is not necessary. The control system for office furniture industry in this case has to contain elements of MRP, OPT and JIT. For medium term planning and control the MRP logic is useful and computer support for automated material requirements calculations is absolutely necessary. For short-term control JIT elements (pull system) should be used, as well as bottle neck calculations. Besides this, the classical MRP idea of restructuring the bill of material has to be added to the control concept. Because of all this, a classical MRP package could be used in this industry with some adaptations. In some of the modern MRP packages several of these adaptations are foreseen however [13].

2.3 LANGUGE BASE DEVOLOPEMENT OF MRP

During the last 30years, manufacturing companies all over the world have spent large amounts of time, effort and money on the implementation of manufacturing control system Typically such systems are based on the application of material requirements planning (MRP)/manufacturing resource planning (MRPII) approaches Yet survey after survey continues to revel that only a small proportion of such systems can be regarded as really effective [14, 15 & 16]. As a result, during the 1980s there has been some decline of interest in MRP/ MRP II system in the face of the increasing popularity of just in time (JIT) manufacturing philosophy. However, there is an increasing realization that MRP and JIT philosophies are complementary, and no competing alternatives as was assumed wrongly. MRP based systems are here to stay, particularly for planning related task, as indicated by the fact that many Japanese companies, which pioneered the implementation of JIT manufacturing and kanban control system are now increasingly implementing MRP systems [17].

While the future of MRP system is assured for the foreseeable future, it is also clear that the system configuration takes account of the real requirements of the organization concerned. This indicates the need for flexible software, which can be adapted, at relatively low cost, to suit the requirements of individual manufacturing environment [18].

Fourth generation languages represent one very attractive method for the development of software, which can be adapted to suit the requirements of individual manufacturing environments [19, 20, 21, 22 & 23]. The term fourth generation language (4GL) is often used to mean a number of different things. In general term 4GLs are easier to use than third generation languages such as Fortran or Cobol. As a result, system can be developed by less experienced users over a shorter time period. Often with the use of such languages, it is not necessary to employ specialist data processing staff.

2.4 LOT SIZE STUDY

With the emergence of *MRP* a need arose for new method to determine lot size under conditions quite different that assumed *independent demand inventories* [3]. Specially the conditions areas 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 organizations.

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 no of periods to be covered by each order rather than no of units to order.

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

It can be proved that, $t^* (t^* - 1) \overset{\text{just}}{\leq} 2k/hr$

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 produce units only needed, with no safety stock and no anticipation of further order. When frequent orders are economical and just in time inventory technique implemented, lot for lot is very efficient. However when ordering cost is significant 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 1 through j where the inventory at the end of period j is zero

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

The equation depicted above to determine f_j, the minimum ordering and carrying cost through period j, 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 look back no further than i_{j-1}, the regeneration point selected in determining f_{j-1}.

CHAPTER 3
COMPANY PROFILE AND ITS PRODUCTION LINE

3.0 INTRODUCTION

The data used in this study were collected from a local transformer manufacturing company. It is located at approximately 50-km north from Dhaka City. Initially the company was involved in importing and distributing the Siemens brand transformer, control and protection equipment. Later in 1986 it started production of distribution transformer and supplied it to BPDB and REB. In 1992, it made 11KV Switchgear first time for domestic market. It continued its effort to manufacture electric utilities locally and in 1996, it manufactured Resin cast 11 kV Current and Potential transformer. The company was striving to go for challenging jobs and making of bigger transformer In 1997, it manufactured power transformer of 10 MVA, 33KV class voltage transformer and current transformer. In 1999, it first time in Bangladesh manufactured 10/15 MVA transformer with on load tap changer [24].

The company has two divisions: Transformer division and switchgear division. In transformer division power transformer & distribution transformer are manufactured. In swithchgear division different ratings of switchgear are manufactured. Switchgear division is actually an assembly section as all the component parts are imported whereas transformer division comprises of both manufacturing and assembling.

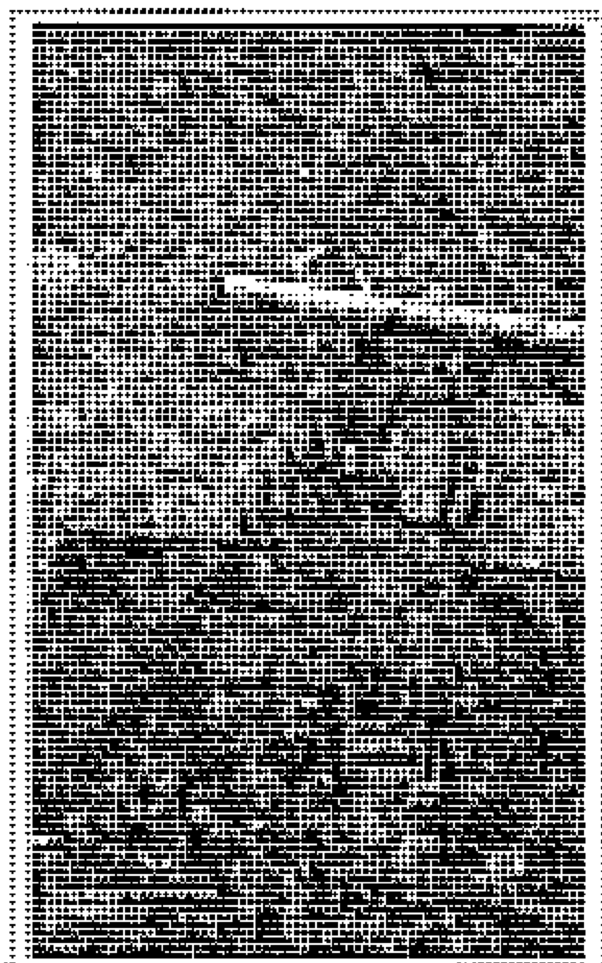
3.1 TRANSFORMER DIVISION

Transformer division is one of the largest divisions contributing the bulk of its turnover. It embodies the knowledge, experience and state of the art of technology in transformer engineering and practice. The company's highly trained engineering and manufacturing team have been successfully manufacturing transformers for the last one-decade.

Keeping pace with latest changes in technology, the company is making considerable investments in manufacturing and allied facilities for modernization and technological upgradation. It enhanced its product range to higher rating of power, furnace and converter transformer.

Power transformer factory can handle power transformer of 50 MVA, 132 kV, which is one of the largest transformer manufacturing unit in Bangladesh. At present it manufactures power transformer of 10/14 MVA, 33 KV class and shortly start manufacturing furnace transformer, converter transformer and power transformer of 132 KV class with on load Tapchanger.

PHPTOGRAPH:
A transformer with two Radiators and one oil level indicator.



3.2 CURRENT PROFILE

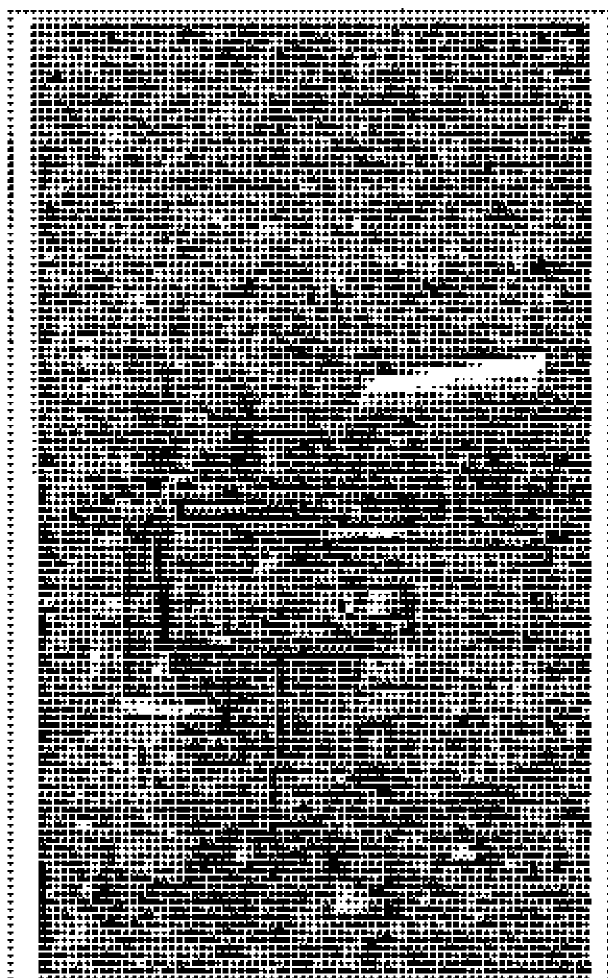
Distribution transformer ranges from 25 KVA to 3000 KVA, having system voltage either 11 KV or 33 KV. Pole type transformers are mainly designed for Rural

Electrification Board. These transformers comply with ANSI, BSS or IEC specifications.

Instrument transformers are both dry and oil immersed for indoor / outdoor type.

Power transformers from 3 MVA to 25 MVA of 33 KV applications are either with off load tap changer. Transformer may have automatic mixed cooling system like ONAN/ONAF by the cooling fan, which runs automatically by sensing the winding temperature.

PHOTOGRAPH:
Insight of a transformer
Showing core coil
assembly.



25 MVA and above 132/33 kV transformer are star/star connected with on load tap changer. Furnace transformer are either with ONAN cooling (heat dissipation through pressed steel radiator) or ONAF cooling with two heat exchanger, keeping one

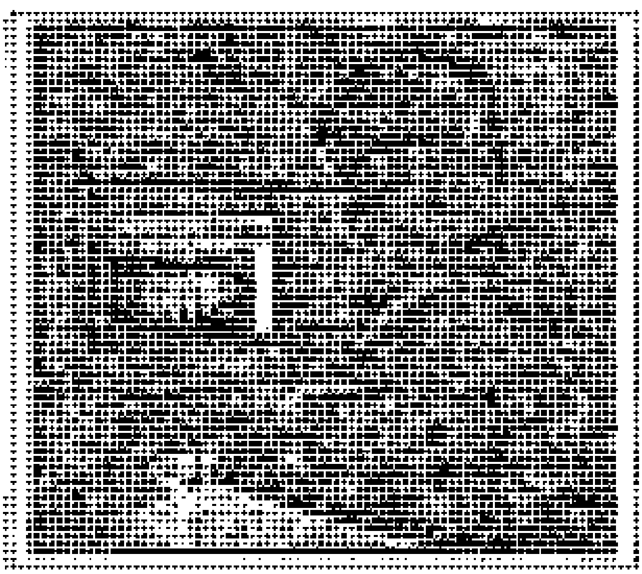
of 100% stand by [25]. The low voltage winding of furnace transformers are made from series of parallel discs, connected to the HV flat riser. Special oil sealing arrangements are made for furnace transformer.

Converter transformers are specially designed for steel rolling mills, considering the harmonic voltage of the thyristor and also rigid overload condition. Auto transformer for motor starter or industrial use are air cooled or oil cooled types, with or without control panel.

3.3 TRANSFORMER FEATURE

The transformers are designed according to the requirement of individual customer, conforming to one or more internationally recognized standard including IEC 76, BSS 171, ANSI 57.12, VDE 0532 [25]

PHOTOGRAPH: Showing the design of a core coil assembly



Design

The company boasts of modern design and production technique supported by Computer Aided Design and required software. Local and foreign technology and experienced consultants and experts are continuously behind the development of quality of production.

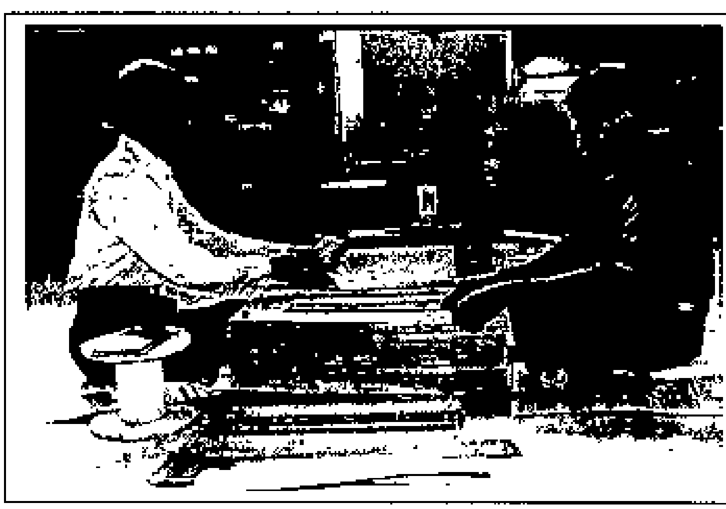
Construction

The core is built of grain oriented cold rolled silicon steel to give low no-load losses and to reduce noise levels as well. Yoke laminations are clamped between steel frames with core clamping bolt and the frame also support the windings through end blocks and rings. The construction ensure low iron loses and magnetizing currents.

Windings

High voltage coil up to 33 kV class is continuous disc wound or cross over type using paper insulated copper conductor. Low voltage coils are normally larger layer wounds using paper insulated copper conductor. High voltage coils of 132 kV class are interleaved or interluded disc wound with paper insulated copper conductor The interleaved or interluded discs improve the initial surge voltage distribution

PHOTOFRAPH: Showing the Assembly operation of silicon steel core



Core-Coil Assembly

Being the only active part of the transformer, it has to withstand all the ranges of short circuit stresses apart from the impulse voltage and thermal stresses. The design of the clamping structure takes the care of the axial short circuit forces. Careful design of the winding supports and spacer enable the winding to withstand the radial as well as loop stress in the outer winding and compressive stress in the inner winding.

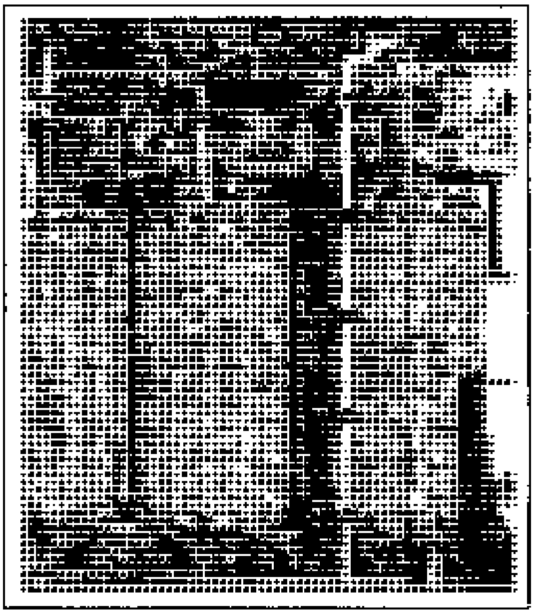
Tapping

Tapping is normally provided in the high voltage windings to cater either for high voltage or low voltage variation. Tapping are adjusted by off circuit tap changer in case of distribution transformer of 11 kV class assembled from top cover, and power transformer of 33 kV class, assembled on the top of core-coil assembly. On load tap changer are for power transformer to cater for voltage variation when the transformer is on load condition.

Processing & Oil filling

To improve the dielectric characteristics of the insulation between the coil and core, coil assembly of transformers is dehydrated in the vacuum autoclaves or air-dying oven. The transformer oil is processed by high vacuum oil centrifugal plant. Before pouring the oil under vacuum, when the transformer is perfectly dried up, the oil is tested for dielectric breakdown at their laboratory.

PHOTOGRAPH:
Showing three coils of a power transformer



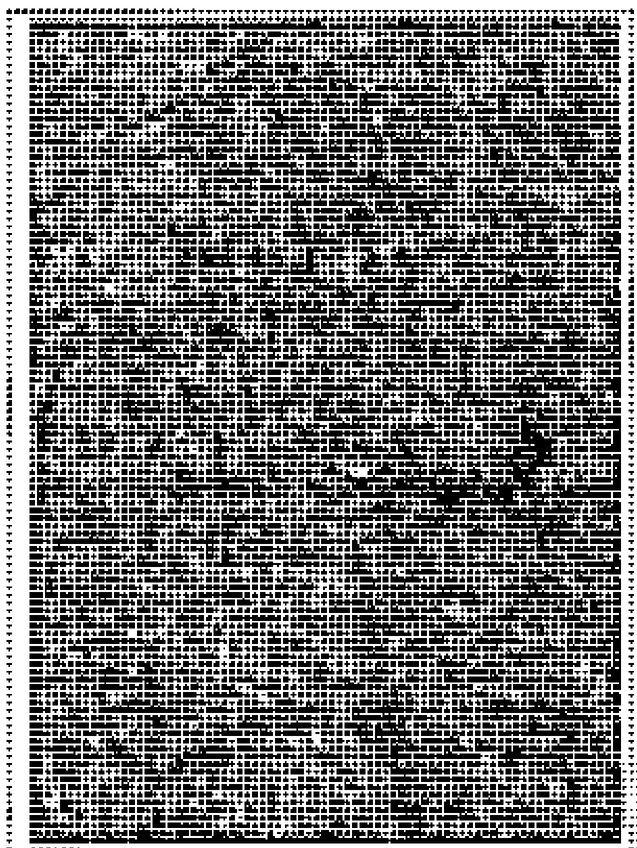
Tank and Cover

Mild steel sheet made tanks and covers are fabricated by welding. Each tank is tested under pressure for detecting any leakage. Tanks employed for housing the core-coil assembly are mechanically strong. Tanks for power transformer are suitable to withstand full vacuum. The steel parts before being painted are shot or sand blasted o remove weld splatters, mill scales etc.

Conservator Tank

Transformer is provided with an overhead conservator tank. It is detachable by providing a flange at its point of connection to the tank cover. The connection to the main tank cover will be at the highest point to prevent trapping of air in conservator tank, which shall be detachable to facilitate cleaning

PHOTOGRAPH:
Showing the radiators in
Enlarge view



Radiators

Pressed steel radiators are specially made from "D" grade CRCA sheets with profile formed and the elements are resistance welded with seam welding machine. Each individual element and radiator under assembled condition is tested with air pressure of approximately 3 kg/cm^2.

Insulating oil

Transformers are delivered with initial oil filling. Transformer oil is so that no further drying will be required before putting into operation. The characteristics of the insulating oil are as follows:

Specific gravity at 15^{0}C	: 0 87
Viscosity at 75^{0}C	: 5.5 Centistokes (Max)
Viscosity at 30^{0}C	: 19.0 Centistokes (Max)
Flash point	. 145^{0}C (Min)
Reaction	: Neutrality
Dielectric Strength	: 50KV (Min), 12.5mm diameter spare electrode gap length 2.5 mm

Tests

Tests are carried out rigorously at every stage of assembly. Transformers are qualified for dispatch on successful completion of routine test as per BS 171/1970 or IEC 76.

- Insulation resistance measurement
- Measurement of voltage ratio and checking voltage vector relationship
- Measurement of winding resistance
- No load current and load loss measurement at 90%, 100 % and 150 % of rated voltage.
- Measurement of impedance voltage and measurement of load loss.
- Separate source voltages withstand test.
- Induced voltage withstand test
- Di-electric strength of oil
- Oil leakage test for transformer tank

Quality

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

Accessories

The following accessories are furnished with the transformers. Drain valve, Filter valve, Thermometer pocket, Earthling terminal, Lifting lugs, Radiator valve, four jacking lugs, pressure relief device, winding temperature indicator, HV and LV bushing, oil temperature indicator and oil level gauge.

3.4 PRODUCT LIST

The company boosts its design section by Computer Aided Design (CAD) and production section by Computer Aided Manufacturing (CAM). It manufactures single phase and three phase transformers, core type or shell type. Oil immersed or dry type, naturally self-cooled or forced air / oil cooled, suitable for outdoor or indoor installation.

Products:

1) 5 kVA 1 phase, 50 Hz
2) 10 kVA 1 phase, 50 Hz
3) 20 kVA 1 phase, 50 Hz
4) 50 kVA 1 phase, 50 Hz
5) 75 kVA 1 phase, 50 Hz
6) 100 kVA 1 phase, 50 Hz
7) 150 kVA 1 phase, 50 Hz
8) 50 kVA 3 phase, 50 Hz.
9) 75 kVA 3 phase, 50 Hz.
10) 100 kVA 3 phase, 50 Hz.
11) 150 kVA 3 phase, 50 Hz.
12) 200 kVA 3 phase, 50 Hz
13) 250 kVA 3 phase, 50 Hz.
14) 315 kVA 3 phase, 50 Hz.
15) 400 kVA 3 phase, 50 Hz
16) 500 kVA 3 phase, 50 Hz.
17) 630 kVA 3 phase, 50 Hz
18) 750 kVA 3 phase, 50 Hz.
19) 1000 kVA 3 phase, 50 Hz.
20) 2 MVA 3 phase, 50 Hz.
21) 3 MVA 3 phase, 50 Hz.
22) 5 MVA 3 phase, 50 Hz.

3.5 LAYOUT OF THE PLANT

The company's layout is the type of process layout where production machines are arranged into groups according to general types of manufacturing processes. Every department i.e. lathes are in one department, cutting machines (both Manual and NC types) are in another, fabrication in another department. Chemical department does the function of chemical treatment of Nut, Bolt, Bushing Rings and Rods. Fabrication department does the function of fabricating tanks and radiators mainly There are also switchgear and current transformer sections but they are independent and not related to transformer department.

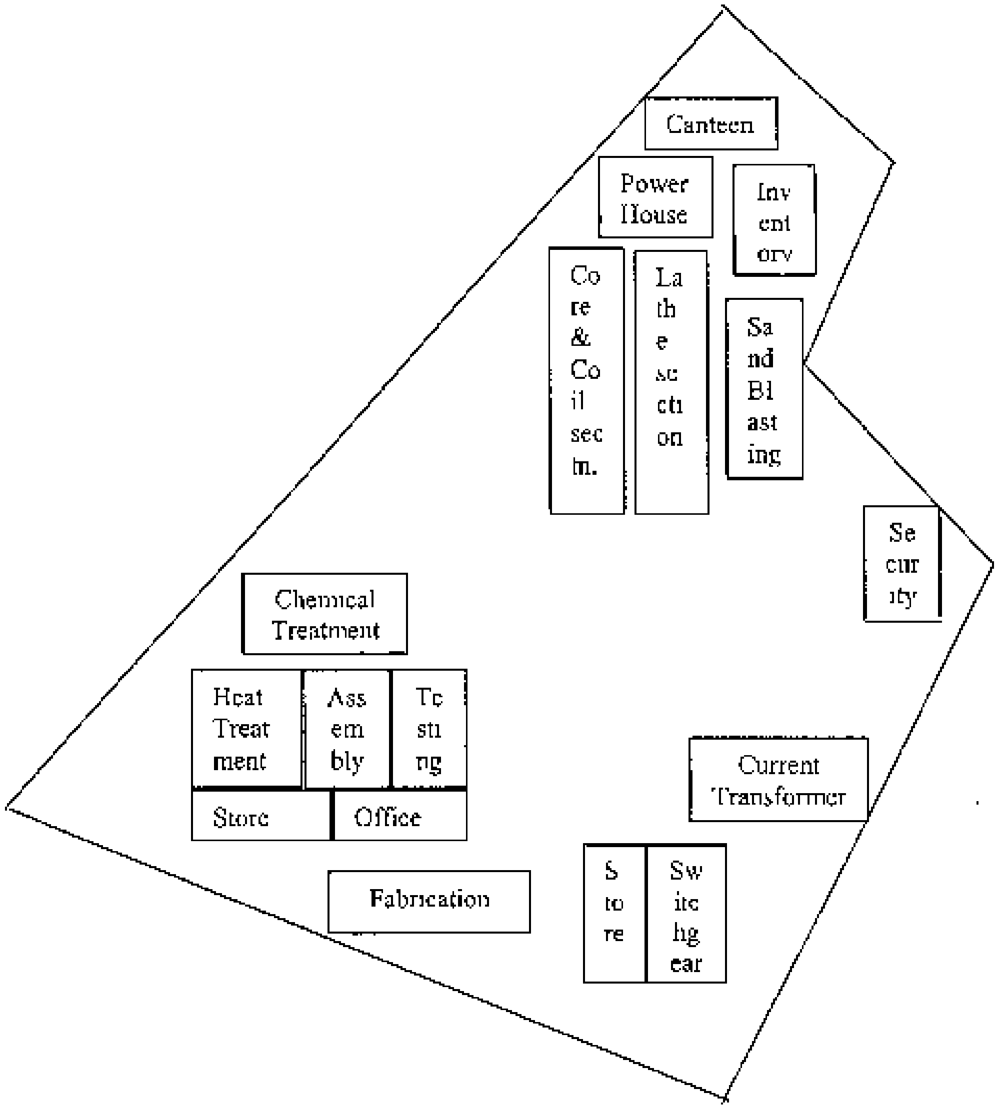


FIGURE 3.1 Plant Layout of the company.

3.6 PROCESS FLOW CHART

The company has sales Engineer all over the country. From the basis on previous sales, clients direct order at sales office & demand collected by sales engineers the sales department give a future forecast of transformer requirement of production. The planning department determines master production schedule, material requirement consulting with stores and design section.

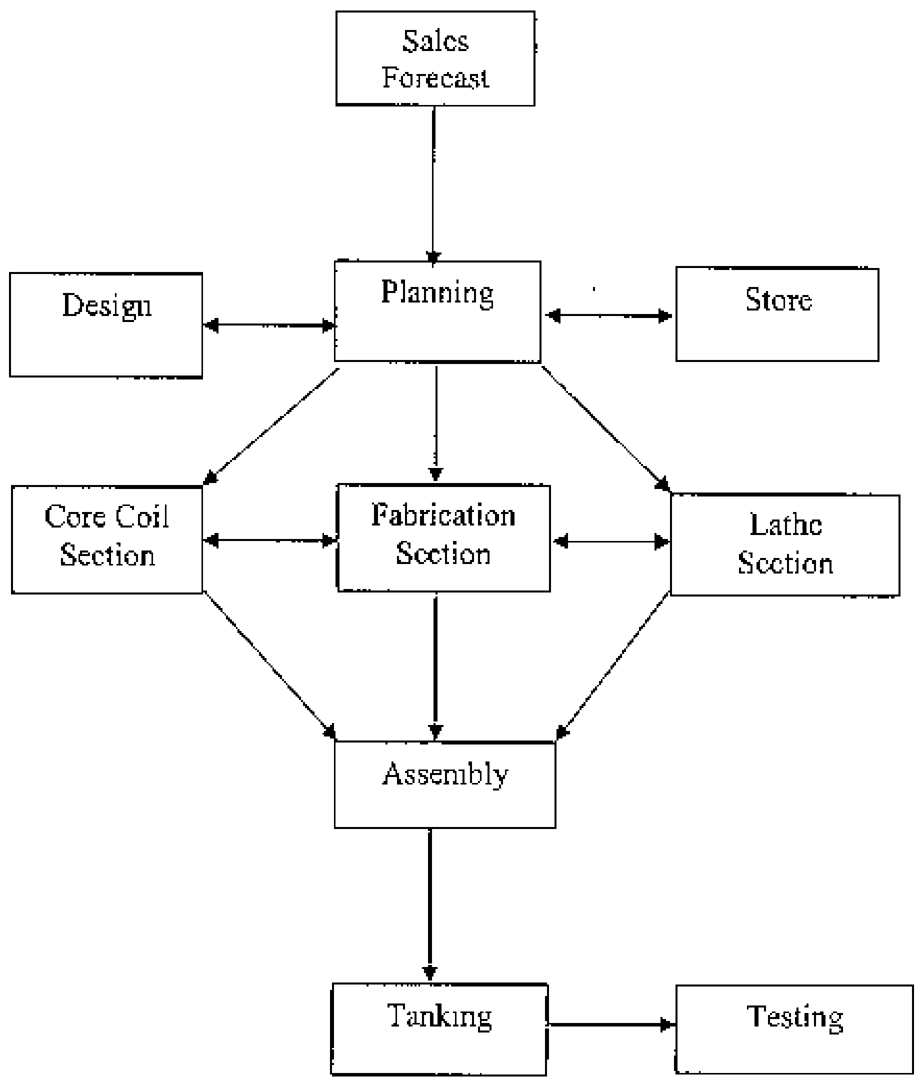


FIGURE 3.2 Process flow chart showing the activities in a transformer manufacturing company.

For every type and specification of transformer there is distinct design, designing department designs with CAD. Store gives the information of finished transformer in inventory and the raw material on hand. Silicon steel is cut by both NC machine and hand operated machine. Normally NC is used in case of power transformer where large

& huge amount of Silicon sheet is required and NC cuts at higher speed. Silicon steel sheets required for distribution transformers are cut manually. Coil imported from abroad is winded in winding section with insulation raping the bared cu wire. Tank & radiators of the transformer are fabricated in fabrication section where a large number of mechanical machines are used. Tank sheets are normally cut by gas cutter where as radiator sheets are cut by hydraulic press bar. All cutting is done according to design. Radiators are seam welded and then fluid test is done. In lathe section all rods, bolts, channels, flanges etc are manufactured. In a medium size transformer 11 long size rods, 4 channels are required to manufactured. The items delivered from these three sections are then assembled to make a final product. After the improvisation of dielectric characteristics of transformer the tank is filled up with oil and then core coil assembly is descended in tank where it is immersed. The tank is then tested and delivered to customer.

CHAPTER 4
METHODOLOGY

4.0 INTRODUCTION

Since there are several categories of transformers are 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 are also briefly discussed.

4.1 WORKING PRINCIPLE OF MRP

The *master production schedule* tells what, when and how many to be produced. What means, what is the end product; when means, the time horizon when it will be ready for shipment and how many means, the quantity that will be produced. A general format of MPS is like Figure 4.1. The master schedule must be based on an accurate estimate of demand and a realistic assessment of its production capacity. In MRP it is not only recorded the current inventory status but also the future changes that will occur against the inventory. Therefore, the inventory status segment lists the gross requirements for the item, schedule receipts, on hand status, and planned order releases.

Week number	6	7	8	9	10
Product P1			20		30
Product P2		50	60	40	
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 simple structure of a product comprises of two subassemblies The product structure is in the form of pyramid, with lower levels feeding into the levels above The dashed line shows the network is up to the raw materials. The items at each successively higher level are called the parents of the items in the level directly below. Suppose S1 is the parent of components C1, C2 and C3. Product P1 is the parent of subassemblies S1and S2. The product structure also specifies how many of each item is to be included in its parent

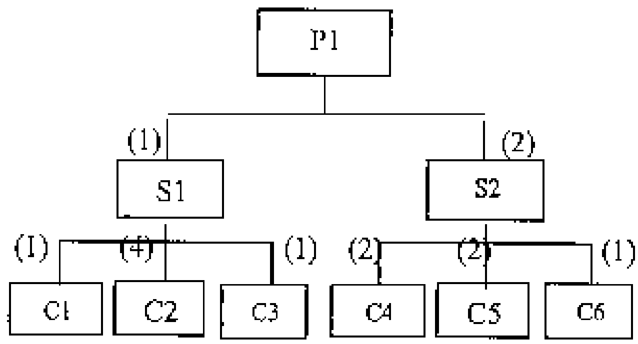


Figure 4.2 Product structure for product P1

The master production schedule specifies the period by period list of end product requirement. The BOM defines what material and component required for each product. The MRP programs computes how many of each component and raw materials needed by exploding the product structure. Now referring the product structure of Figure 4.2, twenty units of P1 explode into twenty units of subassembly S1 and forty units of S2 and the following numbers of units for the components: C1:

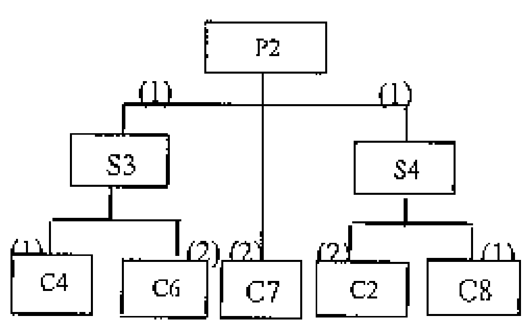


Figure 4.3: Product structure of product P2

20 units, C2: 80 units, C3: 20units. C4: 80 units, C5: 80 units and C6: 40 units. The quantities of raw material can be 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 increased 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) [26]. The net requirement MRP is:

Net Requirements

= [(Gross requirement) + (allocation)] – [(on hand) + (scheduled receipts)]

= [Total requirements] – [available inventory]

<u>Sample Problem:</u>

Let 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 Figure 4.4 (MRP solution) it would be clear to find material requirement and its timing (backward calculation). At last table, on hand material is 35 and schedule receipt is 30 total 65 items is available at period 3 but gross requirement is only 50 therefore 15 items are access. On period 4 this 15 items would act as on hand item and gross requirement is 140 therefore its need 125 items only. These 125 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										
Gross Requirement								20		30
Schedule Receipts.										
On Hand										
Net Requirements								20		30
Planned order Release							20		30	

Period	1	2	3	4	5	6	7	8	9	10
Item: Product P2										
Gross Requirement							50	60	40	
Schedule Receipts.										
On Hand										
Net Requirements							50	60	40	
Planned order Release						50	60	40		

Period	1	2	3	4	5	6	7	8	9	10
Item: Subassembly S2										
Gross Requirement							40		60	
Schedule Receipts.										
On Hand										
Net Requirements							40		60	
Planned order Release						40		60		

Period	1	2	3	4	5	6	7	8	9	10
Item: Subassembly S3										
Gross Requirement						50	60	40		
Schedule Receipts.										
On Hand										
Net Requirements						50	60	40		
Planned order Release					50	60	40			

Period	1	2	3	4	5	6	7	8	9	10
Item: Component C4										
Gross Requirement					50	140	40	120		
Schedule Receipts										
On Hand										
Net Requirements					50	140	40	120		
Planned order Release			50	140	40	120				

Period	1	2	3	4	5	6	7	8	9	10
Item Raw Matl. M4										
Gross Requirement			50	140	40	120				
Schedule Receipts.			30							
On Hand 35			65	15						
Net Requirements			-15	125	40	120				
Planned order Release	125	40	120							

Figure 4.4: MRP Solution of the Sample Problem

4.2 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 transformer there are large 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 sub-assembly. Considering the practical limitations, only the major items were taken into account in constructing the BOM. A typical BOM for 250 KVA transformer is presented in Figure 4.5.

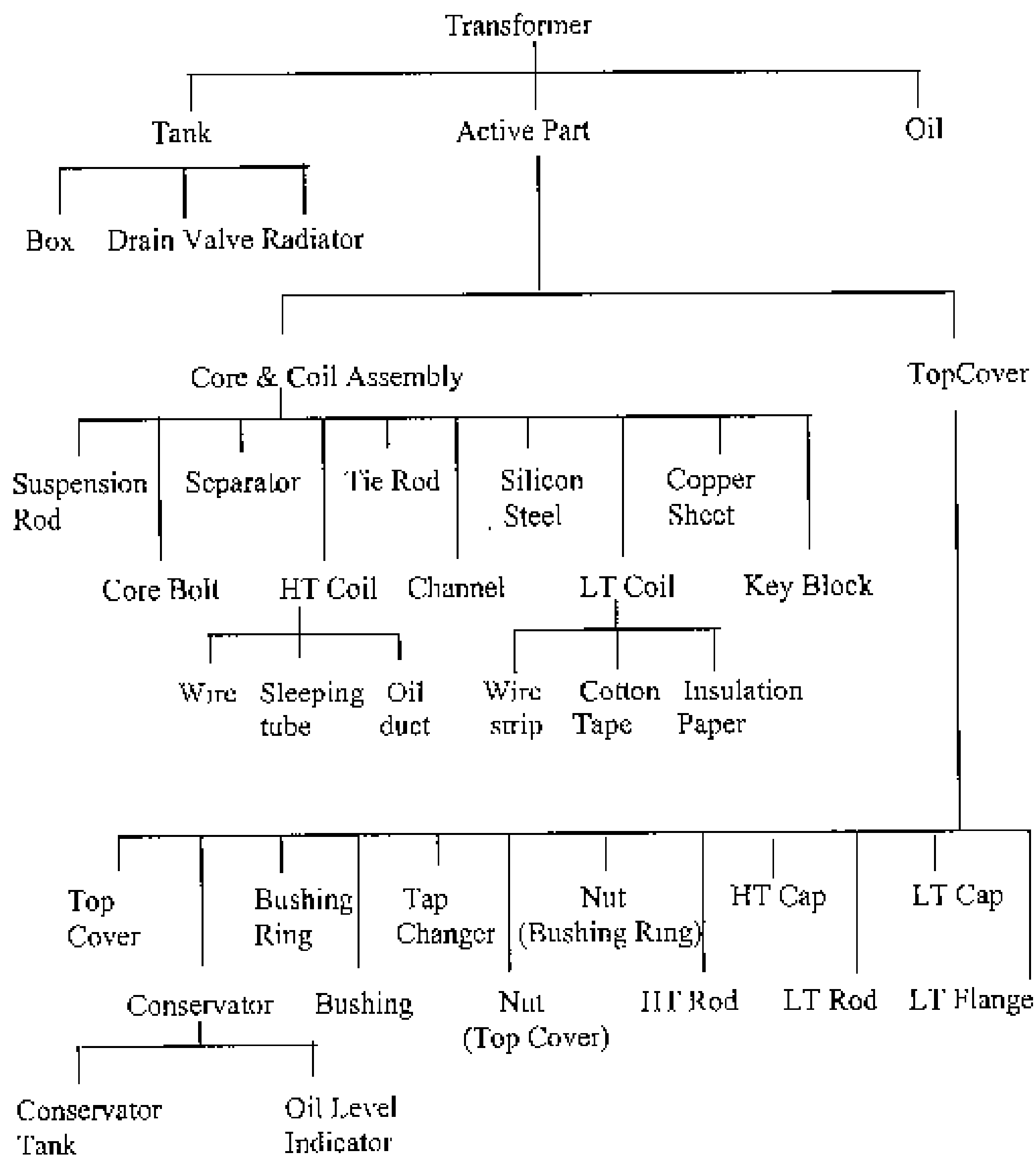


Figure 4.5: The Bill of Material (BOM) of 250 kVA Transformer

4.3 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 manufacturing lead times. 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 week. If the item is fabricated, the lead time may be substantial, perhaps several months [4].

In this case, data on manufacturing 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 is taken on the basis of 'time needed most frequently'. Here it was found manufacturing lead time and assembly lead time is matter of days and ordering lead time is matter of 1 week or 2 weeks for item purchased locally and 120 days for imported items

4.4 SET UP COST AND HOLDING COST

Set up cost is the cost that increases with the no of orders and holding cost is the cost that increases with order quantity. Total cost is therefore, summation of holding cost ordering cost and purchase cost. Figure 4.6 depicts the total cost with

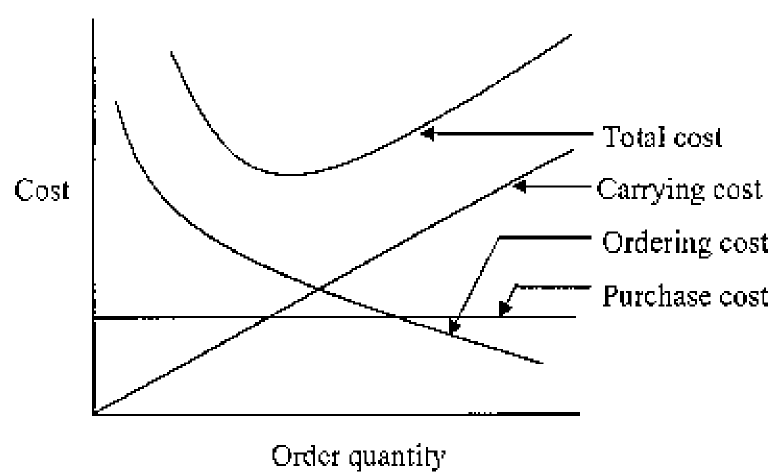


Figure 4.6 Cost element showing total cost

order quantity. The cost elements relating set up and holding cost being enormous therefore its determination became quite difficult. The difficulty arose due to non-availability of data as formatted in text. Therefore data were collected on the basis of procurement officer's buying experience. The data will not be exact due to guise and rough estimation. However, holding cost elements [26] and its percentage value of inventory is shown in Table 4.1 and ordering cost elements [3] is in Table 4 2

Table 4.1 Holding cost element

1.	Housing costs such as building rent, depreciation, operating cost, taxes, insurance.............	(3-10%)
2.	Mat. 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 element

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

4.5 FINAL ITEMS FOR CALCULATION

There are as many as 31 end items for transformers according to BOM chart. But all these items are neither costly nor frequently ordering items. Therefore only 11 items were taken into account for lot sizing determinations that are used in bulk quantity. The items are as follows:

1) Tank RM	5) HT wire	9) press board
2) Radiator RM	6) Transformer oil	10) copper rod
3) Silicon steel	7) channel RM	11) Nut bolt
4) LT wire	8) conservator RM	

CHAPTER 5
DATA COLLECTION AND ANALYSIS

5.0 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 (transformers) were considered for a time-period of twelve months to calculate the demand for the subsequent periods.

5.1 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. It may be a piece, kilogram or liter. For example, per parent 195 is written against transformer oil for 250 KVA transformer implies that each transformer requires 195 liters oil.

The sample calculation presented in this section is for 250 KVA transformer whose product structure comprises of five levels. Since the available POM software is of educational version, it does not accommodate more than 40 periods. But the transformer composes of components or raw materials, which may require lead times as long as 120 days. So the time-phased material requirements were evaluated by adopting manual approach. The data obtained have been arranged in a tabular form from the low level (0) item to high level (5) item starting with total requirement (*TOT. REQ.*); on hand inventory (*ON HAND*); scheduled receipt (*SCHD. REC.*); net requirement (*NET REQ.*); planned receipt (*PLAN REC.*) and order release (*ORD REL*) against the period.

5.2 DATA COLLECTION

In manufacturing transformer raw materials or parts are either procured from local markets or imported from foreign countries. Some of these items are used directly whereas others pass through some 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. 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 1-2 weeks for item purchased locally and about 3-4 months for items imported from foreign countries.

5.3 MRP OF 250 KVA TRANSFORMER

MRP as it is already mentioned can be determined by POM. But POM does not facilitate the aggregation of same component/parts used in different products. Again if it (aggregation) is done from manually done spreadsheet it would be time consuming and also there would be chance of enormous errors. Therefore to avoid a lot of data handling and errors and also to lessen the tedious effort, it is better to calculate the quantity of raw material requirement by Excel. It may be noted here that the results determined by Excel will be exactly same as the data determined by manually done spreadsheet. It will be discussed later in detail. The result of material requirement planning (done manually) for 250-KVA transformer is shown from next page and that done by POM is enclosed in Appendix I. A sample calculation for determining 5, 250 kva transformer is given from Table 5.1 to Table 5.2, Figure 5.1, and Table 5.3

Table 5.1 Material Requirements Planning for 250 KVA Transformer (sample)

Item Name	Level	Lead Time (days)	Per Parent	On Hand Inv.	Lot Size	Min Quantity	Pd 1	Pd 2	Pd 139	Pd 140
Transformer	0	1	0	0						5
T. Oil	1	120	300	0						
T. Tank	1	1	1	0						
Tank Box	2	1	1	0						
Ta. Box RM	3	15	70	0						
Drain Valve	2	7	1	0						
Radiator	2	1	4	0						
Radiator RM	3	15	20	0						
Active Part	1	4	1	0						
Core Coil Ass	2	4	1	0						
Sus. Rod	3	1	4	0						
S. Rod RM	4	7	0.8	0						
Core Bolt	3	1	4	0						
C. Bolt RM	4	7	0.8	0						
Separator	3	1	2	0						
Sep. RM	4	7	0.17	0						
Channel	3	1	4	0						
Channel RM	4	7	15	0						
Tie Rod	3	1	4	0						
T. Rod RM	4	7	1.48	0						
Si Steel	3	1	1	0						
Si Steel RM	4	120	432.3	0						
Key Block	3	1	156	0						
K. Block RM	4	7	0.0033	0						
Copp. Sheet	3	1	4	0						
C. S. RM	4	7	0.5	0						
HT Coil	3	1	6	0						
HT Wire	4	15	15.92	0						
Sleep. Tube	4	7	2	0						
Oil Duct	4	7	1	0						
LT Coil	3	7	3	0						
LT Wire Strip	4	120	26.6	0						
Cotton Tap	4	7	1	0						
Ins. Paper	4	120	1	0						
Top Cover Ass.	2	1	1	0						
Top Cover	3	1	1	0						
T. C. RM	4	15	15	0						
Bushing	3	7	7	0						
B. Ring	3	7	3	0						
Tap Changer	3	120	1	0						
Nut T. Cov	3	7	32	0						
Nut B. Ring	3	7	12	0						
LT Flange	3	7	4	0						
HT Rod	3	1	3	0						
HT Rod RM	4	120	0.42	0						
HT Cap	3	7	3	0						
LT Rod	3	1	4	0						
LT Rod RM	4	120	0.75	0						
LT Cap	3	7	7	0						
Conservator	3	1	1	0						
Con. Tank	4	1	1	0						
Con. Tank RM	5	15	15	0						
Oil Lev. Ind	4	120	120	0						

Table 5.2: Indented Bill of Material of 250 kVA Transformer

Item ID	Lead Time	Number per Parent	On hand Inventory	Lot Size	Minimum Quantity
Transformer	1	0	0		
T. Oil	120	300	0		
T. Tank	1	1	0		
Tank Box	1	1	0		
Ta Box RM	15	70	0		
Drain Valve	7	1	0		
Radiator	1	4	0		
Radiator RM	15	20	0		
Active Par	4	1	0		
Core Coil Ass	4	1	0		
Sus. Rod	1	4	0		
Sus. Rod RM	7	0.8	0		
Core Bolt	1	4	0		
Core Bolt RM	7	0 8	0		
Separator	1	2	0		
Sep. RM	7	0 17	0		
Channel	1	4	0		
Channel RM	7	15	0		
Tie rod	1	4	0		
Tie Rod RM	7	1.68	0		
Si Steel	1	1	0		
Si Steel RM	120	432 3	0		
Key Block	1	156	0		
K. Block RM	7	0.0033	0		
Copp. Sheet	1	4	0		
C. S. RM	7	0.5	0		
HT Coil	1	6	0		
HT Wire	15	15.92	0		
Sleep. Tube	7	2	0		
Oil Duct	7	1	0		
LT Coil	7	3	0		
LT Wire Strip	120	26 6	0		
Cotton Tap	7	1	0		
Ins. Paper	120	1	0		
Top Cover ASS	1	1	0		
Top Cov	1	1	0		
T. C. RM	15	15	0		
Bushing	7	7	0		
B. Ring	7	3	0		
Tap Changer	120	1	0		
Nut T. Cov	7	32	0		
Nut B. Ring	7	12	0		
LT Flange	7	4	0		
HT Rod	1	3	0		
HT Rod RM	120	0.42	0		
HT Cap	7	3	0		
LT Rod	1	4	0		
LT Rod RM	120	0 75	0		
LT Cap	7	4	0		
Conservator	1	1	0		
Con. Tank	1	1	0		
Con. Tank RM	15	15	0		
Oil Lev. Ind	120	1	0		

0 1 2 3 4 5

Level →

The indented bill of material shown above has five levels excluding zero level. Demand for level 0 items i.e. 250 KVA transformer is assumed to be as follows:

Period	Demand
1	0
2	0
3	0
4	0
5	0
----------	----------
136	0
137	0
138	0
139	0
140	5

Transformer

Period	131	132	133	134	135	136	137	138	139	140
Tot Req.										5
On Hand										
Schd Rec.										
Net Req										5
Plan Rec.										5
Ord Rel.									5	

Transformer Oil

Period	15	16	17	18	19	20	-----	139	140	
Tot Req								1500		
On Hand										
Schd Rec.										
Net Req								1500		
Plan Rec.								1500		
Ord Rel.					1500					

Figure 5.1: Sample MRP calculation of 250 kva transformer for number of 5 transformers

And so on But to arrange all this tables create unnecessary occupation of space Therefore, in a concise form it is given in the Table 5.3 shown below.

Table 5.3 Concise MRP table for 250 kva Transformer

Item Name	Level	Tot Req (Lead time)	On Hand	Schedule Receipt	Net Req	Plan Rec.	Order Release
Transformer	0	5/140			5/140	5/140	5/139
T Oil	1	1500/139			1500/139	1500/139	1500/19
T. Tank	1	5/139			5/139	5/139	5/138
Active Part	1	5/139			5/139	5/139	5/135
Tank Box	2	5/138			5/138	5/138	5/137
Drain Valve	2	5/138			5/138	5/138	5/131
Radiator	2	20/138			20/138	20/138	20/137
Core Coil Ass	2	5/135			5/135	5/135	5/131
Top Cover Ass	2	5/135			5/135	5/135	5/134
Tank Box RM	3	350/137			350/137	350/137	350/122
Radiator RM	3	400/137			400/137	400/137	400/122
Sus Rod	3	20/131			20/131	20/131	20/130
Core Bolt	3	20/131			20/131	20/131	20/130
Separator	3	10/131			10/131	10/131	10/130
Channel	3	20/131			20/131	20/131	20/130
Tie Rod	3	20/131			20/131	20/131	20/130
Silicon Steel	3	5/131			5/131	5/131	5/130
Key Block	3	780/131			780/131	780/131	780/130
Copper Sheet	3	20/131			20/131	20/131	20/130
HT coil	3	30/131			30/131	30/131	30/130
LT coil	3	15/131			15/131	15/131	15/124
Top cover	3	5/134			5/134	5/134	5/133
Bushing	3	35/134			35/134	35/134	35/127
Bushing Ring	3	15/134			15/134	15/134	15/127
Tap changer	3	5/134			5/134	5/134	5/114
Nut T. cover	3	160/134			160/134	160/134	160/127
Nut B. ring	3	60/134			60/134	60/134	60/127
LT Flange	3	20/134			20/134	20/134	20/127
HT rod	3	15/134			15/134	15/134	15/133
HT cap	3	15/134			15/134	15/134	15/127
LT rod	3	20/134			20/134	20/134	20/133
LT cap	3	20/134			20/134	20/134	20/127
Conservator	3	5/134			5/134	5/134	5/133
Sus Rod RM	4	16/130			16/130	16/130	16/123
Core bolt RM	4	16/130			16/130	16/130	16/123
Separator RM	4	1 7/130			1 7/130	1 7/130	1 7/123
Channel RM	4	300/130			300/130	300/130	300/123
Tr Rod RM	4	33 6/130			33 6/130	33 6/130	33 6/123
Silicon steel RM	4	2160/130			2160/130	2160/130	2160/10
Key block	4	2.57/130			2.57/130	2.57/130	2.57/123
Copper sheet RM	4	10/130			10/130	10/130	10/123
HT wire RM	4	477/130			477/130	477/130	477/115
Sleeping tube	4	60/130			60/130	60/130	6/123
Oil duct	4	30/130			30/130	30/130	30/123
LT wire strip	4	399/124			399/124	399/124	399/4
Cotton tape	4	15/124			15/124	15/124	15/123
Insulation paper	4	15/124			15/124	15/124	15/4
Top cover RM	4	75/133			75/133	75/133	75/118
HT rod RM	4	6 3/133			6.3/133	6 3/133	6 3/13
LT rod RM	4	15/133			15/133	15/133	15/13
Conservator Tank	4	5/133			5/133	5/133	5/132
Oil level indicator	4	5/133			5/133	5/133	5/13
Conservator tank RM	5	75/132			75/132	75/132	75/117

5.4 EVALUATION OF MATERIAS REQUIREMRNTS BY EXCEL

The monthly master production schedule for eight categories of transformers, ranging from 200 KVA to 1000 KVA is presented in Table 5.1 (Appendix II) for twelve months starting from January 2001 to December 2001. Data on demand for the various transformers during January to December 2001 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 fortnight and weekly basis As so many tables were used for raw material determination the complete list of the tables were provided in Appendix II Table 5.2 (Appendix II) provides the requirements on fortnight basis while Table 5.3 (Appendix II) provides the figures on weekly basis. Table 5.4 (Appendix II) provides the information of raw material requirements on transformer 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 53 items, eleven items (raw materials) are procured from internal or foreign market, which do not need any processing in the factory. According to the record the lead times for procuring these materials cannot 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 month, fortnight or week as applicable are presented against the various categories of transformers in the Tables 5.5- 5.15 (Appendix II)

For example to determine periodic demand of Silicon Steel, it would require to multiply the Silicon Steel column of Table 5.4 in Appendix II with the columns of Table 5.1 in Appendix II, the results of which is presented in the Table 5.4 (Table 5.7 in Appendix II).

Table 5.4 Periodic demand of Silicon Steel (Using Excel by combination of Table 5 4 & Table 5.1)

kVA	Jan 01	Feb-01	Mar-01	Apr. 01	May-01	Jun-01	Jul-01	Aug-01	Sep 01	Oct 01	Nov 01	Dec 01
	kg	Kg	kg	Kg	kg	kg	kg	kg	kg	kg	kg	kg
200	1935	2322	774	2322	1548	1161	2322	1548	3096	1161	774	774
250	1728	2592	1296	1728	2160	2592	1296	1296	1728	2592	1728	1296
315	984	492	0	0	984	492	492	492	984	492	492	1476
400	580	0	0	0	580	0	1160	0	0	0	1160	0
500	1896	1896	3160	1896	3160	1896	1896	1264	1264	1896	1264	1264
630	0	0	732	732	0	732	0	0	732	732	0	0
750	0	827	827	0	827	1654	1654	0	0	3308	1654	0
1000	2400	3600	2400	2400	0	1200	0	2400	2400	2400	2400	0
Tot	9523	11729	9189	9078	9259	9727	8820	7000	10204	12581	9472	4810

* 2160 kg Silicon steel the same amount was found by software calculation previously at section 5.1 Si steel backward calculation

5.5 MRP LOT SIZING

To meet all requirements, an order has to be scheduled for completion at the beginning of the first period in which there is a positive net requirement. However, the size of the order may be either just equal to the net requirement in the period in which it is due or it may be larger. The larger lot-size may take the advantage of economies of scale covering the net requirements in some subsequent periods. The decision process on the order quantity is called lot sizing.

5.5.1 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 estimated 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 storage, such as insurance. extra staffing and interest payment. Considering the local conditions and consulting with the involved persons in the company the predicted holding cost elements are presented in Table 5.5

Table 5.5 Estimated holding cost element

Category	Cost as a percent of Inventory value
1. Housing costs such as building rent, depreciation, operating cost, taxes, insurance...	3%
2. Mat. Handling costs including equipment, lease or depreciation, power, operating cost .	2%
3. Labor cost from extra handling	0 5%
4. Investment costs such as borrowing costs, taxes and insurance on inventory	15%
5. Pilferage, scrap and obsolescence... ...	1.5%
Total	22%

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 [26], but annual holding cost often approaches 40% of the value of inventory.

Ordering cost is the cost that increases with the no of orders placed. The cost include cost of supplies, forms, order processing, clerical support and so forth. Ordering cost element can be predicted as Table 5.6.

Table 5.6 Ordering cost element

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

Table 5.7 Cost of Raw material

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

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

$h = fb$

where f = holding cost fraction and

b = unit cost (The value of b are assigned in Table 5.7)

Sample calculation.

The holding cost for inventory of silicon steel for which f = 0.22 per year, b = Taka 215 per Kg is evaluated as **h** = (0.22*215)/12 = Taka 3 94 per Kg -Month. In Table 5.8, the holding and ordering costs for the different raw materials consumed in transformer are presented.

Table 5.8 Holding cost and ordering costs for different materials

Item	Holding Cost. (Tk per unit-month)	Ordering Cost, (Tk per order)
Tank Raw Material	0.23	2750
Radiator RM	0.26	2750
Silicon Steel	3.94	30350
LT wire	3 85	30350
HT wire	3 66	30350
XFR Oil	0.916	30350
Channel RM	0.04	2750
Conservator RM	0.24	2750
Press Board RM	4.03	2750
Cu Rod RM	5.24	30350
Nut Bolt	0.01	2750

5.5.2 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 5.9, the required data for silicon steel 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 5.9 Sample Problem: Lot size determination of Silicon Steel Raw Material

Period	Demand (Kg)	Parameter	Value
1	9,523	Holding cost	3.94 Tk
2	1,1729	Setup cost	30,350 Tk
3	9,189	Initial inventory	39519
4	9,078	Lead time	4
5	9,259		
6	9,727		
7	8,820		
8	7,000		
9	10,240		
10	12,581		
11	9,472		
12	4,810		

Results:

Only one sample result sheet for Wagner-Whitin method is provided in the Table 5.10. the remaining are in Appendix III.

Table 5.10 Lot sizing of Silicon Steel by Wagner – Whitin Method (Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			39519		
1	9523		29996	118184 2	
2	11729		18267	71971.98	
3	9189		9078	35767.32	
4	9078		0		
5	9259	9259	0		30350
6	9727	9727	0		30350
7	8820	15820	7000	27580	30350
8	7000		0		
9	10204	10204	0		30350
10	12581	12581	0		30350
11	9472	14282	4810	18951 4	30350
12	4810		0		
Totals	111392	71873	69151	272454 9	182100
Ave demand	9282.667				
Total Cost =	454554.9				

The complete lot sizing results of all eleven raw materials are provided in APPENDIX III A summarizes result of all the raw material is shown in the Table 5.11 given below.

Table 5.11 Total cost of the individual items for the stipulated period (not annual)

Material	W. Whitin	Lot for lot	EOQ	POQ	PPB	user defined
Tank RM	9,419	32,255	16,441	12,275	10.270	
Radiator RM	11,902	33,670	18,986	15,323	13,950	
Si steel	454,544	1,601,442	1,908,730	1,601,442	481,748	1795691
LT wire	160,014	469,765	427,867	362,852	160,014	417287
HT wire	24,341	52,760	63,834	47,491	25,253	87048
Transformer Oil	162,779	471,268	439,476	363,436	162,779	519402
channel RM	3,227	30,372	4,841	3,349	3,227	
Conservator RM	4,594	30,636	5,562	4,980	4,594	
Press Board	3,551	30,459	5,115	3,761	3,551	
Cu rod RM	43,953	258,603	78,201	57,199	43,953	
Nut Bolt	2,911	30,290	4,170	2.952	2,911	

CHAPTER 6

RESULTS AND DISCUSSION

6.0 INTRODUCTION

Application of MRP requires a master production schedule (MPS) stating the end items a company plans to produce by quantity and time 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. The company usually follows make-to-order policy and currently it receives enough orders to utilize its capacity of resources. The company generally prioritizes the orders depending on the deadlines. 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 estimation of the elements of the inventory costs. 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.

6.1 ESTIMATION OF THE ELEMENTS OF INVENTORY COSTS

Different inventory costs are estimated depending on various available facts and figures. Documentation and recording of the relevant data and information in detailed form are very important. Precise determination of the various cost elements of inventory needs accurate and reliable data. But the recording system of many local companies is not runed accordingly. For example, in case of telephone bill, like many other organizations the company does not record which of the calls are made exactly for ordering or expediting an order. In fact it is not possible also to keep track to that extent unless the organization deliberately adopts such requisite measures. Similarly, records like expenses for lighting, maintenance, security etc., shares of which should be apportioned correctly in inventory holding cost calculation. But absence of precise records of such data and information lead to some sort of guess. To minimize the error in such guesses organization should adopt necessary changes and modifications in its operations system.

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. Irrespective of the method used, it is evident that the imported materials are responsible for major share of the total inventory costs. This may be attributed to the large amount of material per order and to maintain storage for a longer period resulting in huge amount of holding cost.

Table 6.1: Annul inventory costs (Taka) of different materials using different techniques

Annual inventory cost

Material	W. Whitin	Lot for lot	EOQ	POQ	PPB	User defined
Tank RM	18,838	64,510	32,882	24,550	20,540	-
Radiator RM	23,804	67,340	37,972	30,646	27,900	-
Si steel	454,544	1,601,442	1,908,730	1,601,442	481,748	1,795,691
LT wire	160,014	469,765	427,867	362,852	160,014	417,287
HT wire	48,682	105,500	127,668	94,982	50,506	174,096
Transformer Oil	162,779	471,268	439,476	363,436	162,779	519,402
channel RM	12,908	121,488	19,364	13,396	12,908	-
Conservator RM	9,188	61,272	11,124	9,960	9,188	-
Press Board	14,204	121,836	20,460	15,044	14,204	-
Cu rod RM	43,953	258,603	78,201	57,199	43,953	-
Nut Bolt	11,644	121,160	16,680	11,808	11,644	-
total	960,558	3,464,184	3,120,424	2,585,315	995,384	-

In the study the five methods such as Wagner – Whitin, EOQ, Lot for Lot, POQ and Part Period Balancing (PPB) were applied to determine MRP lot-size. Presently the intuitive approach adopted in the company appears to be 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 considered. 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 oil the company places orders of 288 drums (equivalent 60480 liters) of oil 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 519,000, 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 intuitive approach is some times better than EOQ approach and some times worse than 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 4^{th} place among the five standard lot-sizing approaches. Therefore, it can be very easily understand how much the company would gain should they shift from present intuitive approach to Wagner-Whitin approach to determine the order quantity.

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 silicon steel (saving of 76%), HT wire (saving of 62%), LT wire or transformer oil (saving of 63%).

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

Material	W. Whitin	Lot for lot	EOQ	POQ	PPB	User defined
Tank RM	0	0 71	0.43	0.23	0.08	-
Radiator RM	0	0 65	0 37	0.22	0.15	-
Silicon steel	0	0.72	**0.76**	0.72	0.06	0.74
LT wire	0	0.66	**0.63**	0.56	-	0 61
HT wire	0	0.54	**0.62**	0.49	0.04	0.72
Transformer Oil	0	0.65	**0.63**	0.55	-	0 68
channel RM	0	0.89	0.33	0.04	-	-
Conservator RM	0	0.85	0.17	0.08	-	-
Press Board	0	0.88	0.31	0.06	-	-
Cu rod RM	0	0.83	0.44	0.23	-	-
Nut Bolt	0	0.90	0.30	0 01	-	-
Total	0	0 72	0.69	0.63	0.03	-

It is noticeable that proper lot sizing of the bold materials can be highly advantageous in the context of cost savings. While for the other items the scenario is quite different and the percentages of cost savings (for example local items tank, radiator, channel raw materials etc. and foreign item Cu rod only) are relatively low compared to the bold materials.

6.3 COMPREHENSIVE SUMMARY OF MRP RESULTS

Ordering lot-sizes calculated using the Wagner-Whitin method for the four imported items such as silicon steel, low tension wire, transformer oil and Copper rod are presented in Table 6.3. These are actually the most expensive items used in transformer manufacturing. Silicon steel 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 of major imported materials determined by Wagner-Whitin method

Period	Silicon steel	LT wire	Transformer Oil	Copper rod
initial Inv.	39519	6636	29755	335
1				
2				
3				
4				
5	9259	5943	24235	632
6	9727			
7	15620			
8				
9	10204	6408	27355	
10	12581			
11	14282			
12				
Totals	71873	12351	51590	632
Ave demand	9282	1582	6778	80 58
Total Inv. Cost	Tk. 454554	Tk. 160014	Tk. 162779	Tk. 43953

It is apparent from the Table 6.3 above, that silicon steel, being the most expensive item, should be ordered frequently. Similarly the less costly items should be ordered in large quantities leading to infrequent orders. The LT wire, transformer oil etc. are therefore, ordered in every three to four months Low-cost items such as raw materials for the tank, radiator, channel, conservator, pressboard and nut-bolts are ordered in bulk, and therefore the frequency of order is less as depicted in Table 6.4. Again HT wire (in the same table) a locally purchased but too much costly item is required to order frequently since it is costly at the same time it is consumed in bulk amount.

Table 6.4 Lot size of local, raw materials determined by Wagner-Whitin method.

Period	Tank RM	Radiator RM	HT wire	Channel RM	Conservator	Pressboard	Nut bolt
Initial Inv.	540	760	771	260	110	4	352
1							
2	2650	3974	2387	3056	1610	52	4054
3							
4			1400				
5							
6	6070	6330	1747				
7			1858				
8			2213				
9							
10		2852	1867				
11							
12			823				
Totals	8720	13156	12295	3056	1610	52	4054
Ave demand	771	1159	1088	276	143	5	367
Total Cost	Tk 9419	Tk 11902	Tk. 24341	Tk 3227	Tk. 4593	Tk. 3551	Tk 2911

6.4 COMPARING LOT-SIZES DETERMINED BY VARIOUS METHODS

A number of methods have been developed for determining the lot-size for MRP systems. But in the smdy 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 week to week. As an example, (Appendix C, material 1: Tank raw material, method: EOQ) 1646 units are carried over into 6^{th} period when a new order is received. Moreover, the use of average weekly 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 (Appendix C, material 7. HT wire, method: EOQ & POQ) reduce inventory carrying cost 30%, thereby improving total cost 25%. Although the periodic order quantity (POQ) procedure improve the inventory cost performance by allowing the lot size to vary, it also ignores much of the information contained in the requirements schedule. The replenishment orders are constrained to occur at fixed time intervals, thereby ruling out the possibility of combining orders during periods of light product demand.

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 2048, in comparison with the ordering plan produced by the part period balancing procedure (Appendix C, material 2: Radiator raw material, 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 a well-known company for transformer manufacturing in the private sector. The company has recently obtained ISO 9001 certification. As a requirement of this certification it has become imperative for the company to have proper documentation Necessary measures are being adopted to improve the current 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 much to have defined product structures and indented bill of materials for different transformers.

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 or meter) for manufacturing a particular transformer. The in-charge of the section directly evaluates the quantity required for a new order and fills the requisition form and sends it to the store. 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.

The company can make its bill of material to a high level of accuracy by taking necessary measures so that the following three conditions are satisfied:

1. Responsibility for maintenance of the bill is assigned to a single department.
2. A formal process for approval of engineering change is established and religiously followed.
3. A single image of all product data and BOM information is maintained in a central CIM database.

Regarding master production schedule, the approach of the company is like an MTO company. They 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 Recent statistics show that the company receives reasonable number of order for transformers. 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 transformers is not same. Orders for the transformers with the rating of 200 and 250 KVA are quite consistent. In addition to this, there are orders for other categories of transformers. As a result the company remains occupied with fabrication/assembly work for a significant period of time with which it can adapt the process of MPS making frequent adjustments.

The benefit of accurate inventory ensures reliable manufacturing schedule and on-time shipment. 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 appeared to be inadequate. Presently the company keeps the records of only the quantity of incoming raw material and outgoing finished product. They do not take necessary steps to check the type and amount of materials consumed and to keep their records. As a result there is little scope to evaluate the balance of materials for future material requirement calculation. Thus the present practice of the company to proceed with gross and rough estimation leaves enough room to result in unnecessary delays in shipment.

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 thousands 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 he 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 becomes extremely difficult As a result, computer software is used.

However, there are exceptions for some few companies [27] 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.

The company is dealing with products having structures of only about five 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 computer 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 illustrated [28] in Figure 6.1 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 computer hardware. For example, costing base and scheduling software [28] for a job shop operation that runs on a

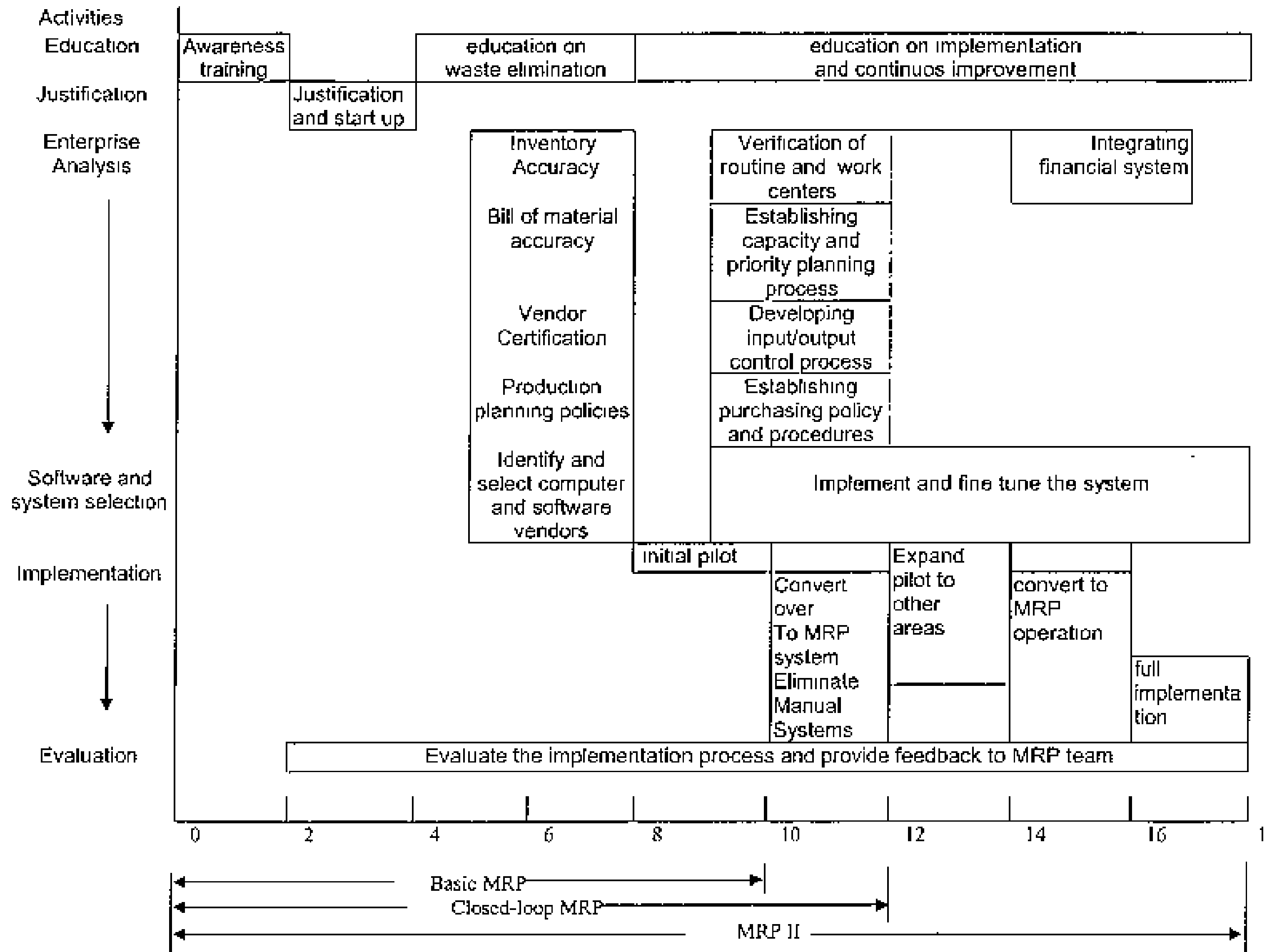


Figure 6.1 MRP II-proven path method

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 most directly involved with the MRP system outputs are planners. The planners have the responsibility for making the detailed decision that keep the material moving through the plant to achieve the shipment of final products. Their range of discretion is carefully limited (i.e. without 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 existing 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 the 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.

Exception Codes

Exception codes in MRP systems are used " to separate the vital few from the trivial many". In most system manufacturing process is under control and the MRP system are functioning correctly, exception coding typically means 10 to 20 percent of the part numbers will require planner review that is to check data accuracy at each processing cycle. It includes the checking of dates beyond planning horizon, quantifying larger or smaller than check figure and identifying non valid part numbers.

Bottom Up Replanning

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

Nervousness

Some of the lot sizing procedures can contribute to the problem of "nervousness" (i.e. instability) in the MRP plans. There are a number of ways that relatively minor changes in MRP system can create nervousness and instability in the MRP plans. These include planned orders that are released in an unplanned quantity or which are prematurely released, unplanned demands and shifts in MRP parameter values such as safety stock, safety lead time or planned lead time values. The nervousness created by such changes is most damaging in MRP systems with many levels in the product structure. Following steps may be taken to reduce nervousness.

1. Reduce the cause of changes in MRP system. It is important to introduce stability.
2. Reduce the incidence of unplanned demand
3. Follow the MRP plan with regard to the timing and the quantity of planned order releases
4. Control the introduction of parameter change in safety stock levels or planned lead times.
5. If still nervousness exists then use different lot sizing procedure.

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 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 of the product. The following list of improvements in the operation of enterprise is frequently attributed to implementing MRP.

- Improved customer service
- Improved 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 material, 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
CONCLUSION AND RECOMMENDATION

7.1 CONCLUSION

The study was undertaken to make an overview of the present status of MRP application in local fabrication/assembly organizations and to discuss the relevant issues and suggest the action plans in the successful implementation of MRP concept. In this regard a local transformer manufacturing company was selected as a representative organization. The analysis, comments, suggestions, action plans etc. are, therefore, based on data and information 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 complete form in future. On careful analysis of the findings, the following conclusions and recommendations can be made in the context of present scenario, benefits of MRP, suggested future action plan for the company, current bottlenecks. future scope of work.

Present scenario in the context of MRP application

- In the context of applying the concept of MRP, it can be said that the position of the company under investigation is in a primary stage. They do not maintain any formal production plan, MPS, BOM and MRP. Recording of data and information regarding on-hand inventory, WIP inventory, lead times, various inventory costs is not properly classified and stored.
- In addition to the unfavorable external factors for MRP, most of the local companies are not aware about the advantages of MRP application in manufacturing organizations. As a consequence, the scenario regarding MRP application is not expected to be encouraging in most of the local companies.

- Since the company is in the primary stage in respect of MRP application, there is a wide scope of improving the current situation through implementation of MRP. At this stage, even an approach with manual MRP can be of remarkable advantage.
- The study reveals that the company currently procures raw materials on the basis of intuitive approach instead of following any formal methods commonly used for lot sizing.
- Compared to present practice of determining the quantity in a lot i.e. the lot-size, MRP approach by using optimum lot-size (Wagner-Whitin) method can significantly reduce the total incremental cost of inventory.

Future action plan of the company

In manufacturing transformer, the company under study is close to both an ETO (engineer to order) and MTO (make to order) type enterprise. The company can be viewed as ETO since according to some order it has to design a transformer with special features. But the company mostly operates like an MTO type enterprise. It is normally difficult for an MTO company to develop formal MPS. However, since there is enough order and the company remains busy in every month with production, it would not be, therefore, difficult for it to build a formal MPS.

During the present study it has been learnt that there is no set up to follow defined product structure or BOM. Due to the absence of product structure, it is quite common to make mistakes in calculating the requirement of different materials. In such cases they have to reorder the item(s) which were short or to sustain with excess materials. A proper inventory record based on BOM is also essential for accurate material requirement calculation. Therefore, the following measures are advised for the company to ensure better planning.

Action plans for accurate data recording

- 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.

- Indented bill of materials for different transformers 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 (MPC) software.
- 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.
- Responsibility should be assigned to a single department for the maintenance of the bill
- Engineering change should also be assigned to an expert group and the change should be infrequent and accurate.
- A single image of all product data and BOM information are required to maintain in central database. It would facilitate in editing inaccurate data if necessary.
- To ensure accurate inventory, physical counting of all of the parts is required. To know the accuracy of the inventory, there is another option evaluating the monetary value of the inventory with the monetary value stated in the financial record. But it has two serious shortcomings therefore, physical count is a better approach.

Action plans for changes in management

To implement a successful MRP system, top management can take the following actions:

- At the initial stage manual MRP should be adopted, keeping in mind 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.

- ABC analysis is necessary to find 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 silicon steel, oil, wire etc. are the example of intrinsic items.
- 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 such as nuts, bolts and washers etc. is not very urgent.
- The practice of ordering materials with thumb rule or intuitive approach should be avoided. There are standard methods for lot size determination, some of which are POQ, PPB, Wagner-Whitin methods etc.
- 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 have sufficiently patient and firm determination to implement a long-term project such as MRP. However, Patience and firmness largely depend on keen sight /deep knowledge of forthcoming profit/ benefit.
- A task force led by an executive should be appointed so that analysis of the problems can be started. It is not uncommon to face as many as 50 to 500 problems.
- 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 environment and the directive from top management to all managers will excel the overall implementation process.
- A formal implementation plan is required to develop covering about two years' 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.
- It is necessary to make sure that all involved receive an education on what MRP can do and their role in it. In practice, it was found that if someone or

somebody wanted to make a change, impedance developed from his/her co-workers or his/her subordinate. Lack of recognition of his involvement or unawareness of his role may impede the implementation work. Therefore, education on MRP and respective one's role on it may excel the work.

- Marketing, finance, manufacturing and personnel all divisions should jointly engage in the implementation process. For closed loop MRP implementation, integration of all the departments is necessary.
- MRP implementation needs considerable patience. Some results may be expected during the initial time before the system is completely implemented.

Action plan for MRP software

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

Contribution of MRP for the company

There are direct and indirect or spin-off benefits in using MRP which may be categorized in the context of superior management and cost reduction. Through the application of MRP, the company can benefit from better management and reduction in cost.

Contribution in Operations and Management

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

- Accurate decision can be taken with reliable and up-to-date information. Proper MRP application demands reliable and up-to-date data and information. Availability of such data allows analyzing the decision-making parameters using mathematical models.
- There is better understanding of capacity constraints. Through the application of MRP F/A company operates with stores, machines, equipment and human resources having limited capacities. While applying MRP, the figures regarding capacities of these resources become crucial and act as constraints or limitations.
- As MRP maintains tight schedule from procurement of raw material to delivery of final product, it is necessary to monitor the work in process and take necessary steps if needed. This certainly helps in reducing past due orders.
- There is a scope of improved customer service, as MRP ensures timely delivery of products. In addition, a company may receive some urgent orders of a product, 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.
- Significant increase in productivity is possible as MRP formulates the work in a very scientific and structured way. Thus material shortage or prolonged idle time of machine and labor are very unlikely in MRP oriented manufacturing.
- 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.
- 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 curved 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 cost
- 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.
- MRP excels customer satisfaction by satisfying demand in time which opens the opportunity for sales increment, generate higher productivity and optimize man-machine-material. As a result 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.

Limitations of the present study

In estimating various cost parameters, some assumptions were made. In reality the assumptions are not strictly valid, which may be considered as limitations of the study. The following have been identified as major limitations:

- In reality a number of items are usually ordered at a time for procurement. This is true for local as well as foreign material. So analysis on the basis of single item may lead to some deviation from reality.
- Fixed lead times were considered, which is not strictly true.
- Same ordering cost was assumed for all the imported items. This may not be the case for all the items in practice.
- Ordering cost was considered to be independent of the lot-size. In real life there may be some deviations.
- Uncertainty was not taken into account. Probabilistic methods could be better option to handle this kind of situation.

- During purchase the fund available may act as constraint. Limitation in liquid money was not treated as a factor.

7.2 RECOMMENDATION OF FUTURE WORK

There is a good opportunity to work on MRP specially considering in the country Software development can be a major area of working. If any body is interested to work on it he may start by learning a computer language related database. There are many problem faced during the work he can eliminate the problems. First he can handle the problem of lead-time and also its units. In the POM software there was no scope to summarize the same raw material used in different transformers.

- Can develop model for ordering cost considering variable lot size
- Can develop forecasting model for MTO company
- Can work on the area of multiple lot sizing.
- Can develop a software on MRP
- In the next phase, can develop software on MRP II. It is an integrated information system that steps beyond first generation MRP to synchronize all aspects of the business. The MRP II system coordinate sales, purchasing, manufacturing, finance and engineering by adapting a focal production plan and by using one data base to plan and update the activities in all the systems.
- Can work on the area of incorporation of JIT and MRP. A lot of work is now being carry out on this approach. The 'marriage' of MRP & JIT has opened the possibility of excellent outcome.
- MRP in its present form work as a continuous chain. If at any place there occurs disruption than the entire system is disrupted. Therefore, a flexible model can be approached so that the system can withstand unavoidable situation.
- There is a scope of work on uncertainty and the effect of uncertainty on MRP.

- There is no consideration for safety stock in the model. Safety stock should be not too large or not too small. Therefore, it may be work area to determine optimum safety stock.

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 tremendous 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 adopted

- Develop the mathematical model for determining lot-size considering multiple items to be ordered at a time
- Develop model for variable lot-size incorporating the constraints of fund, stores, transport facilities etc.

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Appendix I

Material requirement planning by POM software
(The sample calculation is done for 250 kva transformer. As the software is of limited capacity therefore, all lead time is assumed as 1 day just to find the quantity requirements for 5 transformers.)

Problem:

Item name	Level	Lead time	Per parent	On hand	Lot size	Min. quan.	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Transformer	0	1	0	0	0	0	0	0	0	0	0	0	5
T. Oil	1	1	300	600	0	0	0	0	0	0	0	0	0
T Tank	1	1	1	0	0	0	0	0	0	0	0	0	0
Tank Box	2	1	1	2	0	0	0	0	0	0	0	0	0
Ta. Box RM	3	1	70	0	0	0	0	0	0	0	0	0	0
Drain Valve	2	1	1	2	0	0	0	0	0	0	0	0	0
Radiator	2	1	4	3	0	0	0	0	0	0	0	0	0
Radiator RM	3	1	20	0	0	0	0	0	0	0	0	0	0
Active Part	1	1	1	0	0	0	0	0	0	0	0	0	0
Core Coil ass	2	1	1	0	0	0	0	0	0	0	0	0	0
Sus Rod	3	1	4	2	0	0	0	0	0	0	0	0	0
S Rod RM	4	1	0.8	0	0	0	0	0	0	0	0	0	0
Core Bolt	3	1	4	3	0	0	0	0	0	0	0	0	0
C. Bolt RM	4	1	0.8	0	0	0	0	0	0	0	0	0	0
Separator	3	1	2	5	0	0	0	0	0	0	0	0	0
Sep. RM	4	1	0.17	0	0	0	0	0	0	0	0	0	0
Chanel	3	1	4	4	0	0	0	0	0	0	0	0	0
Chanel RM	4	1	15	0	0	0	0	0	0	0	0	0	0
Tie Rod	3	1	4	4	0	0	0	0	0	0	0	0	0
T Rod RM	4	1	1.68	0	0	0	0	0	0	0	0	0	0
Si Steel	3	1	1	0	0	0	0	0	0	0	0	0	0
Si Steel RM	4	1	432.3	0	0	0	0	0	0	0	0	0	0
Key Block	3	1	156	200	0	0	0	0	0	0	0	0	0
K Block RM	4	1	0.0033	0	0	0	0	0	0	0	0	0	0
Copp. Sheet	3	1	4	2	0	0	0	0	0	0	0	0	0
C S RM	4	1	0.5	0	0	0	0	0	0	0	0	0	0
HT Coil	3	1	6	2	0	0	0	0	0	0	0	0	0
Wire	4	1	15.92	0	0	0	0	0	0	0	0	0	0
Sleep. Tube	4	1	2	10	0	0	0	0	0	0	0	0	0
Oil duct	4	1	1	2	0	0	0	0	0	0	0	0	0
LT Coil	3	1	3	0	0	0	0	0	0	0	0	0	0
Wire Streep	4	1	26.6	0	0	0	0	0	0	0	0	0	0
Cotton Tap	4	1	1	8	0	0	0	0	0	0	0	0	0
Insu Paper	4	1	1	1	0	0	0	0	0	0	0	0	0
Top Cov Ass	2	1	1	0	0	0	0	0	0	0	0	0	0
Top Cov	3	1	1	0	0	0	0	0	0	0	0	0	0
T. C RM	4	1	15	0	0	0	0	0	0	0	0	0	0
Bushing	3	1	7	15	0	0	0	0	0	0	0	0	0
B. Ring	3	1	3	2	0	0	0	0	0	0	0	0	0
Tap Changer	3	1	1	2	0	0	0	0	0	0	0	0	0
Nut T. Cov	3	1	32	50	0	0	0	0	0	0	0	0	0
Nut B Ring	3	1	12	10	0	0	0	0	0	0	0	0	0
LT Flange	3	1	4	2	0	0	0	0	0	0	0	0	0
HT Rod	3	1	3	1	0	0	0	0	0	0	0	0	0
HT Rod RM	4	1	0.42	0	0	0	0	0	0	0	0	0	0
HT Cap	3	1	3	5	0	0	0	0	0	0	0	0	0
LT Rod	3	1	4	2	0	0	0	0	0	0	0	0	0
LT Rod RM	4	1	0.75	0	0	0	0	0	0	0	0	0	0
LT Cap	3	1	4	8	0	0	0	0	0	0	0	0	0
Conservator	3	1	1	1	0	0	0	0	0	0	0	0	0
Con Tank	4	1	1	0	0	0	0	0	0	0	0	0	0
Con tank RM	5	1	15	0	0	0	0	0	0	0	0	0	0
Oil Lev. Ind.	4	1	1	3	0	0	0	0	0	0	0	0	0

Solution:

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Transformer (0)								
ON HAND								
Schd REC								
NET REQ								5
Plan REC								5
ORD REL							5	

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
T. Oil (1)								
ON HAND	600	600	600	600	600	600	600	
Schd REC								
NET REQ							900	
Plan REC							900	
ORD REL						900		

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
T. Tank (1)								
ON HAND								
Schd REC.								
NET REQ							5	
Plan REC							5	
ORD REL						5		

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Active Part (1)								
ON HAND								
Schd REC.								
NET REQ							5	
Plan REC							5	
ORD REL.						5		

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Tank Box (2)								
TOT.REQ.						5		
ON HAND	2	2	2	2	2	2		
Schd REC								
NET REQ						3		
Plan REC						3		
ORD REL.					3			

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Drain Valve (2)								
TOT.REQ						5		
ON HAND	2	2	2	2	2	2		
SchdREC.								
NET REQ						3		
PlanREC						3		
ORD REL					3			

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Radiator (2)								
TOT.REQ.						20		
ON HAND	3	3	3	3	3	3		
Schd REC.								
NET REQ						17		
Plan REC						17		
ORD REL.					17			

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Core Coil ass (2)								
TOT.REQ						5		
ON HAND								
Schd REC								
NET REQ						5		
Plan REC						5		
ORD REL.					5			

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Top Cov Ass (2)								
TOT REQ						5		
ON HAND								
Schd REC.								
NET REQ						5		
Plan REC						5		
ORD REL.					5			

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Ta. Box RM (3)								
TOT.REQ					210			
ON HAND								
Schd REC								
NET REQ					210			
Plan REC					210			
ORD REL.				210				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Radiator RM (3)								
TOT REQ					340			
ON HAND								
Schd REC								
NET REQ					340			
Plan REC					340			
ORD REL				340				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Sus. Rod (3)								
TOT.REQ					20			
ON HAND	2	2	2	2	2			
Schd REC.								
NET REQ					18			
Plan REC					18			
ORD REL.				18				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Core Bolt (3)								
TOT.REQ.					20			
ON HAND	3	3	3	3	3			
Schd REC								
NET REQ					17			
Plan REC					17			
ORD REL				17				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Separator (3)								
TOT.REQ					10			
ON HAND	5	5	5	5	5			
Schd REC								
NET REQ					5			
Plan REC					5			
ORD REL				5				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Channel (3)								
TOT REQ					20			
ON HAND	4	4	4	4	4			
Schd REC								
NET REQ					16			
Plan REC					16			
ORD REL				16				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Tie Rod (3)								
TOT.REQ.					20			
ON HAND	4	4	4	4	4			
Schd REC.								
NET REQ					16			
Plan REC					16			
ORD REL.				16				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Silicon Steel (3)								
TOT REQ					5			
ON HAND								
Schd REC.								
NET REQ					5			
Plan REC					5			
ORD REL				5				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Key Block (3)								
TOT REQ					780			
ON HAND	200	200	200	200	200			
SchdREC.								
NET REQ					580			
PlanREC					580			
ORD REL.				580				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Coop Sheet (3)								
TOT REQ.					20			
ON HAND	2	2	2	2	2			
Schd REC								
NET REQ					18			
Plan REC					18			
ORD REL.				18				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
HT Coil (3)								
TOT.REQ					30			
ON HAND	2	2	2	2	2			
Schd REC.								
NET REQ					28			
Plan REC					28			
ORD REL.				28				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
LT Coil (3)								
TOT.REQ					15			
ON HAND								
Schd REC								
NET REQ					15			
Plan REC					15			
ORD REL				15				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Top Cov. (3)								
TOT.REQ					5			
ON HAND								
Schd REC.								
NET REQ					5			
Plan REC					5			
ORD REL				5				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Bushing (3)								
TOT.REQ					35			
ON HAND	15	15	15	15	15			
Schd REC								
NET REQ					20			
Plan REC					20			
ORD REL.				20				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
B. Ring (3)								
TOT REQ.					15			
ON HAND	2	2	2	2	2			
Schd REC								
NET REQ					13			
Plan REC					13			
ORD REL				13				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Tap Changer (3)								
TOT.REQ					5			
ON HAND	2	2	2	2	2			
SchdREC								
NET REQ					3			
PlanREC					3			
ORD REL.				3				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Nut T Cov (3)								
TOT.REQ					160			
ON HAND	50	50	50	50	50			
Schd REC.								
NET REQ					110			
Plan REC					110			
ORD REL.				110				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Nut B Ring (3)								
TOT.REQ					60			
ON HAND	10	10	10	10	10			
Schd REC.								
NET REQ					50			
Plan REC					50			
ORD REL				50				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
LT Flange (3)								
TOT.REQ.					20			
ON HAND	2	2	2	2	2			
Schd REC								
NET REQ					18			
Plan REC					18			
ORD REL.				18				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
HT Rod (3)								
TOT REQ.					15			
ON HAND	1	1	1	1	1			
Schd REC.								
NET REQ					14			
Plan REC					14			
ORD REL.				14				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
HT Cap (3)								
TOT.REQ					15			
ON HAND	5	5	5	5	5			
Schd REC.								
NET REQ					10			
Plan REC					10			
ORD REL				10				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
LT Rod (3)								
TOT.REQ.					20			
ON HAND	2	2	2	2	2			
Schd REC								
NET REQ					18			
Plan REC					18			
ORD REL.				18				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
LT Cap (3)								
TOT.REQ					20			
ON HAND	8	8	8	8	8			
Schd REC								
NET REQ					12			
Plan REC					12			
ORD REL				12				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Conservator (3)								
TOT.REQ					5			
ON HAND	1	1	1	1	1			
Schd REC.								
NET REQ					4			
Plan REC					4			
ORD REL.				4				

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
S Rod RM (4)								
TOT.REQ.				14				
ON HAND								
Schd REC.								
NET REQ				14				
Plan REC				14				
ORD REL			14					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
C Bolt RM (4)								
TOT REQ				14				
ON HAND								
Schd REC								
NET REQ				14				
Plan REC				14				
ORD REL.			14					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Sep RM (4)								
TOT.REQ.				1				
ON HAND								
Schd REC								
NET REQ				1				
Plan REC				1				
ORD REL.			1					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Channel RM (4)								
TOT REQ				240				
ON HAND								
Schd REC								
NET REQ				240				
Plan REC				240				
ORD REL			240					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
T. Rod RM (4)								
TOT REQ				27				
ON HAND								
Schd REC.								
NET REQ				27				
Plan REC				27				
ORD REL			27					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Silicon Steel RM (4)								
TOT REQ				2162				
ON HAND								
Schd REC								
NET REQ				2162				
Plan REC				2162				
ORD REL			2162					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
K. Block RM (4)								
TOT REQ				2				
ON HAND								
Schd REC								
NET REQ				2				
Plan REC				2				
ORD REL.			2					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
C. S RM (4)								
TOT REQ				9				
ON HAND								
Schd REC								
NET REQ				9				
Plan REC				9				
ORD REL			9					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Wire (4)								
TOT.REQ				446				
ON HAND								
Schd REC.								
NET REQ				446				
Plan REC				446				
ORD REL			446					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Sleep Tube (4)								
TOT REQ.				56				
ON HAND	10	10	10	10				
Schd REC.								
NET REQ				46				
Plan REC				46				
ORD REL			46					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Oil duct (4)								
TOT.REQ.				28				
ON HAND	2	2	2	2				
Schd REC.								
NET REQ				26				
Plan REC				26				
ORD REL			26					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Wire Strip (4)								
TOT REQ.				399				
ON HAND								
Schd REC								
NET REQ				399				
Plan REC				399				
ORD REL.			399					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Cotton Tap (4)								
TOT REQ				15				
ON HAND	8	8	8	8				
Schd REC								
NET REQ				7				
Plan REC				7				
ORD REL.			7					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Insu. Paper (4)								
TOT.REQ.				15				
ON HAND	1	1	1	1				
Schd REC								
NET REQ				14				
Plan REC				14				
ORD REL.			14					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
T. C. RM (4)								
TOT.REQ				75				
ON HAND								
Schd REC								
NET REQ				75				
Plan REC				75				
ORD REL.			75					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
HT Rod RM (4)								
TOT.REQ				6				
ON HAND								
Schd REC								
NET REQ				6				
Plan REC				6				
ORD REL			6					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
LT Rod RM (4)								
TOT.REQ				14				
ON HAND								
Schd REC.								
NET REQ				14				
Plan REC				14				
ORD REL.			14					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Con Tank (4)								
TOT.REQ				4				
ON HAND								
Schd REC								
NET REQ				4				
Plan REC				4				
ORD REL.			4					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Oil Lev. Ind. (4)								
TOT.REQ.				4				
ON HAND	3	3	3	3				
Schd REC								
NET REQ				1				
Plan REC				1				
ORD REL			1					

Item name (low level)	Pd 0 and before	Pd 1	Pd 2	Pd 3	Pd 4	Pd 5	Pd 6	Pd 7
Con tank RM (5)								
TOT.REQ			60					
ON HAND								
Schd REC								
NET REQ			60					
Plan REC			60					
ORD REL.		60						

APPENDIX II

Table 5.1

Monthly Master Production Schedule (MPS) of Transformer from Jan 01 to Dec 01

kVA	Jan 01	Feb.01	Mar-01	Apr 01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01
	no	no	no	no	no	no	no	no	no	no	no	no
200	5	6	2	6	4	3	6	4	8	3	2	2
250	4	6	3	4	5	6	3	3	4	6	4	3
315	2	1	0	0	2	1	1	1	2	1	1	3
400	1	0	0	0	1	0	2	0	0	0	2	0
500	3	3	5	3	5	3	3	2	2	3	2	2
630	0	0	1	1	0	1	0	0	1	1	0	0
750	0	1	1	0	1	2	2	0	0	4	2	0
1000	2	3	2	2	0	1	0	2	2	2	2	0

Table 5.2

Fortnight basis Master Production Schedule (MPS) from Jul 01 to Dec 01

KVA	July. 01		Aug 01		Sep 01		Oct 01		Nov 01		dec 01	
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
	no	No	no	no	no	no	no	No	no	no	no	no
200	2	4	1	3	4	4	2	1	2	0	1	1
250	3	0	3	0	1	3	4	2	0	4	1	2
315	0	1	1	0	2	0	0	1	1	0	1	2
400	1	1	0	0	0	0	0	0	1	1	0	0
500	1	2	1	1	0	2	2	1	1	1	0	2
630	0	0	0	0	0	1	1	0	0	0	0	0
750	0	2	0	0	0	0	2	2	1	1	0	0
1000	0	0	1	1	0	2	1	1	0	2	0	0

Table 5.3

Weekly Master Production Schedule of Transformer from Oct 01 to Dec. 01

KVA	Oct 01				Nov 01				Dec 01			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
	no	no	no	no	no	no	no	no	no	no	no	no
200	0	2	0	1	1	1	0	0	1	0	0	1
250	3	1	0	2	0	0	1	3	0	1	1	1
315	0	0	0	1	1	0	0	0	0	1	1	1
400	0	0	0	0	1	0	1	0	0	0	0	0
500	1	1	0	1	0	1	0	1	0	0	0	2
630	0	1	0	0	0	0	0	0	0	0	0	0
750	0	2	2	0	1	0	1	0	0	0	0	0
1000	0	1	1	0	0	0	2	0	0	0	0	0

Table 5.4

Raw material requirement on Transformer Basis

KVA	Tank RM	Rad RM	Si Steel	LT Wire	HT Wire	XFR Oil	Channel	Consvtr	Pr Board	Cu rod	Nut Bolt
	kg	kg	Kg	kg	kg	liter	kg	kg	piece	meter	piece
200	60	80	387	63	88	195	48	15	0 85	4	82
250	70	80	432	79 8	95.5	300	60	15	0 85	4 26	82
315	70	100	492	99	117	350	60	15	0 69	4 26	82
400	90	150	580	96	156	420	80	15	0 99	4 52	106
500	120	210	632	96	156	420	80	20	1.17	5 5	106
630	140	210	732	120	180	520	100	20	1 5	6 5	106
750	170	252	827	153	250	610	100	25	1 81	7.1	128
1000	230	400	1200	200	312	1260	120	30	2 63	7 28	132

Table 5.5

Periodic demand of Tank raw material (Using Excel by combination of Table 5 4 & Table 5.2)

KVA	July 01		August 01		September 01		October 01		November 01		December 01	
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
	kg	Kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
200	120	240	60	180	240	240	120	60	120	0	60	60
250	210	0	210	0	70	210	280	140	0	280	70	140
315	0	70	70	0	140	0	0	70	70	0	70	140
400	90	90	0	0	0	0	0	0	90	90	0	0
500	120	240	120	120	0	240	240	120	120	120	0	240
630	0	0	0	0	0	140	140	0	0	0	0	0
750	0	340	0	0	0	0	340	340	170	170	0	0
1000	0	0	230	230	0	460	230	230	0	460	0	0
Tot	540	980	690	530	450	1290	1350	960	570	1120	200	580

Table 5 6

Periodic demand of Radiator raw material (Using Excel by combination of Table 5.4 & Table 5 2)

KVA	July 01		August 01		September 01		October 01		November 01		December 01	
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1^{st} half	2^{nd} half
	kg	Kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
200	160	320	80	240	320	320	160	80	160	0	80	80
250	240	0	240	0	80	240	320	160	0	320	80	160
315	0	100	100	0	200	0	0	100	100	0	100	200
400	150	150	0	0	0	0	0	0	150	150	0	0
500	210	420	210	210	0	420	420	210	210	210	0	420
630	0	0	0	0	0	210	210	0	0	0	0	0
750	0	504	0	0	0	0	504	504	252	252	0	0
1000	0	0	400	400	0	800	400	400	0	800	0	0
Tot	760	1494	1030	850	600	1990	2014	1454	872	1732	280	860

Table 5.7

Periodic demand of Silicon Steel (Using Excel by combination of Table 5.4 & Table 5.1)

kVA	Jan 01	Feb-01	Mar-01	Apr. 01	May-01	Jun-01	Jul-01	Aug-01	Sep 01	Oct 01	Nov 01	Dec 01
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
200	1935	2322	774	2322	1548	1161	2322	1548	3096	1161	774	774
250	1728	2592	1296	1728	2160	2592	1296	1296	1728	2592	1728	1296
315	984	492	0	0	984	492	492	492	984	492	492	1476
400	580	0	0	0	580	0	1160	0	0	0	1160	0
500	1896	1896	3160	1896	3160	1896	1800	1264	1264	1896	1264	1264
630	0	0	732	732	0	732	0	0	732	732	0	0
750	0	827	827	0	827	1654	1654	0	0	3308	1654	0
1000	2400	3600	2400	2400	0	1200	0	2400	2400	2400	2400	0
Tot	9523	11729	9189	9078	9259	9727	6820	7000	10204	12581	9472	4810

* 2160 kg Si steel the same amount was found by software calculation previously at section 5.1 Si steel backward calculation.

Table 5.8

Periodic demand of LT Wire (Using Excel by combination of Table 5.4 & Table 5.1)

kVA	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug 01	Sep-01	Oct-01	Nov-01	Dec-01
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
200	315	378	126	378	252	189	378	252	504	189	126	126
250	319.2	478.8	239.4	319.2	399	478.8	239.4	239.4	319.2	478.8	319.2	239.4
315	198	99	0	0	108	99	99	99	198	99	99	297
400	96	0	0	0	96	0	197	0	0	0	192	0
500	288	288	480	288	480	288	288	192	192	288	192	192
630	0	0	120	120	0	120	0	0	120	120	0	0
750	0	153	153	0	153	306	306	0	0	612	306	0
1000	400	600	400	400	0	200	0	400	400	400	400	0
Tot	1616.2	1996.8	1518.4	1505.2	1578	1680.8	1502.4	1182.4	1733.2	2166.8	1634.2	854.4

* 399 kg of LT wire the same amount was found by software calculation previously at section 5.1 LT wire backward calculation

Table 5.9

Periodic demand of HT wire raw material (Using Excel by combination of Table 5.4 & Table 5.2)

kVA	Jul 01		Aug 01		Sep 01		Oct 01		Nov 01		Dec 01	
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
200	172	344	86	258	344	344	172	86	172	0	86	86
250	286.5	0	286.5	0	95.5	286.5	382	191	0	382	95.5	191
315	0	117	117	0	234	0	0	117	117	0	117	234
400	156	156	0	0	0	0	0	0	156	156	0	0
500	156	312	156	156	0	312	312	156	156	156	0	312
630	0	0	0	0	0	180	180	0	0	0	0	0
750	0	500	0	0	0	0	500	500	250	250	0	0
1000	0	0	312	312	0	624	312	312	0	624	0	0
Tot	770.5	1429	957.5	726	673.5	1746.5	1858	1362	851	1568	298.5	823

Table 5.10

Periodic demand of XFR (Transformer) Oil (Using Excel by combination of Table 5.4 & Table 5.1)

KVA	Jan 01	Feb. 01	Mar-01	Apr 01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01
	Liter	liter	liter	liter	liter	liter	liter	liter	liter	liter	liter	liter
200	975	1170	390	1170	780	585	1170	780	1560	585	390	390
250	1200	1800	900	1200	1500	1800	900	900	1200	1800	1200	900
315	700	350	0	0	700	350	350	350	700	350	350	1050
400	420	0	0	0	420	0	840	0	0	0	840	0
500	1260	1260	2100	1260	2100	1260	1260	840	840	1260	840	840
630	0	0	520	520	0	520	0	0	520	520	0	0
750	0	610	610	0	610	1220	1220	0	0	2440	1220	0
1000	2520	3780	2520	2520	0	1260	0	2520	2520	2520	2520	0
Tot	7075	8970	7040	6670	6110	6995	5740	5390	7340	9475	7360	3180

* 1500 liter of XFR Oil the same amount was found by software calculation previously at section 5.1 XFR Oil backward calculation

Table 5.11

Periodic demand of Channel raw material (Using Excel by combination of Table 5.4 & Table 5.3)

KVA	October 01				November 01				December 01			
	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
200	0	96	0	48	48	48	0	0	48	0	0	48
250	180	60	0	120	0	0	60	180	0	60	60	60
315	0	0	0	60	60	0	0	0	0	60	60	60
400	0	0	0	0	60	0	60	0	0	0	0	0
500	80	80	0	80	0	80	0	80	0	0	0	160
630	0	100	0	0	0	0	0	0	0	0	0	0
750	0	200	200	0	100	0	100	0	0	0	0	0
1000	0	120	120	0	0	0	240	0	0	0	0	0
Tot	260	656	320	308	288	128	460	260	48	120	120	328

Table 5.12

Periodic demand of Conservator raw material (Using Excel by combination of Table 5.4 & Table 5.2)

KVA	July 01		August 01		September 01		October 01		November 01		December 01	
	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd
	kg	Kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg
200	30	60	15	45	60	60	30	15	30	0	15	15
250	45	0	45	0	15	45	60	30	0	60	15	30
315	0	15	15	0	30	0	0	15	15	0	15	30
400	15	15	0	0	0	0	0	0	15	15	0	0
500	20	40	20	20	0	40	40	20	20	20	0	40
630	0	0	0	0	0	20	20	0	0	0	0	0
750	0	50	0	0	0	0	50	50	25	25	0	0
1000	0	0	30	30	0	60	30	30	0	60	0	0
Tot	110	180	125	95	105	225	230	160	105	180	45	115

Table 5.13
Periodic demand of Press Board raw material (Using Excel by combination of Table 5.4 & Table 5.3)

	October 01				November 01				December 01			
200	0	1.7	0	0.85	0.85	0.85	0	0	0.85	0	0	0.85
250	2.55	0.85	0	1.7	0	0	0.85	2.55	0	0.85	0.85	0.85
315	0	0	0	0.89	0.89	0	0	0	0	0.89	0.89	0.89
400	0	0	0	0	0.99	0	0.99	0	0	0	0	0
500	1.17	1.17	0	1.17	0	1.17	0	1.17	0	0	0	2.34
630	0	1.5	0	0	0	0	0	0	0	0	0	0
750	0	3.62	3.62	0	1.81	0	1.81	0	0	0	0	0
1000	0	2.63	2.63	0	0	0	5.26	0	0	0	0	0
Tot	3.72	11.47	6.25	4.61	4.54	2.02	8.91	3.72	0.85	1.74	1.74	4.93

* Summation of Key Block & Separator raw material

Table 5.14
Periodic demand of Cu rod raw material (Using Excel by combination of Table 5.4 & Table 5.1)

kVa	Jan. 01	Feb 01	Mar 01	Apr 01	May-01	Jun-01	Jul-01	Aug-01	Sep 01	Oct 01	Nov 01	Dec 01
	Meter	meter	meter	meter	meter	meter	meter	meter	meter	meter	meter	meter
200	20	24	8	24	16	12	24	16	32	12	8	8
250	17.04	25.56	12.78	17.04	21.3	25.56	12.78	12.78	17.04	25.56	17.04	12.78
315	8.52	4.26	0	0	8.52	4.26	4.26	4.26	8.52	4.26	4.26	12.78
400	4.52	0	0	0	4.52	0	9.04	0	0	0	9.04	0
500	16.5	16.5	27.5	16.5	27.5	16.5	16.5	11	11	16.5	11	11
630	0	0	6.5	6.5	0	6.5	0	0	6.5	6.5	0	0
750	0	7.1	7.1	0	7.1	14.2	14.2	0	0	28.4	14.2	0
1000	14.56	21.84	14.56	14.56	0	7.28	0	14.56	14.56	14.56	14.56	0
Tot	81.14	99.26	76.44	78.6	84.94	86.3	80.78	58.6	89.62	107.78	78.1	44.56

Table 5.15
Periodic demand of Nut Bolt (Using Excel by combination of Table 5.4 & Table 5.3)

	October 01				November 01				December 01			
kVA	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
	piece	piece	piece	piece	piece	piece	piece	piece	piece	piece	piece	piece
200	0	164	0	82	82	82	0	0	82	0	0	82
250	246	82	0	164	0	0	82	246	0	82	82	82
315	0	0	0	82	82	0	0	0	0	82	82	82
400	0	0	0	0	106	0	106	0	0	0	0	0
500	106	106	0	106	0	106	0	106	0	0	0	212
630	0	100	0	0	0	0	0	0	0	0	0	0
750	0	256	256	0	128	0	128	0	0	0	0	0
1000	0	132	132	0	0	0	264	0	0	0	0	0
Tot	352	846	366	434	398	188	580	352	82	164	164	458

APPENDIX III

MATERIAL 1:
Problem Title.
Lot size determination of Tank Raw Material

Period	Demand(kg)	Parameter	Value
1	540	Holding cost	0.23 Tk
2	980	Setup cost	2,750 Tk
3	690	Initial inventory	540 Kg
4	530	Lead time	1
5	450		
6	1,290		
7	1,350		
8	960		
9	570		
10	1,120		
11	200		
12	580		

Results
Tank RM, Method: Wagner – Whitin
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			540		
1	540		0		
2	980	2650	1670	384 1	2750
3	690		980	225 4	
4	530		450	103.5	
5	450		0		
6	1290	6070	4780	1099 4	2750
7	1350		3430	788 9	
8	960		2470	568 1	
9	570		1900	437	
10	1120		780	179 4	
11	200		580	133 4	
12	580		0		
Totals	9260	8720	17040	3919 2	5500
Ave demand	771 6667				
Total Cost	9419 2				

Tank RM, Method: Lot for lot
July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			540		
1	540	980	980	225.4	2750
2	980	690	690	158 7	2750
3	690	530	530	121.9	2750
4	530	450	450	103 5	2750
5	450	1290	1290	296 7	2750
6	1290	1350	1350	310 5	2750
7	1350	960	960	220 8	2750
8	960	570	570	131 1	2750
9	570	1120	1120	257 6	2750
10	1120	200	200	46	2750
11	200	580	580	133 4	2750
12	580		0		
Totals	9260	8720	8720	2005.6	30250
Ave demand	771.6667				
Total Cost	32255 6				

Tank RM, Method. Economic Order Quantity
July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			540		
1	540	4296	4296	988 08	2750
2	980		3316	762.68	
3	690		2626	603 98	
4	530		2096	482 08	
5	450		1646	378.58	
6	1290	4296	4652	1069.96	2750
7	1350		3302	759.46	
8	960		2342	538 66	
9	570		1772	407 56	
10	1120		652	149.96	
11	200	4296	4748	1092 04	2750
12	580		4168	958 64	
Totals	9260	12888	35616	8191 681	8250
Ave demand	771 6667		EOQ	4296	
Total Cost	16441 68				

Tank RM, Method Period Order Quantity
July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			540		
1	540	5290	5290	1216 7	2750
2	980		4310	991 3	
3	690		3620	832 6	
4	530		3090	710.7	
5	450		2640	607.2	
6	1290		1350	310.5	
7	1350	3430	3430	788 9	2750
8	960		2470	568 1	
9	570		1900	437	
10	1120		780	179 4	
11	200		580	133.4	
12	580		0		
Totals	9260	8720	29460	6775 8	5500
Ave demand	771.6667		EOQ	4296	
Total Cost	12275 8		POQ	6	

Tank RM, Method. Part Period Balancing
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			540		
1	540		0		
2	980	5290	4310	991 3	2750
3	690		3620	832.6	
4	530		3090	710.7	
5	450		2640	607.2	
6	1290		1350	310.5	
7	1350		0		
8	960	3430	2470	568.1	2750
9	570		1900	437	
10	1120		780	179 4	
11	200		580	133 4	
12	580		0		
Totals	9260	8720	20740	4770.2	5500
Ave demand	771.6667				
Total Cost	10270 2				

MATERIAL: 2

Problem title
Lot size determination of Radiator Raw Material

Period	Demand (kg)	Parameter	Value
1	760	Holding cost	0.26 Tk
2	1494	Setup cost	2750
3	1030	Initial inventory	760
4	850	Lead time	1
5	600		
6	1990		
7	2014		
8	1454		
9	872		
10	1732		
11	260		
12	860		

Results
Radiator RM, Method: Wagner Whitin
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			760		
1	760		0		
2	1494	3974	2480	644.8	2750
3	1030		1450	377	
4	850		600	156	
5	600		0		
6	1990	6330	4340	1128.4	2750
7	2014		2326	604.7599	
8	1454		872	226.72	
9	872		0		
10	1732	2852	1120	291.2	2750
11	260		860	223.6	
12	860		0		
Totals	13916	13156	14048	3652.48	8250
Ave demand	1159.667				
Total Cost	11902.48				

Radiator RM, Method: Lot for lot
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			760		
1	760	1494	1494	388.44	2750
2	1494	1030	1030	267.8	2750
3	1030	850	850	221	2750
4	850	600	600	156	2750
5	600	1990	1990	517.4	2750
6	1990	2014	2014	523.64	2750
7	2014	1454	1454	378.04	2750
8	1454	872	872	226.72	2750
9	872	1732	1732	450.32	2750
10	1732	260	260	67.6	2750
11	260	860	860	223.6	2750
12	860		0		
Totals	13916	13156	13156	3420.56	30250
Ave demand	1159.667				
Total Cost	33670.56				

Radiator RM, Method Economic Order Quantity
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			760		
1	760	4953	4953	1287 78	2750
2	1494		3459	899 34	
3	1030		2429	631 54	
4	850		1579	410 54	
5	600	4953	5932	1542.32	2750
6	1990		3942	1024 92	
7	2014		1928	501 28	
8	1454	4953	5427	1411 02	2750
9	872		4555	1184.3	
10	1732		2823	733 98	
11	260		2563	666.38	
12	860		1703	442.78	
Totals	13916	14859	41293	10736 18	8250
Ave demand	1159 667		EOQ	4953	
Total Cost	18986 18				

Radiator RM, Method: Period Order Quantity
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			760		
1	760	3974	3974	1033.24	2750
2	1494		2480	644.8	
3	1030		1450	377	
4	850		600	156	
5	600	6330	6330	1645 8	2750
6	1990		4340	1128.4	
7	2014		2326	604.7599	
8	1454		872	226.72	
9	872	2852	2852	741.52	2750
10	1732		1120	291 2	
11	260		860	223 6	
12	860		0		
Totals	13916	13156	27204	7073 04	8250
Ave demand	1159.667		EOQ	4953	
Total Cost	15323 04		POQ	4	

Radiator RM, Method: Part Period Balancing
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			760		
1	760		0		
2	1494	5964	4470	1162.2	2750
3	1030		3440	894 4	
4	850		2590	673 4	
5	600		1990	517 4	
6	1990		0		
7	2014	6332	4318	1122.68	2750
8	1454		2864	744.64	
9	872		1992	517.92	
10	1732		260	67.6	
11	260		0		
12	860	860	0		2750
Totals	13916	13156	21924	5700.24	8250
Ave demand	1159.667				
Total Cost	13950.24				

MATERIAL 3

Problem title:
Lot size determination of Silicon Steel Raw Material

Period	Demand (Kg)	parameter	Value
1	9,523	Holding cost	3.94 Tk
2	1,1729	Setup cost	30,350 Tk
3	9,189	Initial inventory	39519
4	9,076	Lead time	4 months
5	9,259		
6	9,727		
7	8,820		
8	7,000		
9	10,240		
10	12,581		
11	9,472		
12	4,810		

Results
Silicon Steel, Method, Wagner – Whitin
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			39519		
1	9523		29996	118184.2	
2	11729		18267	71971 98	
3	9189		9078	35767.32	
4	9078		0		
5	9259	9259	0		30350
6	9727	9727	0		30350
7	8820	15820	7000	27580	30350
8	7000		0		
9	10204	10204	0		30350
10	12581	12581	0		30350
11	9472	14282	4810	18951 4	30350
12	4810		0		
Totals	111392	71873	69151	272454 9	182100
Ave demand	9282.667				
Total Cost	454554 9				

Silicon Steel, Method: Lot for lot
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			39519		
1	9523	9259	39255	154664.7	30350
2	11729	9727	37253	146776.8	30350
3	9189	8820	36884	145323	30350
4	9078	7000	34806	137135 6	30350
5	9259	10204	35751	140858.9	30350
6	9727	12581	38605	152103 7	30350
7	8820	9472	39257	154672 6	30350
8	7000	4810	37067	146044	30350
9	10204		26863	105840 2	
10	12581		14282	56271.08	
11	9472		4810	18951.4	
12	4810		0		
Totals	111392	71873	344833	1358642	242800
Ave demand	9282 667				
Total Cost	1601442				

Silicon Steel, Method Economic Order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			39519		
1	9523	11959	41955	165302.7	30350
2	11729	11959	42185	166208.9	30350
3	9189	11959	44955	177122.7	30350
4	9078		35877	141355.4	
5	9259	11959	38577	151993.4	30350
6	9727	11959	40809	160787.5	30350
7	8820	11959	43948	173155.1	30350
8	7000	11959	48907	192693.6	30350
9	10204		38703	152489.8	
10	12581		26122	102920.7	
11	9472		16650	65601	
12	4810		11840	46649.6	
Totals	111392	83713	430528	1696280	212450
Ave demand	9282.667		EOQ	11959	
Total Cost	1908730				

Silicon Steel, Method Period Order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv			39519		
1	9523	9259	39255	154664.7	30350
2	11729	9727	37253	146776.8	30350
3	9189	8820	36884	145323	30350
4	9078	7000	34806	137135.6	30350
5	9259	10204	35751	140858.9	30350
6	9727	12581	38605	152103.7	30350
7	8820	9472	39257	154672.6	30350
8	7000	4810	37067	146044	30350
9	10204		26863	105840.2	
10	12581		14282	56271.08	
11	9472		4810	18951.4	
12	4810		0		
Totals	111392	71873	344833	1358642	242800
Ave demand	9282.667		EOQ	11959	
Total Cost	1601442		POQ	1	

Silicon Steel, Method Part Period Balancing
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			39519		
1	9523		29996	118184.2	
2	11729		18267	71971.98	
3	9189		9078	35767.32	
4	9078		0		
5	9259	18986	9727	38324.38	30350
6	9727		0		
7	8820	15820	7000	27580	30350
8	7000		0		
9	10204	22785	12581	49569.14	30350
10	12581		0		
11	9472	14282	4810	18951.4	30350
12	4810		0		
Totals	111392	71873	91459	360348.5	121400
Ave demand	9282.667				
Total Cost	481748.5				

MATERIAL 4

Problem Title:
Lot size determination of LT Wire Raw Material

Period	Demand (Kg)	parameter	Value
1	1616	Holding Cost	3.85
2	1997	Set up Cost	30350
3	1518	Initial Inventory	6636
4	1505	Lead time	4
5	1578		
6	1681		
7	1502		
8	1182		
9	1733		
10	2187		
11	1634		
12	854		

Results
LT wire, Method: Wagner – Whitin
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv			6636		
1	1616		5020	19327	
2	1997		3023	11638 55	
3	1518		1505	5794.25	
4	1505		0		
5	1578	5943	4365	16805 25	30350
6	1681		2684	10333 4	
7	1502		1182	4550 7	
8	1182		0		
9	1733	6408	4675	17998.75	30350
10	2187		2488	9578 8	
11	1634		854	3287.9	
12	854		0		
Totals	18987	12351	25796	99314.59	60700
Ave demand	1582.25				
Total Cost	160014 6				

LT Wire, Method: Lot for lot
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv			6636		
1	1616	1578	6598	25402 3	30350
2	1997	1681	6282	24185.7	30350
3	1518	1502	6266	24124 1	30350
4	1505	1182	5943	22880 55	30350
5	1578	1733	6098	23477.3	30350
6	1681	2187	6604	25425.4	30350
7	1502	1634	6736	25933.6	30350
8	1182	854	6408	24670.8	30350
9	1733		4675	17998 75	
10	2187		2488	9578 8	
11	1634		854	3287 9	
12	854		0		
Totals	18987	12351	58952	226985.2	242800
Ave demand	1582 25				
Total Cost	469765 2				

LT wire, Method: Economic Order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			6636		
1	1616	4995	10015	38557.75	30350
2	1997		8018	30869 3	
3	1518		6500	25025	
4	1505	4995	9990	38461 5	30350
5	1578		8412	32386 2	
6	1681		6731	25914 35	
7	1502	4995	10224	39362 4	30350
8	1182		9042	34811.7	
9	1733		7309	28139.65	
10	2187		5122	19719 7	
11	1634		3488	13428.8	
12	854		2634	10140 9	
Totals	18987	14985	87485	336817.3	91050
Ave demand	1582 25		EOQ	4995	
Total Cost	427867.3				

LT wire, Method Period Order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			6636		
1	1616	4761	9781	37656 85	30350
2	1997		7784	29968 4	
3	1518		6266	24124.1	
4	1505	5102	9863	37972 55	30350
5	1578		8285	31897 25	
6	1681		6604	25425 4	
7	1502	2488	7590	29221.5	30350
8	1182		6408	24670 8	
9	1733		4675	17998 75	
10	2187		2488	9578 8	
11	1634		854	3287 9	
12	854		0		
Totals	18987	12351	70598	271802 3	91050
Ave demand	1582 25		EOQ	4995	
Total Cost	362852 3		POQ	3	

LT wire, Method: Part Period Balancing
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			6636		
1	1616		5020	19327	
2	1997		3023	11638.55	
3	1518		1505	5794 25	
4	1505		0		
5	1578	5943	4365	16805 25	30350
6	1681		2684	10333.4	
7	1502		1182	4550.7	
8	1182		0		
9	1733	6408	4675	17998.75	30350
10	2187		2488	9578 8	
11	1634		854	3287 9	
12	854		0		
Totals	18987	12351	25796	99314 59	60700
Ave demand	1582 25				
Total Cost	160014 6				

MATERIAL 5

Problem Title:
Lot size determination of HT Wire Raw Material

Period	Demand (Kg)	parameter	Value
1	771	Holding Cost	1.83
2	1429	Set up Cost	2750
3	958	Initial Inventory	771
4	726	Lead time	1
5	674		
6	1747		
7	1858		
8	1362		
9	851		
10	1568		
11	299		
12	823		

Results
HT wire, Method: Wagner – Whitin
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			771		
1	771		0		
2	1429	2387	958	1753 14	2750
3	958		0		
4	726	1400	674	1233 42	2750
5	674		0		
6	1747	1747	0		2750
7	1858	1858	0		2750
8	1362	2213	851	1557.33	2750
9	851		0		
10	1568	1867	299	547.17	2750
11	299		0		
12	823	823	0		2750
Totals	13066	12295	2782	5091 06	19250
Ave demand	1088 833				
Total Cost	24341 06				

HT Wire, Method Lot for lot
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			771		
1	771	1429	1429	2615 07	2750
2	1429	958	958	1753.14	2750
3	958	726	726	1328.58	2750
4	726	674	674	1233.42	2750
5	674	1747	1747	3197 01	2750
6	1747	1858	1858	3400.14	2750
7	1858	1362	1362	2492 46	2750
8	1362	851	851	1557.33	2750
9	851	1568	1568	2869 44	2750
10	1568	299	299	547 17	2750
11	299	823	823	1506.09	2750
12	823		0		
Totals	13066	12295	12295	22499.85	30250
Ave demand	1088 833				
Total Cost	52749 85				

HT wire, Method: Economic order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			771		
1	771	1809	1809	3310 47	2750
2	1479	1809	2189	4005 87	2750
3	958		1231	2252 73	
4	726	1809	2314	4234 62	2750
5	674	1809	3449	6311 67	2750
6	1747	1809	3511	6425 13	2750
7	1858		1653	3024 99	
8	1362	1809	2100	3843	2750
9	851	1809	3058	5596 14	2750
10	1568		1490	2726 7	
11	299		1191	2179.53	
12	823		368	673.44	
Totals	13066	12663	24363	44584.3	19250
Ave demand	1088 833		EOQ	1809	
Total Cost	63834.3				

HT wire, Method, Period Order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			771		
1	771	2387	2387	4368 21	2750
2	1429		958	1753 14	
3	958	1400	1400	2562	2750
4	726		674	1233.42	
5	674	3605	3605	6597.15	2750
6	1747		1858	3400.14	
7	1858	2213	2213	4049.79	2750
8	1362		851	1557.33	
9	851	1867	1867	3416 61	2750
10	1568		299	547.17	
11	299	823	823	1506 09	2750
12	823		0		
Totals	13066	12295	16935	30991.05	16500
Ave demand	1088 833		EOQ	1809	
Total Cost	47491 05		POQ	2	

HT wire, Method: Part Period Balancing
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			771		
1	771		0		
2	1429	2387	958	1753.14	2750
3	958		0		
4	726	1400	674	1233 42	2750
5	674		0		
6	1747	3605	1858	3400 14	2750
7	1858		0		
8	1362	2213	851	1557.33	2750
9	851		0		
10	1568	2690	1122	2053 26	2750
11	299		823	1506 09	
12	823		0		
Totals	13066	12295	6286	11503.38	13750
Ave demand	1088 833				
Total Cost	25253 38				

MATERIAL_6

Problem title:
Lot size determination of Transformer Oil

Period	Demand (Kg)	parameter	Value
1	7075	Holding Cost	0 916
2	8970	Set up Cost	30350
3	7040	Initial Inventory	29755
4	6670	Lead time	4
5	6110		
6	6995		
7	5740		
8	5390		
9	7340		
10	9475		
11	7360		
12	3180		

Transformer Oil, Method: Wagner – Whitin
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			29755		
1	7075		22680	20774.88	
2	8970		13710	12558 36	
3	7040		6670	6109 72	
4	6670		0		
5	6110	24235	18125	16602.5	30350
6	6995		11130	10195.08	
7	5740		5390	4937.24	
8	5390		0		
9	7340	27355	20015	18333 74	30350
10	9475		10540	9654.64	
11	7360		3180	2912.88	
12	3180		0		
Totals	81345	51590	111440	102079	60700
Ave demand	6778.75				
Total Cost	162779				

Transformer Oil, Method Lot for lot
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			29755		
1	7075	6110	28790	26371.64	30350
2	8970	6995	26815	24562.54	30350
3	7040	5740	25515	23371.74	30350
4	6670	5390	24235	22199.26	30350
5	6110	7340	25465	23325.94	30350
6	6995	9475	27945	25597.62	30350
7	5740	7360	29565	27081.54	30350
8	5390	3180	27355	25057 18	30350
9	7340		20015	18333.74	
10	9475		10540	9654 64	
11	7360		3180	2912.88	
12	3180		0		
Totals	81345	51590	249420	228468.7	242800
Ave demand	6778 75				
Total Cost	471268 7				

Transformer Oil, Method: Economic order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			29755		
1	7075	21194	43874	40188 59	30350
2	8970		34904	31972 06	
3	7040		27864	25523 42	
4	6670	21194	42388	38827 41	30350
5	6110		36278	33230.65	
6	6995		29283	26823 23	
7	5740	21194	44737	40979.09	30350
8	5390		39347	36041.85	
9	7340		32007	29318 41	
10	9475		22532	20639.31	
11	7360		15172	13897.55	
12	3180		11992	10984 67	
Totals	81345	63582	380378	348426 3	91050
Ave demand	6778 75		EOQ	21194	
Total Cost	439476.3				

Transformer Oil, Method' Period Order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			29755		
1	7075	18845	41525	38036.9	30350
2	8970		32555	29820.38	
3	7040		25515	23371.74	
4	6670	22205	41050	37601.8	30350
5	6110		34940	32005 04	
6	6995		27945	25597 62	
7	5740	10540	32745	29994 42	30350
8	5390		27355	25057.18	
9	7340		20015	18333 74	
10	9475		10540	9654.64	
11	7360		3180	2912.88	
12	3180		0		
Totals	81345	51590	297365	272386 3	91050
Ave demand	6778 75		EOQ	21194	
Total Cost	363436 3		POQ	3	

Transformer Oil, Method Part Period Balancing
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			29755		
1	7075		22680	20774 88	
2	8970		13710	12558.36	
3	7040		6670	6109.72	
4	6670		0		
5	6110	24235	18125	16602.5	30350
6	6995		11130	10195.08	
7	5740		5390	4937 24	
8	5390		0		
9	7340	27355	20015	18333 74	30350
10	9475		10540	9654.64	
11	7360		3180	2912 88	
12	3180		0		
Totals	81345	51590	111440	102079	60700
Ave demand	6778 75				
Total Cost	162779				

MATERIAL 7

Problem title:
Lot size determination of Channel-Raw Material

Period	Demand (Kg)	parameter	Value
1	260	Holding Cost	0.04
2	656	Set up Cost	2750
3	320	Initial Inventory	260
4	308	Lead time	1
5	288		
6	128		
7	480		
8	260		
9	48		
10	120		
11	120		
12	328		

Channel RM, Method: Wagner – Whitin
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			260		
1	260		0		
2	656	3056	2400	96	2750
3	320		2080	83.2	
4	308		1772	70.88	
5	288		1484	59.36	
6	128		1356	54.24	
7	480		876	35.04	
8	260		616	24.64	
9	48		568	22.72	
10	120		448	17.92	
11	120		328	13.12	
12	328		0		
Totals	3316	3056	11928	477.12	2750
Ave demand	276.3333				
Total Cost	3227.12				

Channel RM, Method Lot for lot
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			260		
1	260	656	656	26.24	2750
2	656	320	320	12.8	2750
3	320	308	308	12.32	2750
4	308	288	288	11.52	2750
5	288	128	128	5.12	2750
6	128	480	480	19.2	2750
7	480	260	260	10.4	2750
8	260	48	48	1.92	2750
9	48	120	120	4.8	2750
10	120	120	120	4.8	2750
11	120	328	328	13.12	2750
12	328		0		
Totals	3316	3056	3056	122.24	30250
Ave demand	276.3333				
Total Cost	30372.24				

Channel RM, Method. Economic order Quantity
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			260		
1	260	6164	6164	246.56	2750
2	656		5508	220.32	
3	320		5188	207.52	
4	308		4880	195.2	
5	288		4592	183.68	
6	128		4464	178.56	
7	480		3984	159.36	
8	260		3724	148.96	
9	48		3676	147.04	
10	120		3556	142.24	
11	120		3436	137.44	
12	328		3108	124.32	
Totals	3316	6164	52280	2091.2	2750
Ave demand	276.3333		EOQ	6164	
Total Cost	4841.2				

Channel RM, Method Period Order Quantity
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			260		
1	260	3056	3056	122.24	2750
2	656		2400	96	
3	320		2080	83.2	
4	308		1772	70.88	
5	288		1484	59.36	
6	128		1356	54.24	
7	480		876	35.04	
8	260		616	24.64	
9	48		568	22.72	
10	120		448	17.92	
11	120		328	13.12	
12	328		0		
Totals	3316	3056	14984	599.3599	2750
Ave demand	276.3333		EOQ	6164	
Total Cost	3349.36		POQ	22	

Channel RM, Method Part Period Balancing
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			260		
1	260		0		
2	656	3056	2400	96	2750
3	320		2080	83.2	
4	308		1772	70.88	
5	288		1484	59.36	
6	128		1356	54.24	
7	480		876	35.04	
8	260		616	24.64	
9	48		568	22.72	
10	120		448	17.92	
11	120		328	13.12	
12	328		0		
Totals	3316	3056	11928	477.12	2750
Ave demand	276.3333				
Total Cost	3227.12				

MATERIAL 8

Problem title:
Lot size determination of Conservator Raw Material

Period	Demand (kg)	Parameter	Value
1	110	Holding cost	0 24
2	180	Setup cost	2750
3	125	Initial inventory	110
4	95	Lead time	1
5	105		
6	225		
7	230		
8	160		
9	150		
10	180		
11	45		
12	115		

Results:
Conservator RM, Method: Wagner – Whitin
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			110		
1	110		0		
2	180	1610	1430	343.2	2750
3	125		1305	313 2	
4	95		1210	290 4	
5	105		1105	265.2	
6	225		880	211.2	
7	230		650	156	
8	160		490	117 6	
9	150		340	81.6	
10	180		160	38.4	
11	45		115	27.6	
12	115		0		
Totals	1720	1610	7685	1844.4	2750
Avg demand	143 3333				
Total Cost	4594.4				

Conservator RM, Method Lot for lot
July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv			110		
1	110	180	180	43 2	2750
2	180	125	125	30	2750
3	125	95	95	22 8	2750
4	95	105	105	25.2	2750
5	105	225	225	54	2750
6	225	230	230	55 2	2750
7	230	160	160	38.4	2750
8	160	150	150	36	2750
9	150	180	180	43 2	2750
10	180	45	45	10.8	2750
11	45	115	115	27.6	2750
12	115		0		
Totals	1720	1610	1610	386 4	30250
Avg demand	143 3333				
Total Cost	30636.4				

Conservator RM, Method Economic Order Quantity
July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			110		
1	110	1812	1812	434 88	2750
2	180		1632	391.68	
3	125		1507	361 68	
4	95		1412	338 88	
5	105		1307	313 68	
6	225		1082	259.68	
7	230		852	204 48	
8	160		692	166.08	
9	150		542	130 08	
10	180		362	86 88	
11	45		317	76.08	
12	115		202	48 48	
Totals	1720	1812	11719	2812.56	2750
Ave demand	143 3333		EOQ	1812	
Total Cost	5562.56				

Conservator RM, Method Period Order Quantity
July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			110		
1	110	1610	1610	386.4	2750
2	180		1430	343 2	
3	125		1305	313 2	
4	95		1210	290.4	
5	105		1105	265.2	
6	225		880	211 2	
7	230		650	156	
8	160		490	117 6	
9	150		340	81.6	
10	180		160	38.4	
11	45		115	27.6	
12	115		0		
Totals	1720	1610	9295	2230 8	2750
Ave demand	143 3333		EOQ	1812	
Total Cost	4980 8		POQ	13	

Conservator RM, Method Part Period Balancing
(July 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			110		
1	110		0		
2	180	1610	1430	343.2	2750
3	125		1305	313 2	
4	95		1210	290 4	
5	105		1105	265 2	
6	225		880	211 2	
7	230		650	156	
8	160		490	117 6	
9	150		340	81.6	
10	180		160	38.4	
11	45		115	27 6	
12	115		0		
Totals	1720	1610	7685	1844.4	2750
Ave demand	143 3333				
Total Cost	4594 4				

MATERIAL 9

Problem title.
Lot size determination of Pressboard Raw Material

Period	Demand (kg)	Parameter	Value
1	4	Holding cost	4.03
2	11	Setup cost	2750
3	6	Initial inventory	4
4	5	Lead time	1
5	5		
6	2		
7	9		
8	4		
9	1		
10	2		
11	2		
12	5		

RESULT:
Pressboard, Method Wagner – Whitin
(October 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			4		
1	4		0		
2	11	52	41	165.23	2750
3	6		35	141 05	
4	5		30	120 9	
5	5		25	100 75	
6	2		23	92 69	
7	9		14	56 42	
8	4		10	40 3	
9	1		9	36.27	
10	2		7	28 21	
11	2		5	20 15	
12	5		0		
Totals	56	52	199	801 9701	2750
Ave demand	4 666667				
Total Cost	3551 97				

Pressboard, Method, Lot for lot
(October 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			4		
1	4	11	11	44 33	2750
2	11	6	6	24.18	2750
3	6	5	5	20.15	2750
4	5	5	5	20 15	2750
5	5	2	2	8.06	2750
6	2	9	9	36.27	2750
7	9	4	4	16 12	2750
8	4	1	1	4 03	2750
9	1	2	2	8 06	2750
10	2	2	2	8 06	2750
11	2	5	5	20 15	2750
12	5		0		
Totals	56	52	52	209 56	30250
Ave demand	4.666667				
Total Cost	30459 56				

Pressboard, Method. Economic Order Quantity
(October 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv			4		
1	4	80	80	322.4	2750
2	11		69	278.07	
3	6		63	253.89	
4	5		58	233.74	
5	5		53	213.59	
6	2		51	205.53	
7	9		42	169.26	
8	4		38	153.14	
9	1		37	149.11	
10	2		35	141.05	
11	2		33	132.99	
12	5		28	112.84	
Totals	56	80	587	2365.61	2750
Ave demand	4.666667		EOQ	80	
Total Cost	5115.61				

Pressboard, Method Period Order Quantity
(October 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			4		
1	4	52	52	209.56	2750
2	11		41	165.23	
3	6		35	141.05	
4	5		30	120.9	
5	5		25	100.75	
6	2		23	92.69	
7	9		14	56.42	
8	4		10	40.3	
9	1		9	36.27	
10	2		7	28.21	
11	2		5	20.15	
12	5		0		
Totals	56	52	251	1011.53	2750
Ave demand	4.666667		EOQ	80	
Total Cost	3761.53		POQ	17	

Pressboard, Method. Part Period Balancing
(October 01 to December 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			4		
1	4		0		
2	11	52	41	165.23	2750
3	6		35	141.05	
4	5		30	120.9	
5	5		25	100.75	
6	2		23	92.69	
7	9		14	56.42	
8	4		10	40.3	
9	1		9	36.27	
10	2		7	28.21	
11	2		5	20.15	
12	5		0		
Totals	56	52	199	801.9701	2750
Ave demand	4.666667				
Total Cost	3551.97				

MATERIAL 10

Problem title:
Lot size determination of Cu Rod Raw Material

Period	Demand (Kg)	parameter	Value
1	81	Holding Cost	
2	99	Set up Cost	
3	76	Initial Inventory	
4	79	Lead time	
5	85		
6	86		
7	81		
8	59		
9	90		
10	108		
11	78		
12	45		

Cu Rod RM, Method: Wagner – Whitin
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			335		
1	81		254	1330.96	
2	99		155	812.2	
3	76		79	413.96	
4	79		0		
5	85	632	547	2866.28	30350
6	86		461	2415.64	
7	81		380	1991.2	
8	59		321	1682.04	
9	90		231	1210.44	
10	108		123	644.52	
11	78		45	235.8	
12	45		0		
Totals	967	632	2596	13603.04	30350
Ave demand	80.58334				
Total Cost	43953.04				

Cu Rod RM, Method: Lot for lot
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			335		
1	81	85	339	1776.36	30350
2	99	86	326	1708.24	30350
3	76	81	331	1734.44	30350
4	79	59	311	1629.64	30350
5	85	90	316	1655.84	30350
6	86	108	338	1771.12	30350
7	81	78	335	1755.4	30350
8	59	45	321	1682.04	30350
9	90		231	1210.44	
10	108		123	644.52	
11	78		45	235.8	
12	45		0		
Totals	967	632	3016	15803.84	242800
Ave demand	80.58334				
Total Cost	258603.8				

Cu Rod RM, Method: Economic order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
			335		
Initial Inv					
1	81	966	1220	6392.8	30350
2	99		1121	5874.04	
3	76		1045	5475.8	
4	79		966	5061.84	
5	85		881	4616.44	
6	86		795	4165.8	
7	81		714	3741.36	
8	59		655	3432.2	
9	90		565	2960.6	
10	108		457	2394.68	
11	78		379	1985.96	
12	45		334	1750.16	
Totals	967	966	9132	47851.68	30350
Ave demand	80.58334		EOQ	966	
Total Cost	78201.68				

Cu Rod RM, Method: Period Order Quantity
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
			335		
Initial Inv.					
1	81	632	886	4642.64	30350
2	99		787	4123.88	
3	76		711	3725.64	
4	79		632	3311.68	
5	85		547	2866.28	
6	86		461	2415.64	
7	81		380	1991.2	
8	59		321	1682.04	
9	90		231	1210.44	
10	108		123	644.52	
11	78		45	235.8	
12	45		0		
Totals	967	632	5124	26849.76	30350
Ave demand	80.58334		EOQ	966	
Total Cost	57199.76		POQ	12	

Cu Rod RM, Method: Part Period Balancing
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
			335		
Initial Inv					
1	81		254	1330.96	
2	99		155	812.2	
3	76		79	413.96	
4	79		0		
5	85	632	547	2866.28	30350
6	86		461	2415.64	
7	81		380	1991.2	
8	59		321	1682.04	
9	90		231	1210.44	
10	108		123	644.52	
11	78		45	235.8	
12	45		0		
Totals	967	632	2596	13603.04	30350
Ave demand	80.58334				
Total Cost	43953.04				

MATERIAL 11

Problem title:
Lot size determination of Nut Bolt

Period	Demand (Kg)	parameter	Value
1	352	Holding Cost	.01
2	846	Set up Cost	2750
3	388	Initial Inventory	352
4	434	Lead time	1
5	398		
6	188		
7	580		
8	352		
9	82		
10	164		
11	164		
12	458		

RESULT:
Nut bolt, Method: Wagner – Whitin
(Jan 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			352		
1	352		0		
2	846	4054	3208	32.08	2750
3	388		2820	28.2	
4	434		2386	23 86	
5	398		1988	19 88	
6	188		1800	18	
7	580		1220	12 2	
8	352		868	8 679999	
9	82		786	7.86	
10	164		622	6.22	
11	164		458	4.58	
12	458		0		
Totals	4406	4054	16156	161.56	2750
Ave demand	367 1667				
Total Cost	2911 56				

Nut Bolt, Method: Lot for lot
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			352		
1	352	846	846	8 46	2750
2	846	388	388	3 88	2750
3	388	434	434	4 34	2750
4	434	398	398	3 98	2750
5	398	188	188	1.88	2750
6	188	580	580	5 8	2750
7	580	352	352	3.52	2750
8	352	82	82	0 82	2750
9	82	164	164	1 64	2750
10	164	164	164	1 64	2750
11	164	458	458	4 58	2750
12	458		0		
Totals	4406	4054	4054	40 54	30250
Ave demand	367.1667				
Total Cost	30290 54				

Nut Bolt, Method: Economic order Quantity
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv			352		
1	352	14211	14211	142 11	2750
2	846		13365	133 65	
3	388		12977	129 77	
4	434		12543	125 43	
5	398		12145	121.45	
6	188		11957	119 57	
7	580		11377	113 77	
8	352		11025	110 25	
9	82		10943	109.43	
10	164		10779	107 79	
11	164		10615	106.15	
12	458		10157	101.57	
Totals	4406	14211	142094	1420.94	2750
Ave demand	367.1667		EOQ	14211	
Total Cost	4170.94				

Nut Bolt, Method, Period Order Quantity
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			352		
1	352	4054	4054	40 54	2750
2	846		3208	32.08	
3	388		2820	28.2	
4	434		2386	23 86	
5	398		1988	19.88	
6	188		1800	18	
7	580		1220	12 2	
8	352		868	8 679999	
9	82		786	7 86	
10	164		622	6 22	
11	164		458	4.58	
12	458		0		
Totals	4406	4054	20210	202.1	2750
Ave demand	367.1667		EOQ	14211	
Total Cost	2952 1		POQ	39	

Nut Bolt, Method, Part Period Balancing
(Oct 01 to Dec 01)

Period	Demand	Produce	Inventory	Holding Cost Tk	Set up Cost Tk
Initial Inv.			352		
1	352		0		
2	846	4054	3208	32 08	2750
3	388		2820	28 2	
4	434		2386	23 86	
5	398		1988	19 88	
6	188		1800	18	
7	580		1220	12 2	
8	352		868	8 679999	
9	82		786	7 86	
10	164		622	6 22	
11	164		458	4.58	
12	458		0		
Totals	4406	4054	16156	161.56	2750
Ave demand	367 1667				
Total Cost	2911.56				