DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

MRP-MRPII SYSTEMS AT PRODUCTION PLANNING AND CONTROL AND IMPLEMENTATIONS IN A PACKAGING COMPANY

by
Ayşegül BİLDİRİCİ

January, 2007
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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"MRP-MRPII SYSTEMS AT PRODUCTION PLANNING AND CONTROL AND IMPLEMENTATIONS IN A PACKAGING COMPANY"** completed by **AYŞEGÜL BİLDİRİCİ** under supervision of **PROF. DR. HASAN ESKİ** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

Good customer service begins with a high quality manufacturing process. Software that tracks the production system cycle enables management to control the product. One such software, Material Requirements Planning (MRP) provides complete scheduling capability of addressing a wide range of production scenarios. MRP became popular in the 1970s. It automated the production line. MRPII, the second generation, coordinates all the resources involved in making a product, including projected sales, personnel, plant capacity and distribution. MRPII offers management a tool that covers personnel, equipment, material, facilities and customer requirements. These entire features contribute to the success of manufacturing a high quality product.

In this study, firstly some general information about MRP and MRPII systems have been given, and then, in a packaging company (BARAN AMABALAJ A.Ş.), implementation steps and implementation results of MRPII software package MFG/PRO which is created by QAD, have been analyzed. Then material requirements plans for selected items are created by using data of a company.

Keywords: Material requirements planning (MRP), manufacturing resource planning (MRPII).

ÜRETİM PLANLAMA VE KONTROLÜNDE MRP-MRPII SİSTEMLERİ VE BİR AMBALAJ FİRMASINDAKİ UYGULAMALARI

ÖZ

İyi müşteri hizmeti, yüksek kaliteli üretim süreci ile başlar. Üretim sistemi döngüsünün izlenmesini sağlayan bilgisayar yazılımları, yönetime üretimi kontrol edebilme olanağı sağlar. Bu yazılımlardan bir tanesi olan malzeme ihtiyaç planlaması, birçok üretim çeşidine, eksiksiz bir programlama kapasitesine sahip olduğu için hitap eder. MRP 1970 lerde popular hale gelmiş ve üretim hattının otomasyonunu sağlamıştır. İkinci nesil olan MRPII, ürün yapımına dahil olan, satış, personel, fabrika kapasitesi ve dağıtım gibi tüm kaynakları koordine eder. MRPII yönetime; personeli, ekipmanları, malzemeleri ve müşteri ihtiyaçlarını gözetim altında tutma olanağı sağlar. Tüm bu özellikler, üretimin yüksek kaliteli ürün yapımında başarılı olmasına katkıda bulunur.

Bu çalışmada, MRP ve MRPII ile ilgili genel bilgiler verilmiş ve bir ambalaj firmasında (BARAN AMBALAJ A.Ş), QAD tarafında oluşturulan MRPII bilgisayar yazılımı MFG/PRO'nun uygulama aşamaları ve uygulama sonuçları analiz edilmiştir. Daha sonra firma verileri kullanılarak seçilen kalemler için malzeme ihtiyaç planları oluşturulmuştur.

Anahtar sözcükler: Malzeme ihtiyaç planlaması (MRP), üretim kaynakları planlaması (MRPII).

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CHAPTER ONE

INTRODUCTION TO REQUIREMENTS PLANNING

Nowadays, in business climate, it is important to keep a tight control over inventories, including raw materials, work in process (WIP), and finished goods inventories. The ability to control the levels of these various inventories is a function of the control exerted over the inputs that comprise those same inventories. Material requirements planning (MRP) is a system that attempts to reign in material needs. MRP has evolved as a set of logical planning techniques which better enables management to operate in a manufacturing environment.

It is a network scheduling concept which integrates company-wide information to plan the activities of the manufacturing function. The four relevant questions that are at the heart of MRP are: 1) What are we going to make? ; 2) What does it take to make it? ; 3) What have we got? ; 4) What do we have to get? This information allows the derivation of the fundamental shortage equation. This is the basics of MRP. MRP offered management the capability to identify the products that were actually going to be produced. These items came from the production plan which is an extension of the material requirements plan. The material requirements plan in turn identifies what the designated work centers and the factory floor, including vendor, requirements are going to be over a designated period of time. The material requirements plan is a sophisticated computer generated calculation quantifying procurements and production requirements from the relationships of the above four reference questions. Specifically these inter-relationships are generated from the master production schedule, the inventory records and the bill of material (Wong & Kleiner, 2001).

It is a technique that is based around the concept of dependent demand. The concept of dependent demand states that the demand for one item is dependent on the demand for another item. These items are complimentary and one may require the other in order to function. When the demand is dependent, it is then possible to

forecast the demand for the product and the quantities of materials needed to produce the final product. All components and subassembly requirements can be determined once dependency is established.

Material Requirements Planning (MRP) has been the most widely implemented large scale production management system since the early 1970s, with several thousands MRP type systems implemented in industry around the world. Manufacturing companies use large amounts of data, including information about parts, vendors, orders, costs, and schedules. To remain competitive, manufacturers must have accurate, current information to inventory levels, work-in process (WIP), and order due dates, vendor delivery schedules and all of the other information necessary to calculate the production cost (Tomas, 1990).

The computer has simply allowed all these clerical data processing activities and file handling tasks to be accomplished more efficiently. As computer technology has rapidly developed, companies have struggled to find efficient, effective, and cheaper ways to satisfy their needs by using computers. Companies would like to handle the problems of production and operations management by using computer hardware and software. For this purpose, many management philosophies and production technologies have been developed, among these JIT (just in time production), MRP (Material Requirements Planning), and MRPII (Manufacturing Resource Planning) may be cited. Manufacturing resource planning (MRPII) extends the use of MRP to strategic business planning. MRPII helps to coordinate manufacturing, finance, and marketing functions so that strategic business goals can be achieved.

In this thesis, in the first chapter, some basic information has been given related with its content. The second chapter gives basic information about the Material Requirements Planning System, its objectives, benefits and failures. Lot sizing Policies are discussed in the third chapter. Three of these techniques have been applied in the company in order to reduce purchasing costs. The fourth chapter discusses the Manufacturing Resource Planning System. Other manufacturing techniques DRP, ERP and JIT systems are discussed in the fifth chapter. Although

the focus of the study was on MRPII softwares, in the fifth chapter the latest advances have been noted and information about new production planning and control systems have been given. In the sixth chapter, the problems that led the application company to buy new MRPII software, the suggestions for a healthy implementation and the results obtained with implementation have been evaluated. How the investment decision to discard the existing hardware and software systems and to renew all systems was made, what kind of problems in the system had been identified before the installation of new software and what sort of solutions had been proposed, the corrective and precautionary measures taken have all been explained. Finally, whether or not the benefits expected from the MRP system had been realized was discussed. In the implementation section, the results achieved with the new purchasing process which employs scientific methods owing to the implementation of the new software have been analyzed. For our application study, a company producing packaging product has been used and by applying a number of techniques, to a chosen product and its components, to determine the lot size, a material requirement plan has been formed. By comparing different lot size techniques, cost wise, the most suitable technique has been determined.

1.1 History of Requirements Planning

MRP originated in the early 1960s in the USA as a computerized approach for the planning of materials acquisition and production .The definite textbook on the technique is by Orlicky (1975). The technique had undoubtedly been manually practiced in aggregate form prior to the World War II in several locations in Europe. However, what Orlickly realized was that a computer enabled the detailed application of the technique, which would make it effective in managing manufacturing inventories (Aghazadeh, 2003).

These early computerized application of MRP were built around a Bill of Material Processor (BOMP) , which converted a discrete plan of production for a parent item into a discrete plan of production or purchasing for component items. This was accomplished by exploding the requirements for the top-level product, through the

bill of material (BOM), to generate component demand. The projected gross demand was then compared with available inventory and open orders over the planning time horizon and at each level in the BOM. These systems were implemented on large mainframe computers and run in centralized material departments for large companies.

As time passed, the installation of the technique became more widespread and various operational functions were added to extend the range of tasks that these software systems supported. In particular, these extensions included Master Production Scheduling (MPS), production activity control (PAC), Rough Cut Capacity Planning (RCCP), Capacity Requirements Planning (CRP), and purchasing.

The combination module of the planning (MPS, MRP, and CRP) and execution modules (PAC and Purchasing) with the potential for feedback form execution cycle to the planning cycle was termed CLOSED LOOP MRP. With the addition of certain financial modules , as well as the extension of master production scheduling to deal with full range of tasks in master planning and the support of business planning in financial terms, it was realized the resultant system offered an integrated approach to the management of the manufacturing resources. This extended MRP was labeled Manufacturing Resource Planning or MRPII. Since 1980, the number of the MRP installations has continued to increase as MRP applications became available at lower cost mini-computers and micro-computers (Aghazadeh, 2003).

One of the significant reasons of MRP was adopted as readily as the production management technique was that it made use of the computer's ability to store centrally and provide access to run a company. It helped to coordinate the activities of various functions in the manufacturing firm such as engineering, production and materials. Thus the attraction of MRP II lay not only in its role as decision making support, but more importantly, in its integrative role within the manufacturing organization.

1.2 The Attributes of MRP

Prior the widespread use of MRP, the planning of manufacturing inventory and production was generally handled through the inventory control approaches, for example (Ghobbar & Friend, 2003):

(1) The two bin policy under which inventory availability is continuously reviewed and predetermined quantity (fixed batch size) of items is ordered each time stocks fall below a predetermined level (reorder point).
(2) The periodic order cycle policy under which inventory is reviewed on a fixed periodic basis and sufficient items (a variable quantity) are ordered to bring the stock level up to a predefined level (target inventory).

The implicit assumptions of these inventory control approaches are that the replenishment of inventory items can be planned independently of each other. The planning philosophy is that the inventory availability of each component should be maintained.

MRP is to be seen as a priority planning system in that it determines requirements, but it does not acknowledge all constraints that exist in the planning problem, particularly capacity. In the case of material constraints it points out the constraint violation but leaves the replanning to the user. In this way, MRP tells the users what must be done in order to meet the master schedule, as opposed to what can be done.

The starting point for MRP thus is the recognition that products to be manufactured or assembled can be represented by a bill of material (BOM). A bill of material describes the parent/child relationship between an assembly and its component parts or raw materials.

The bills of material may have an arbitrary number of levels and will typically have purchased items at the bottom level of each branch in the hierarchy. An implicit assumption is that there is an adequate part numbering system in the company to differentiate all parts components at various stages of manufacturing where planning intervention may be required. The MRP system is based very simple on the fact that the BOM relationship allows one to derive the demand for component material based on the demand for the parent item. MRP was thus proposed a technique for managing dependent component demand by transmitting the independent demand for top level products and spares through the component hierarchy, as presented by the BOM.

MRP system is driven by the Master Production Schedule, which records the independent demand for top level items. It is derived from evaluating forecasts, customer orders, and distribution center requirements. MRP uses this requirements information, together with information on product structure from the bill of materials file, current inventory status from the inventory file and component lead times data from the item master file. MRP produces a time-phased schedule of planned order releases on lower level items for purchasing and manufacturing. This time-phased schedule is known as the materials requirements plan. This flow of information is illustrated in Figure (1.1) (Tomas, 1990).

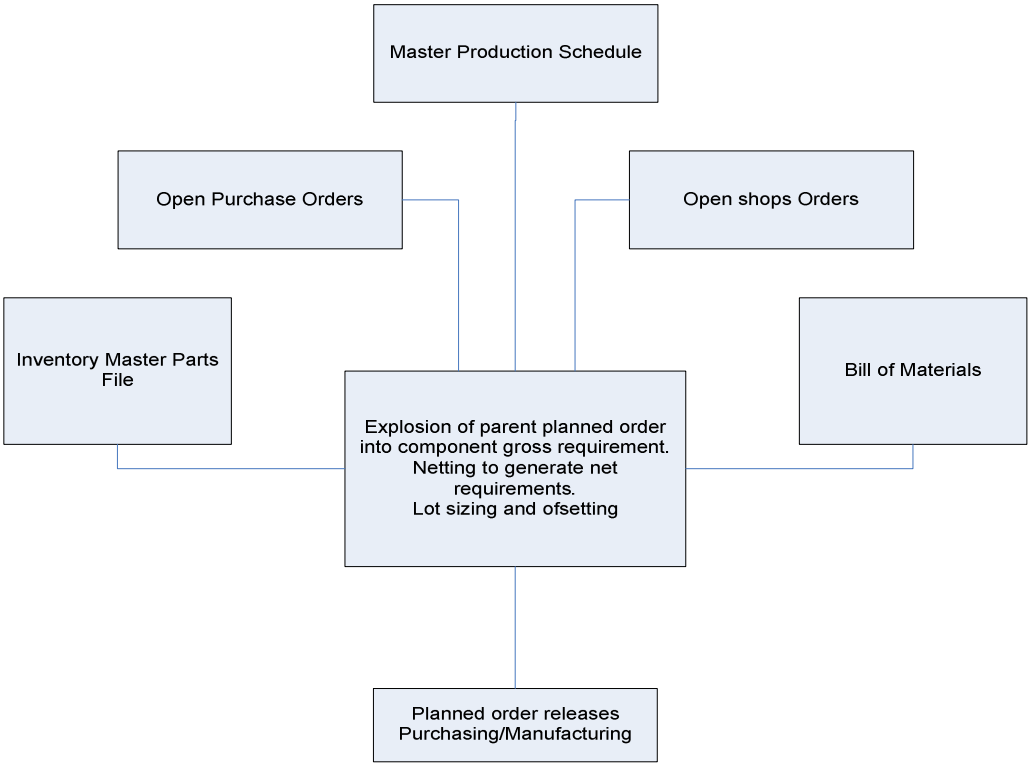

Figure 1.1 Basic structure of MRP system

So, some of the main characteristics of MRP include:

(1) MRP is product oriented in that it operates on a BOM to calculate the component and assembly requirements to manufacture and assemble final product.
(2) MRP is future oriented in that it uses planning information from the master production schedule to calculate the future component requirements instead of forecasts based on historical data.
(3) MRP involves time phased requirements in that during MRP processing; the requirements for individual are calculated and offset by their expected lead time to determine the correct requirement date.
(4) MRP involves priority planning in that it establishes what needs to be done to meet the master schedule, as opposed to what can be done, given capacity and material constraints.

(5) MRP promotes control by focusing on orders, whether purchase orders or orders for manufacturing plant.

1.3 How Does MRP Work?

In MRP, time is assumed to be discrete. Time is typically represented as a series of one week intervals, though system which operate on daily planning periods are readily be available. Demand for a component can derive from any of the products in which it is used, as well as independent spares parts orders.

A materials requirement planning system starts with the master production schedule of net requirements (and planned coverage of such requirements) for each component needed to implement the master production schedule. The system works down the BOM, level by level and component by component, until all parts are planned. It applies the following procedure for each component:

(1) Netting of the gross requirement against projected inventory and taking into account any open orders scheduled for receipt, as well as material already allocated from current inventory, thus yielding net requirements.

Net requirements=Gross Requirements+Allocations-Projected Inventory–Scheduled Receipts

(2) Conversion of the net requirements to a planned order quantity using a lot size.
(3) Placing a planned order in the appropriate period by backward scheduling from the required date by the lead time to fulfill the order for that component.
(4) Generating appropriate action and exception messages to guide the users' attention.
(5) Explosion of parent item planned production to gross requirements for all components, using the bill of materials relationships.

As it apparent, the prerequisites to operate an MRP system include:

(1) A master production schedule must exist. This master production schedule is a clear statement of the requirements in terms of quantities and due dates for top level items.
(2) For every parent item there must be a corresponding bill of materials, which gives an accurate and complete statement of the structure of that item.
(3) For every planned part there must be a set of inventory status information available. Inventory status is a statement of physical stock on hand, material allocated to release orders but not yet drawn from physical stock and scheduled receipts for the item in question.
(4) For each planned part, either purchased or manufactured, a planning lead time must be set.

This chapter is dedicated to the MRP which is the key to successful operations management in a manufacturing company. History of MRP, the attributes of MRP and working procedures of MRP are described.

In chapter second, objectives, benefits and failures, elements, inputs and outputs of MRP systems are described.

CHAPTER TWO

THE MATERIAL REQUIREMENTS PLANNING SYSTEM

2.1 General Overview of MRP

Material requirements planning (MRP) systems help manufacturers determine precisely when and how much material to purchase and process based upon a time-phased analysis of sales orders, production orders, current inventory, and forecasts. They ensure that firms will always have sufficient inventory to meet production demands, but not more than necessary at any given time. MRP will even schedule purchase orders and/or production orders for just-in-time receipt.

MRP modules take the guesswork out of purchasing by automatically calculating material requirements, and coordinating purchase orders and production orders for timely receipt. Unrealistic manufacturing plans can be easily identified, which may arise when there is not enough time to manufacture an intermediate for a target production date, or if a vendor is unlikely to deliver materials by the time they are required.

Since MRP determines requirements based upon master production schedule (MPS), the modules offer several ways to help keep schedule current. For instance, production orders may be scheduled based upon current customer orders and/or inventory levels, thus accommodating both “make to order “and “make to stock” procedures. The MPS can also include product forecasts, which may be calculated automatically using data from sales or production history (Lunn, 1994).

Despite its simplicity, MRP systems hold great potential for making significant contributions in the quest for productivity that would allow small firms to compete in an international marketplace. However, in their zeal to quickly correct several decades of poor manufacturing practices, many small companies rushed to introduce MRP which they viewed to be a magical and simplistic method of doing business. In this context, manufacturers may have overlooked a very important aspect of MRP

systems: implementation. Despite the growth in MRP systems sales worldwide, their implementation is, in fact, often a cumbersome process (Manthou, 1996; Ritter, 1992). There are still many problems involved with the effective running of MRP/MRPII (Smith, 1993; Turnipseed et, 1992) and a general lack of confidence in the system is frequently reported (Clode, 1993). Without software adoption the considerable resources invested in MRP will be at best under-utilized and at worst wasted. Therefore, the research seeks to provide an understanding of the adoption process by predicting what stage small and medium-sized firms are most likely to go through before they are ready for MRP adoption. Equipped with the knowledge, managers can employ the necessary strategies to move their organization efficiently through the adoption process so that funds and other valuable resources will not be lost.

2.2 Objectives, Benefits and Failures of MRP

MRP systems are intended to provide the followings (Petroni, 2002):

(1) Better ability to meet volume/product changes,
(2) Better capacity planning,
(3) Better cost estimation,
(4) Better inventory control,
(5) Better meeting of delivery promises,
(6) Better product customization,
(7) Better production scheduling,
(8) Higher inventory rotation,
(9) Improved cooperation between managers and employees,
(10) Improved coordination with finance,
(11) Improved coordination with marketing and sales departments,
(12) Improved employee job satisfaction,
(13) Improved employee morale,
(14) Improved personnel ability to perform own job,
(15) Improved product quality,
(16) Improved productivity,

(17) Increased information on which to base decisions since MRP has been implemented,
(18) Increased throughput,
(19) Reduced “expediting” costs,
(20) Reduced costs (materials),
(21) Reduced delivery lead times,
(22)Reduced informal systems for materials management/inventory/production control,
(23) Reduced inventory costs. (Supervising and controlling),
(24) Reduced lead times,
(25) Reduced manpower costs,
(26) Reduced overtime,
(27) Reduced safety stock,
(28) Reduced work in progress (WIP),
(29) Scrap reduction.

MRP accomplishes these objectives;

(1) MRP determines how many of materials are needed and when the master schedule is met. It enables the manager to supply that material as it is needed. Therefore, cost of continuously carrying it and excessive safety stocks in inventory can be avoided.

(2) The right materials are delivered to production at the right time since MRP controls the quantity and timing of deliveries of raw materials, parts, and intermediate products to production operations. Delays in production are avoided by successful coordination of inventories, procurement, and production decisions.

(3) Realistic delivery promises can enhance customer satisfaction. The MRP system contains the bill of materials, inventory status, lead time (production and procurement) information, and a schedule of the existing production load. Potential customer orders can be added to the system to show the manager

how the revised total load can be handled with existing capacity. The result can be a more realistic delivery date.

(4) MRP provides close coordination among various work centers. Therefore, production can proceed with fewer indirect personnel, and with fewer unplanned production interrupts because MRP focuses on having all materials available at scheduled times.

MRP systems are based on the philosophy that each raw material, part and subassembly needed in production should arrive simultaneously at the right time to produce the end items in the MPS.

MRP system requires an accurate inventory, a realistic master production schedule (MPS), accurate product buildup information, and a certain discipline, to provide all benefits specified above.

Summarily, the managerial objective in using material requirements planning is to avoid inventory stock outs, in order to provide smoothly running production according to the plans; to reduce investment in raw materials and work in process inventories; and to improve customer service (Acar, 1999).

The difficulties encountered by firms in the implementation process of MRP may be traced back to a number of factors:

The first is the complexity of MRP systems, which, of course, is a relative concept varying according to the level of knowledge and experience available inside the firm prior to implementation (Wilson, 1994; Luscombe, 1994). There are usually several parameters to be initiated when implementing standard Software (Bancroft, 1997).

Second, a considerable amount of intensive training is required. In fact, even though end-users are usually trained on a limited amount of functionality, key users need to acquire considerable technical competence.

In general terms, many re-implementations of MRP systems are the result of a failure to implement business changes along with the software. One of the principal reasons why MRP and other large technologically sophisticated systems fail is that organizations simply under-estimate the extent to which they have to change in order to accommodate their purchase. The effective management of technological change requires transformational leadership (Brown, 1994).

Thus, a critical factor making implementation a hard task is that the implementation of MRP packages is often combined with the restructuring of business processes. It is a feature common to large as well as smaller firms that the adoption of advanced logistics techniques is coupled with an increased integration of different functional areas and organizational units according units according to the firm's work flows.

One of the issues largely felt as critical concerns the resistance of managers and personnel to the organizational change that is induced by the adoption of new technologies. To this regard, several authors have underlined the importance of a sound involvement of shop-floor workers (Sommer, 1998; Weill, 1991).Going from a basic to a more modern system is fraught with the initial danger that people will not understand the capabilities and will simply map the same processes onto the new system.

Valuable relevance has also been placed in the referring literature to technological problems, such as the unsuitability of MRP systems to optimize the internal workflow. In fact, frequent changes in schedules, a problem referred to as production nervousness, is an obstacle to successful implementation of MRP systems (Duchessi, 1988).

Summarizing, MRP systems must be implemented as a total system and implementation of any part of it without the rest will not be successful. A piecemeal approach can create "islands" of MRP but can fall short of achieving the company-wide improvements that increase the firm's competitiveness. This implies that there are critical factors of MRP implementation that cannot be overlooked without resulting in MRP failure. Obviously, implementation can be hindered when a firm is not quite sure exactly what it is trying to implement (Petroni, A. 2002).

2.3 Dependent Demand Inventory systems

In this part, the emphasis is on the managing of the dependent demand items. Dependent demand inventories consist of items whose demand depends on the demands for other items also held in inventory.

Typically, the demand for raw materials and components can be calculated if we can estimate the demand for the finished goods that these materials go into. Order quantity and order point decisions for dependent demand inventories are different from those of independent demand inventories (Gaither, 1994, p.397).

Independent demand inventory systems keep items on hand almost constantly because demand may occur at any time. On the other hand, in dependent demand inventory systems, the company schedules what to be produced and when, therefore, company controls when dependent components will be needed. It is possible to schedule backward from the date at which the assembly will be completed. It is less expensive to have these items available only when they are needed.

Materials Requirements planning (MRP) is used to perform these calculations, to schedule purchases of components, or to schedule production operations.

2.4 Elements of MRP

Material Requirements planning is a production inventory system that requires both production and inventory information in order to produce its output. Figure (2.1) illustrates the flows of information within an MRP system.

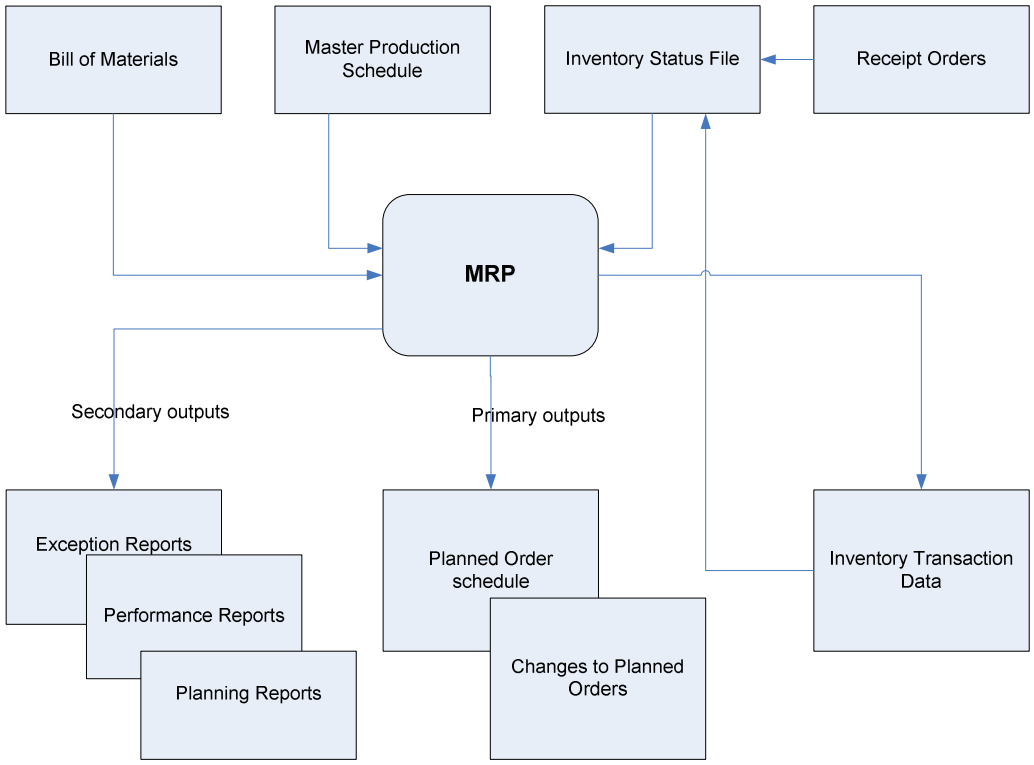

Figure 2.1 MRP systems (Gaither, 1994, p.457)

2.4.1 MRP Inputs

The primary inputs of the MRP are;

(1) Master Production Schedule,
(2) Bill of Materials File,
(3) Inventory Master File,
(4) Orders for components originating from sources external to the plant using the system,

(5) Forecasts for item subject to the independent demand.

MRP uses this information to determine time phased gross and net requirements for manufacturing inventory. The master production schedule (MPS) identifies how many of each end product (item) is needed during the time periods in the planning horizon. The bill of materials (BOM) identifies a list of the materials and their quantities required to produce one unit of a product or end item. The third source of information, the inventory status file, contains the current availabilities of every item controlled by MRP (quantity on hand, safety stock level, and quantity allocated to various job orders).

2.4.1.1 Master Production Schedule

The MASTER PRODUCTION SCHEDULE expresses the overall plan of production. It is stated in terms of end items, which may be either (shippable) products or highest-level assemblies from which these products are eventually built in various configurations, according to a final assembly schedule. The span of time the MPS covers, termed the planning horizon, is related to the cumulative procurement and manufacturing lead times for components of the products in question. The planning horizon normally equals or exceeds this cumulative lead time.

The MPS serves as the main input to the MRP system, in the sense that the essential purpose of this system is to translate the schedule into individual component requirements and other inputs merely supply reference data that are required to achieve this end. In concept, the MPS defines the entire manufacturing program of a plant and therefore contains not only the products the plants will produce, but also orders for components that originate from sources external to the plant, as well as forecasts for items subject to independent demand. In practice, however, such orders and forecasts are normally not incorporated into the MPS document, but are fed directly to the MRP system as separate inputs. It is a time phased production plan that indicates when and in what quantity final products are produced to meet the customer orders. If actual orders exceed the forecast level of

sales, deliveries of these orders must be delayed or capacity adjustments must be made such as subcontracting, and working overtime. Materials ordered for future delivery may be pulled in earlier to supply these production needs.

MRP can not distinguish feasible and infeasible master production schedule. MRP requires a realistic MPS to obtain useful results. In short, MRP assumes that the MPS can be produced within the production capacity constraints. MRP explodes the master schedule into material requirements. If these requirements can not be met by the materials available from inventory, or from materials on order, or if insufficient time is available for new orders, then the MPS will need to be modified to a new MPS.

2.4.1.2 Bill of Materials (BOM)

THE BILL OF MATERIAL FILE, also known as the product structure file, contains information on the relationship of components and assemblies, which are essential to the correct development of gross and net requirements. The bill of material plays a passive role in the requirements computation process. In this process, the function of the bill of material is akin to that of a city directory which the MRP program consults when it needs to "visit" the inventory records to the components of an assembly. All assembled items carry the storage addresses (called pointers) of the respective bills of material in their inventory records. The inventory file and the bill of material file are thus cross-referenced or chained for purposes of requirements computation. The bill of materials file indicates all the raw materials, components, and subassemblies required to produce an item. The MRP computer system accesses the Bill of Materials File to determine exactly what items, and in what quantities, is required to complete an order for a given item.

Accuracy of the bills of materials file that also called the product structure file is a major problem in a firm. The bill of materials file must be structured to reflect the sequence of steps necessary to produce the product, accurately.

The MRP processing logic is applied first to the high level items (end products) in the product structure, and then it proceeds to the next lower items. It continues downward, until it has determined the all requirements for all items in the product structure that will be needed to meet the master production schedule. Required quantities and the lead times for each item are determined at each level.

2.4.1.3 Inventory Status File

Inventory status file that also called inventory master file contains detailed information regarding the number or quantity of each item on hand, on order, and allocated to use in various time periods.

The job of the inventory master file is to keep data for the projected use, receipts of each material, and to determine the amount of inventory that will be available in each time period. The MRP program accesses the inventory status file to determine the quantity available for use. If enough quantities are available for order needs, program allocates the quantities for use during the time period by updating the inventory record. If sufficient materials are not available system reports these items on the planned order release report, recommends that the item to be ordered.

Items that are not available for use, are reported in planned order report according to their lot sizes, lead times, safety stock levels, and scrap rates information in inventory status file.

2.4.1.4 Orders for Components Originating from Sources External to the Plant Using the System

Externally originating orders for components include service-part orders, inter-plant orders, original equipment manufacturer orders by other manufacturers who use these components in their products, and any other special purpose orders not related to the regular production plan. Components may be ordered for purposes of experimentation, destructive testing, promotion, equipment maintenance, etc. The

MRP system treats order of this category as additions to the gross requirements for the respective component items.

2.4.1.5 Forecasts for Item Subject to the Independent Demand

Forecasts of independent demand for component items subject to this type of demand can be made outside of the MRP system, or the system can be programmed to perform this function, by means of applying some statistical forecasting technique. The forecast quantities are treated as item gross requirements by the MRP systems. Items subject only to independent demand (such as service parts no longer used in regular production) should be under "time phased order point" control. Items subject both dependent and independent demands have the forecast quantities simply added to the (computed) gross requirements (Braglia, 1999).

2.4.2 MRP Outputs

The material requirements planning system, properly designed and used, can provide a number of desirable outputs containing valid and timely information. The primary outputs of an MRP system are the following:

(1) Order-release notices, calling for the placement of planned orders,
(2) Rescheduling notices, calling for changes in open-order due dates,
(3) Cancellation notices, calling for the cancellation or suspension of open orders,
(4) Item status analysis of backup data,
(5) Planned orders scheduled for release for the future.

Secondary or byproduct outputs come in a great variety and are being generated by the MRP system at the user's option. These outputs are the following:

(1) Exception notices reporting errors, incongruities, and out-of-bounds situations,
(2) Inventory level projections (inventory forecasts),

(3) Purchase commitment reports,

(4) Traces to demand sources,

(5) Performance reports.

All MRP system outputs are produced by processing inputs (relating data) from the sources, illustrated in Figure (2.1).

2.5 MRP Computations

MRP processing begins from the end products which have the planning level codes equal to zero, then it proceeds to the lower items which have the level codes greater then zero.

2.5.1 Gross and Net Requirements

The gross requirement for an inventory item equals the quantity of demand for that item. Its net requirement is arrived at by allocating the available inventory on hand and on order to (subtracting from) the gross requirement.

Demands of end products are determined for each time period by using Master Production Schedule. Master Production Schedule is exploded into gross requirements for all materials, for each time period by using the bill of material files. Then, the gross requirements for each item are subtracted from on hand inventory to determine the net requirements by using the inventory status file. The net requirements of each material for each time period are computed as follows;

Net requirements = Gross requirements- (inventory on hand- Safety stock- Inventory allocated to other uses)

When the net requirements become positive, orders for the item must be placed.

2.5.2 Lead Times

Planned or normal, lead times must be used by the MRP system for purposes of planning, but their “accuracy” is not crucial. These lead times are, after all, used

merely to determine order release dates, which are considerably less important than the completion dates related to actual lead times. The lead time of a manufacture item is made up of a number of elements, listed here in descending order of significance:

(1) Queue (waiting to be worked on) time,

(2) Running (machining, fabrication, assembly, etc) time,

(3) Set up time,

(4) Waiting (for transportation) time,

(5) Inspection time,

(6) Move time,

(7) Other elements.

In a general machine shop environment, the first of the elements listed normally accounts for roughly 90 percent of average total elapsed time. In an individual case, the queue time is a function of a job's relative priority, as it finds itself in contention for a given productive facility with other jobs. The queue time, the actual lead time of the respective order, will increase or decrease as its priority is changed (Lunn, 1994).

Lead times of the individual inventory items are a complicating factor in the computation of material requirements. The preceding example of the net requirements for material A, B, C, etc., was oversimplified in ignoring, among other things, item lead times. It is these lead times that will determine the timing of releases and scheduled completions for the others in questions. Because a component item order musts be completed before the parent item order that will consume it an be started, the back-to-back lead times of the four items in the example make up the cumulative lead time, a sort of critical path that determines the earliest time that the end products could be built, or, given the end product scheduled date, the latest time for the start of the lowest-level item order.

If the manufacturing lead times for the four items in the example were: Material D (3 weeks) + Material C (6 weeks) + Material B (2 weeks) + Material A (1 weeks) = 12 weeks (cumulative lead times) and assembly of the end product were scheduled for a date arbitrarily designed as week 50, component-order release dates and completion dates could be calculated by successively subtracting the lead time values from 50.

Complete order for item A: week 50
Minus lead time of item A: 1

Release order for item A : 49

Complete order for item B: week 49
Minus lead time of item B: 2

Release order for item B : 47

Complete order for item C: week 47
Minus lead time of item C: 6

Release order for item C : 41

Complete order for item D: week 41
Minus lead time of item D: 3

Release order for item D : 38

Table 2.1 Inventory condition and order plan for x part (Lead time: 2 weeks)

X part	weeks										
	13	14	15	16	17	18	19	20	21	22	23
Gross requirements			140			150				250	
Inventory on hand	40	40	40								
Net requirements			100			150				250	
Planning received											
Planning order	100			150				250			

2.5.3 Safety Stock

Safety stocks are a quantity of stock planned to be maintained in inventory, to protect against unexpected fluctuations in demand and/or supply. In this sense, safety stocks can be considered as a type of insurance policy to cover unexpected events, whether such events are the failure of a vendor to meet a promised delivery date or an unexpected increase in demand for the product. However, given the high cost of tying up capital in inventory, the use of safety stocks can be expensive.

Safety stocks can be incorporated into the MRP analysis. In the master parts database there is normally a field within each record which can indicate the safety stock of each part.

It is clear that if we insert a safety stock requirement for high level item then we will automatically generate additional requirements for lower level dependent items. This distortion of demand may more than outweigh the benefit of safety stocks.

Besides the inventory cost, safety stocks have an additional disadvantage in the case of dependent demand items, since their use tends to cover up and make it easy to live with problem. The safety stocks may encourage the ongoing acceptance of a poor quality manufacturing process or poor delivery service by a supplier. As such, no one will be motivated to eliminate the problem.

On the other hand, safety lead time can also be used in these situations. In this case, the item is put into production in advance of actual requirements. This would result in much higher inventory holding cost, and excess inventory will have to be carried although it seems to be not needed. Therefore, the lead time should be determined by balancing the cost of holding and cost of stock out, but the proper solution is to reduce the variability in lead times by proper scheduling and coordinated production control system so that safety lead times and safety stocks can be kept at a minimum.

An open area of manufacturing research concerns the use of safety stocks for long lead time items. This can have the effect of improving a firm's ability to react quickly to unexpected demand. It is a matter of debate as to whether this is better handled by a floating MPS hedge or by using safety stock on a few key long lead time items (Tang & Grubbstrom, 2002).

2.5.4 Computation of Gross Requirements

Change is continuous within the manufacturing environment. The master schedule changes. The inventory status changes. Engineering activity modifies bill of materials. Orders are released to the shop floor or purchasing. Orders are completed. Some of these events are planned. Some are unplanned. For example, if an order is completed on time then this is a planned event. In this case the original material plan should still be valid. If, however, an order is completed ahead of time or is late, then this usually means that the material plan is no longer valid. In either case, the MRP system must accommodate such changes. There two basic approaches to re planning within MRP systems. These are top-down planning and bottom-up re planning.

2.5.4.1 Top-down Planning with MRP

There are four important aspects of top-down planning:

(1) Regenerative planning and net change:

There are two basic styles to top-down planning. These are termed the regenerative approach and the net change approach. These involve alternative approaches to the system-driven recalculating of an existing material plan based on changes in the input to the plan.

Regenerative MRP starts with the master production schedule and totally re-explodes it down through all the bill of materials to generate valid priorities. Net requirements and planned orders are completely regenerated at that time. The regenerative approach thus involves a complete re-analysis of each and every item identified in the master schedule, the explosion of all relevant BOM's and the calculation of gross and net requirements for planned items. The entire process is

carried out in a batch processing mode on the computer and for all but the simplest of master schedules, involves extensive data processing. Because of this, regenerative systems are typically operated in weekly and occasionally monthly replanning cycles.

In the net change MRP approach, the materials requirements plan is continuously stored in the computer. Whenever there is an unplanned event, such as a new order in the master schedule, an order being completed late, or early, scrap or loss of inventory or reengineering changes to the BOM's , a partial explosion is initiated only for those parts affected by the change. If an event is planned, for example an order is completed on time, and then the original material plan should still be valid. The system is updated to reflect the new status but replanning is not initiated. Net change MRP can operate in two ways. One mode is to have on-line net change system by which the system reacts instantaneously to unplanned changes as they occur. In most cases, however, change transactions are batched (typically by day) and replanning happens over night.

In the regenerative approach there is vulnerability because of the need to maintain the validity of the requirements plan between systems driven replanning runs. The MRP system also supports transactions that modify the status of the various planning inputs, such as inventory status, the MPS or the BOM's. However, in a regenerative system, these changes are only reflected in a new requirements plan after a new planning run. Net change systems typically operate with many frequent partial replanning runs and as a result are not subject to the same degree of vulnerability in plan validity between runs.

Both regenerative and net changes have advantages and disadvantages. Regenerative is simpler. It is generally thought to require less computer processing, although this would have to be examined for a particular case. By generating a new plan, it purges errors which may have accumulated in prior plans. The major disadvantage is that the MRP is increasingly out of date as time passes between regeneration's.

The principal advantage of net change is that the MRP is kept up to date on a continuous basis, or at least daily. Also the computer processing can be spread out over the week rather than require a long weekly run. A disadvantage is that net change is believed to require more computer processing. Also, the system may be "nervous"-making many changes, sometimes to schedules that were changed only yesterday.

Many software packages include both regeneration and net change. It is quite common for companies to operate a hybrid system using net change for continuous updating but regenerating every few months in order to purge accumulated errors.

As regeneration is the simpler system, it is often recommended that a company new to MRP start off with regeneration and master that before going to net change in perhaps one or two years.

"For companies with simple product lines, long production runs or long lead times, low scrap rates, and relatively stable market conditions, regenerations may prove quite satisfactory. But for other companies making short runs of many complex products and serving a more volatile market, net change is a necessity for MRP to be successful" (Smith,1993, p.271).

(2) The frequency of top-down planning:

As we have seen, regenerative systems are typically replanned on a weekly or monthly basis. Net change systems support more frequent replanning, either on-line or batched in daily or weekly increments. There is a tradeoff between data processing costs and the maintenance of valid priorities on manufacturing and purchase orders. The consensus view seems to be that the replanning cycle should be no longer than a week.

(3) The use of low-level coding:

Low level codes determine the sequence in which the processing of part requirements is carried out. Components may be common to many bills of materials.

In regenerative systems, if MRP processing were simply to follow a path through the bill of material hierarchies in its replanning, I would, as a result, replan common components several times over. Low level coding is a data processing mechanism which serves to overcome this inefficiency. The procedure is to assign to each component a code which designates the lowest level in any bill of material on which it is found. MRP processing then can proceed level by level and a component will not be planned until the level currently being processed is that of its low level code. Low level codes are also useful in net change systems when the systems are operated on a batch basis.

(4) Rescheduling in top-down planning:

When an MRP system is replanning in a top-down fashion, it typically will adjust either the due date or the quantity of any planned order. If it identifies the need to make a change to an open order, it typically sends an exception message for the materials planner to execute the change.

We may need to reschedule existing planned orders because of modifications to the master schedule, or because of failure of a vendor or shop to deliver in the planned lead time or, indeed, any unplanned event. Rescheduling may involve the retiming of a planned order or it may require the modification of the order size or perhaps both.

2.5.4.2 Bottom-up Planning

As pointed out earlier, an MRP system must react to change. In top-down planning, the system itself does the planning. An alternative is for the planner to manage the replanning process. This is termed bottom-up replanning and makes use of two tools- the pegged requirements report and the firm planned order both of which are described in this section.

Pegging allows the user to identify the sources of demand for a particular component’s gross requirements. These gross requirements typically originate either

from its parent assemblies or from independent demand in the MPS; or from the demand for spare parts.

A report allows the materials planner to retrace the steps of the MRP analysis and to understand the sources of the total gross requirements for the item in question. The procedure of the identifying each gross requirement with its source at the next immediate higher level in the BOM is termed single level pegging. Through a series of single level pegging reports, we can eventually trace a set of requirements back to their sources in the master schedule.

An alternative facility is full pegging where each individual requirement for a planned item is identified against a master production scheduled item and/or a customer order. This, however, is quite rare in practice for a number of reasons. Requirements tend to arise from a number of sources in the master schedule. If a lot sizing technique is used, it becomes practically impossible to associate individual batches or lots with stocks, shrinkage and scrap allowances, further complicate the situation. As a result, the single level pegging facility is standards practice and full pegging is rarely used.

The technique of pegging is useful in that allows the user to retrace the MRP systems planning steps in the event of an unexpected event, such as a supplier being unable to deliver in the planning lead time. By retracing the original calculations the user can detect what orders are likely to be affected and perhaps identify appropriate remedial action. The remedial action often involves overriding the planning procedures of MRP. This is done by using the firm planned order technique.

The firm planned order allows the materials planner to force the MRP system to plan in a particular way, thus overriding lot size or lead time rules. A firm planned order differs from an ordinary planned order in the MRP explosion procedure will not change it in any way. This technique can aid planners working with MRP systems to respond to specific material and capacity problems.

The firm planned order can also override lot sizing rules. The availability of pegging facility, combined with the use of the firm planned orders, are the planner's chief tools in handling inevitable, unforeseen events in manufacturing.

2.5.4.3 Time Representation

In this section bucket and bucketless MRP systems will be discussed. Bucketed systems limit the time horizon that may be considered and the granularity of timing that may be ascribed to an order. Bucketless system enable daily visibility to an order's, are the planner's chief tools in handling inevitable, unforeseen events in manufacturing.

The data structure used to represent time in an MRP system can be bucketed or non- bucketed.

In the bucketed approach, a predetermined number of data cells are reserved to accumulate quantity by period. This is illustrated by the matrix structure used in our calculations of requirements. These data cells are known as time buckets. A weekly time bucket contains all of the relevant planning data for an entire week. Since the number of buckets is predetermined, this means that there is a bound on the planning horizon, depending on what time divisions the buckets represent.

Weekly time buckets are considered to be the granularity necessary for near and medium term planning by MRP, whereas monthly buckets are considered too coarse. However, the normal bucket of one week may itself be too coarse to facilitate detailed short term planning. Further out in the planning horizon, monthly or perhaps quarterly time buckets are acceptable. There is no reason why the MRP system cannot accommodate a variable time bucket size over the span of the planning horizon.

In the non-bucketed approach, each element of time phased data has a specific time label associated with it and is not accumulated into buckets. What this means is that there is a provision for daily visibility on requirements timing. Moreover, the

bucketless approach has no limit on the extent of the planning horizon. Consequently, the bucketless approach is more flexible (Kumar & Meade, 2002).

The planning horizon refers to the span of time from the current date out to some future date, over which materials plans are generated. The chief factor in determining the planning horizon is the longest cumulative manufacturing and procurement time for a master scheduled item. If our horizon thus not extend this far, then a new order at the end of the planning horizon may require a release of a purchase order last week, and the master scheduled will be infeasible before we start.

A planning horizon longer than the cumulative product leads time will avoid this problem and will give sufficient visibility to facilitate material procurement. The planning horizon is often extended further than the longest cumulative lead time for the purpose of gaining visibility of manufacturing capacity needs in the future.

The upper limit on the range of the planning horizon is determined by our ability to make meaningful statements about the nature and contents of the master production schedule. The longer the planning horizon, the more difficult it is to make useful forecasts about the market place and the likely demand for products and end level items. The need to put in place a master schedule over this planning horizon is the chief vulnerability of MRP systems.

2.6 Computerized MRP

When the firm decides to include all the products in the system, excessive amount of items are included in MRP calculations, and all the requirements of an item from final products are accumulated. Orders would be scheduled simultaneously to meet all the requirements rather than being scheduled on a product-by-product basis. The necessity of using computer becomes obvious when there are over 1000 finished products and 30000 purchased and manufactured components (Burlingame, 1982). The need for rapid computation and summarization of requirements is obvious by handling of massive bills of materials and inventory master files.

The advantages of using computer in material management are described in the literature (Burlingame, 1982, p.30) and (Devarajan, 1978, p.22) as follows;

Computerizing material management can offer significant advantages. These include cost savings, improved control, fewer clerical errors, faster reporting, the ability to increase volume without increasing clerical personnel and new ways of analyzing and interpreting information.

In situations such as, changing for the promises to customers, order cancellations, a computerized MRP system can immediately reflect the effects of changed order quantities, cancellations, and delayed material deliveries. A manager can change the master schedule and quickly see the results by means of simulation capability.

The second chapter is related to the material requirements planning. Inputs, outputs, computations, managerial objectives in using MRP, and benefits are described.

The topic of the chapter three is methods used to find the lot sizes for dependent demand materials.

CHAPTER THREE

LOT SIZING POLICIES

Whenever there is a net requirement for a material or subassembly, a decision must be made concerning how much of the material to order, or how much of the subassembly to manufacture. These decisions are considered as lot sizing decision. On the other hand, safety stock policy places an important role in the firm. Because of the better control of MRP, the use of safety stock is usually discouraged in MRP systems. The only exceptions may be in higher level items such as end items (finished goods and spares), where demands are unknown, or critical items whose supply is at risk. In this chapter lot sizing policies are examined.

In recent years, the traditional interest in the classic problem of the economic order quantity (EOQ) has shifted to lot sizing in an environment of discrete period demands. This development has been stimulated by the emergence of MRP systems, which express demand for inventory items in discrete time-series fashion, by computing time-phased gross and net requirements (Ghobbar & Friend, 2003).

The most widely recognized approaches to lot sizing are as follows:

(1) Fixed order quantity,
(2) Economic order quantity (EOQ),
(3) Lot for lot (LFL),
(4) Period order quantity (POQ),
(5) Least unit cost (LUC),
(6) Least total cost (LTC),
(7) Part-period balancing,
(8) Wagner-Whitin algorithm,
(9) Silver Meal Algorithm.

The first two of the above are demand-rate oriented; the others are called discrete lot-sizing techniques, because they generate order quantities that equal the net requirements in an integral number of consecutive planning periods. Discrete lot

sizing does not create “remnants” quantities that would be carried in inventory for same length of time without being sufficient to cover a future period’s requirements in full.

Lot sizing techniques can be categorized into those that generate fixed, repetitively ordered quantities, and those that generate varying order quantities. This distinction between fixed and variable is not to be confused with that between static and dynamic order quantities. A static order quantity is defined as one that, once computed, continues unchanged in the planned-order schedule. A dynamic order quantity is subject to continuous re computation, as and if required by changes in net-requirement data. A given lot-sizing technique can generate either static or dynamic order quantities, depending on how it is being used.

Of the nine techniques listed above, only the first one is always static, and the third one is, by definition, dynamic. The rest, including the EOQ, can be used for dynamic replanning at the user’s option. The last four are expressly intended for such replanning. It must be pointed out that dynamic order quantities are a mixed blessing in a material requirements planning environment. While they always reflect the most up-to-date version of the materials plan, they affect the requirements (and thus also the planned coverage) for their component items. A recomputation of a parent planned-order quantity will often mean that component-item open orders have to be rescheduled, in addition to recomputing and/or retiming planned orders.

A review of the nine lot-sizing techniques enumerated above follows. These techniques are usually discussed in connection with manufactured inventory items and the term setup covers all (fixed) costs of ordering. The logic on which these techniques are based is not limited to manufactured items. Where the cost of ordering purchased items is significant and/or where quantity discounts apply, any of the economics-oriented lot-sizing techniques can be used, after appropriate modification.

3.1 Fixed Order Quantity (FOQ)

A fixed order quantity policy may be specified for any item under MRP system, but in practice it would be limited to selected items only, if used at all. This policy would be applicable to items with ordering cost sufficiently high to rule out ordering in net requirement quantities, period by period.

The fixed order quantity specified for a given inventory item may be determined arbitrarily, or it can be based on intuitive/empirical factors.

The quantity may reflect extraneous considerations, facts not taken into account by any of the available lot-sizing algorithms. Such facts may be related to the capacities of certain facilities or processes, die life, packaging, storage, etc. It is understood (and the MRP system would be programmed accordingly) that when using this lot-sizing rule, the order quantity will be increased if necessary, to equal an unexpectedly high net requirement in the period the order is intended to cover.

3.2 Economic Order Quantity (EOQ)

Economic Order Quantity, also called economic lot size and economic production quantity, is the quantity of materials ordered at each order point that minimizes the total annual stocking costs for a material in a fixed order quantity inventory system. In this policy, EOQ is calculated based on the following formula;

$EOQ=\sqrt{2RC_p/C_h}$ (Buffa&Sarin, 1987, p.149)

R: The number of units of a material estimated to be demanded per year.

C_p: Ordering cost/setup cost is the average cost of each inventory replenishment for a material. It can include such costs as processing, purchasing requisitions, purchase orders, machine changeovers, postage, telephone calls, quality inspections, and receiving.

C_h: Carrying cost is the cost of financing, warehousing, damaging or losing, and any other cost directly related to holding materials in inventory.

If the net requirements for a period are greater than the EOQ amount, then either a multiple of the EOQ (e.g. 2*EOQ, or 3*EOQ) can be produced and ordered, or the amount equal to the requirements is produced (Buffa&Sarin, 1987, p. 149).

EOQ policy is not optimal in MRP because the assumption of the constant demand is not met. EOQ assumes that the demand for a material is uniform from period to period, but in MRP the demand is lumpy. Addition to this, in an EOQ policy, extra inventory is unnecessarily carried to the end of the planning horizon.

3.3 Lot for Lot Ordering

This technique, sometimes also referred to as discrete ordering, is the simplest and most straightforward of all. It provides period-by-period coverage of net requirements, and the planned-order quantity always equals the quantity of the net requirements being covered. These order quantities are, by necessity, dynamic; they must be recomputed whenever the respective net requirements change. The use of this technique minimizes inventory carrying cost. It is often used for expensive purchased items, and for any items, purchased or manufactured, that have highly discontinuous demand. Conversely, items in high-volume production and items that pass through specialized facilities geared to continuous production (equivalent to permanent setup) are normally also ordered lot for lot.

3.4 Fixed Period Requirements

This technique is equivalent to the primitive rule of ordering “X months’ supply,” used in some stock replenishment systems, expect that here the supply is determined not by forecasting but by adding up discrete future net requirements. In its rationale, it is similar to the fixed order quantity approach-the span of coverage may be determined arbitrarily or intuitively.

Under this technique, the user specified how many periods of coverage every planned order should provide. Whereas under the fixed order quantity approach the quantity is constant and the ordering intervals vary, under fixed period requirements the ordering interval is constant and the quantities are allowed to vary.

3.5 Period Order Quantity

This technique, popularly known as POQ, is based on logic of the classic EOQ, modified for use in an environment of discrete period demand. Using known future demand as represented by the net requirements schedule of a given inventory item, the EOQ is computed through the standard formula, to determine the number of planning periods constituting a year is then divided by this quantity to determine the ordering interval is computed. Both of these fixed-interval techniques avoid "remnants", in an effort to reduce inventory carrying cost. For this reason, the POQ is more effective than the EOQ, as setup cost per year is the same but carrying cost will tend to be lower under POQ.

The potential difficulty with this approach, however, lies in the possibility that discontinuous net requirements will be distributed in such a way that the predetermined ordering interval shows zero requirements, thus forcing the POQ technique to order fewer times per year than intended.

3.6 Least Unit Cost

This technique and the three that follows have certain thing in common. All of them allow both the lot size and the ordering interval to vary. They share a common assumption of discrete inventory depletion at the beginning of each period, which means that a portion of each order, equal to the quantity of the requirements in the first period covered by the order, is consumed immediately upon arrival in stock and thus incurs no inventory carrying charge. Inventory carrying cost, under all four of these lot-sizing methods, is computed on the basis of the assumption rather than on average inventories in each period.

All four of the techniques share the EOQ objective of the minimizing the sum of setup and inventory carrying cost, but each of them employs a somewhat different attack. The Least Unit Cost (LUC) technique is the best explained in terms of trial error, and this approach is used here although less primitive methods of computation do exist. In determining the order quantity, the LUC technique asks, in effect, whether this quantity should equal the first period's net requirements or whether it should be increased also to cover the next period's net requirements, or the one after that, etc. The decision is based on the "unit cost" (i.e. setup plus inventory carrying cost per unit) computed for each of the successive order quantities. The one with the least unit cost is chosen to be lot size (Gaither, 1994, p.469).

3.7 Least Total Cost

The least total cost technique (LTC) is based on the rationale that sum of setup and inventory carrying costs (total cost) for all lots within the planning horizon will be minimized if these costs are as nearly equal as possible , the same as under the classic EOQ approach. The LTC technique attempts to reach this objective by ordering in quantities at which the setup cost per unit and the carrying cost per unit are most nearly equal

The LTC technique is able to avoid the relatively laborious computation procedure of LUC and can proceed toward its goal in a more direct fashion. The vehicle for this is the computation of the so-called ECONOMIC PART PERIOD factor, or EPP. The EPP is defined as that quantity of the inventory item which, if carried in inventory for one period, would result in a carrying cost equal to the cost of setup. It is computed simply by dividing the inventory carrying charge per unit per period (IpC) into setup cost(S) (Gaither, 1994, p.469).

EPP=S/IpC

The LTC technique selects that order quantity at which the part period cost nearly equals the EPP.

3.8 Part-Period Balancing

Part Period balancing method generates various lot order sizes by considering holding cost versus ordering costs. Holding costs and setup costs are balanced as closely as possible for each lot size decision. It does not provide the optimal lot size but it is a low cost method that approaches optimality.

3.9 Wagner-Whitin Algorithm

This technique embodies an optimizing procedure based on a dynamic programming model. The procedure is too mathematically involved to be suitable for detailed description here. Basically, it evaluates all possible ways or ordering to cover net requirements in each period of the planning horizon. Its objective is to arrive at the optimum ordering strategy for the entire net requirements schedule. The Wagner-Whitin algorithm is “elegant” in that it reaches this objective without actually having to consider, specifically, each of the strategies that are possible.

In Wagner-Within algorithm, a batch is produced only when on-hand inventory is zero, and lot size is determined so that it exactly matches the net requirements for some number of periods (Buffa&Sarin, 1987, p.151).

The Wagner-Whitin algorithm does minimize the combined (total) cost of setup and carrying inventory, and it is used as a standard for measuring the relative effectiveness, usually mentioned in the literature, are a high computational burden and the near impossibility of explaining it to the average MRP system user.

In this chapter, the important factor in inventory planning, lot sizing policies are examined. Three of these policies are going to be used in application in chapter seven. They are lot for lot, periodic order quantity and fix order quantity techniques.

In the next chapter, Manufacturing Resource Planning (MRPII), Master Production Scheduling (MPS), Rough Cut Capacity Planning (RCCP), Capacity Requirements Planning (CRP) and Production Activity Control (PAC) are described.

CHAPTER FOUR

MANUFACTURING RESOURCE PLANNING (MRPII)

This chapter describes Manufacturing Resource Planning (MRPII). Manufacturing resource planning represents an extension of the MRP system to support many other manufacturing functions beyond the material planning, inventory control and BOM control. We shall review how evaluation from MRP to MRPII took place and examine the notion of Closed Loop MRP. Some of the major MRPII modules will also be outlined.

MRPII is a formal and disciplined management process to plan and control the total resources of a manufacturing business to effectively allocate limited resources to the most profitable opportunities and produce predictable performance (Jacobi, 1994).

The functions of an MRPII system can be divided into three groups. These represent the three levels of management planning and execution, which are (Jacobi, 1994):

(1) Top management planning: high-level strategic plans,
(2) Operations management planning: detailed and specific plans,
(3) Operations management execution: executing the detailed and specific plans.

Top management planning consists of the business, sales, and production plans being discussed, agreed to, and put into writing by senior management. These are dynamic, ever-changing plans that need to be revisited on a regular basis. Communication to all people is needed to develop the detailed and specific actions to execute these plans in the day-to-day operation. This is required to give the direction, allowing the manufacturing operation to make good weekly, and daily, decisions that support the business (Kobu, 1998).

To illustrate further, successful companies, in retrospect, say that 50 percent or more of the benefits of MRPII evolve from planning and scheduling plans. If you re executing on a poor, outdated, not-agreed to plan, or no plan at all, you are guessing at what to do right. Unfortunately, you will often guess wrong (Ip & Kam, 1998).

Operations management planning takes top management planning techniques and applies them to the daily business operation. The limited resources of people, material, and capacity are formally scheduled to the best possible use.

The master schedule in support of the production plan is the key. It is the schedule of all schedules; it identifies the objectives so that others in materials finance, manufacturing, and purchasing can develop valid plans to support this schedule and meet the desired objectives.

Benefits to be achieved by implementing MRPII are (Wilson, Desmond & Roberts, 1994);

(1) Improved capacity utilization,
(2) Improved process yields,
(3) Uncovered ‘hidden’ capacity,
(4) Reduced inventories and safety stocks,
(5) Better cost identification and management,
(6) Quicker response to market changes,
(7) Reduced downtime,
(8) More efficient use of warehouse space,
(9) Improved inventory accuracy,
(10) Improved operating flexibility.

4.1 The Evolution from MRP to MRPII

Manufacturing resource planning evolved from MRP by a gradual series of extensions to MRP system functionality. These extensions were natural and not very complicated as, for example, in the addition of transaction processing software to

support the purchasing, inventory and financial functions of the firm. In supporting the extension of decision support, similar and quite reasonable assumptions are made and similar procedures to those of MRP are applied. In this way, MRP was extended to support Master Planning, Rough Cut Capacity Planning (RCCP), Capacity Requirements Planning (CRP) and Production Activity Control (PAC). Production activity control is the term favored by the American Production and Inventory Control Society to cover activities traditionally described by shop floor control (Brown, 1994).

The term Closed Loop MRP denotes a stage of MRP system developed wherein the planning functions of master scheduling, MRP and capacity requirements planning are linked with the execution functions of production activity control and purchasing. These execution modules include features for input-output measurement, detailed scheduling and dispatching on the shop floor, planned delay reports from the shop floor and vendors, as well as purchasing follow-up and control functionality. Closed loop signifies that not only are the execution modules part of the overall system, but there is also feedback from the execution functions so that plans can be kept valid at all times. Figure (4.1) illustrates the flows of information within a closed loop MRP system.

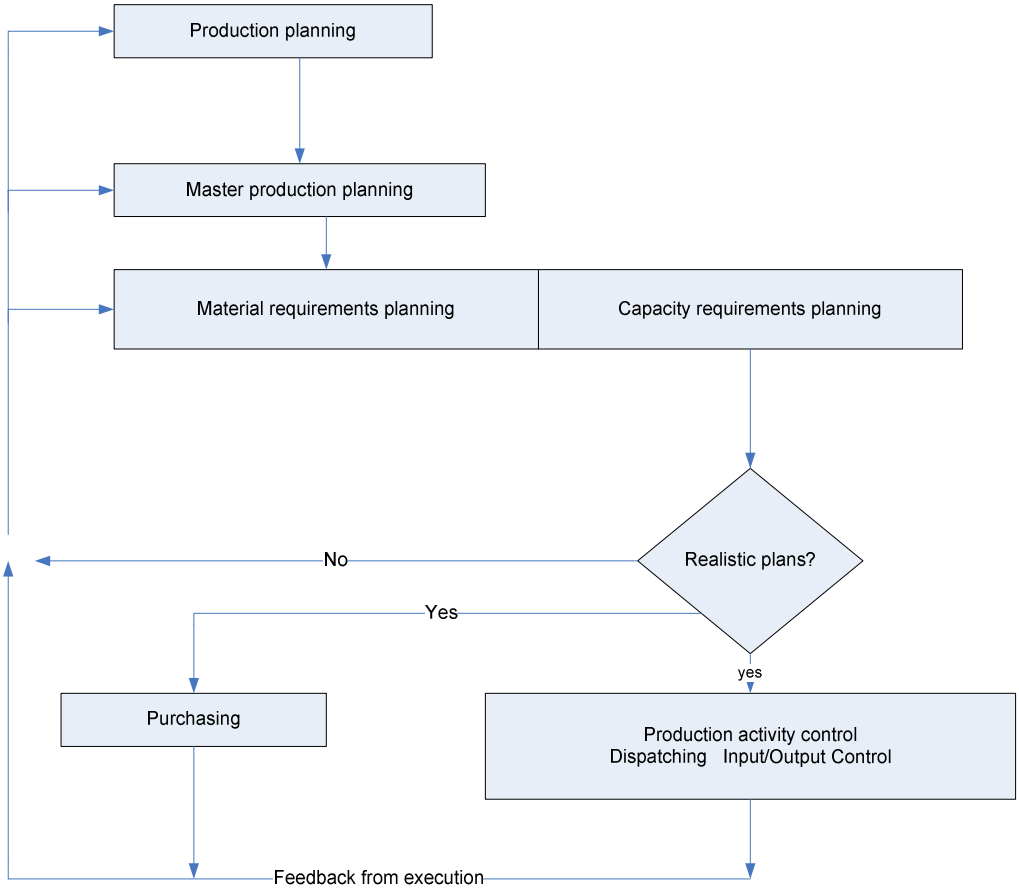

Figure 4.1 Closed loop MRP (Ip, 1998)

With the extension of master production scheduling to deal with all master planning and the support of business planning in financial terms, and through the addition of certain financial features to the purchase commitment report, shipping budget and inventory projection could be produced, it was realized that the resultant system offered an integrated approach to the management of all manufacturing resources. This extended MRP was labeled manufacturing resource planning or MRPII. The MRPII system is this closed loop MRP system with additional features to cover business and financial planning. MRPII nominally includes an extensive what if capability. However, several of the additional features included in MRPII software packages remain unused in practice.

MRPII is made up of a variety of functions, each linked together; Business Planning, Production Planning, Master Schedulin, Material Requirements Planning and Capacity Requirements Planning. Outputs from these systems are integrated with financial reports such as the business plan, purchase commitment report, shipping budget, inventory projection, etc. In general, MRPII functions can be grouped into three macro elements, namely Top Management Planning, Operation Planning and Execution. Figure (4.2) shows the framework of MRPII built up by the macro elements (Ip & Kam, 1998).

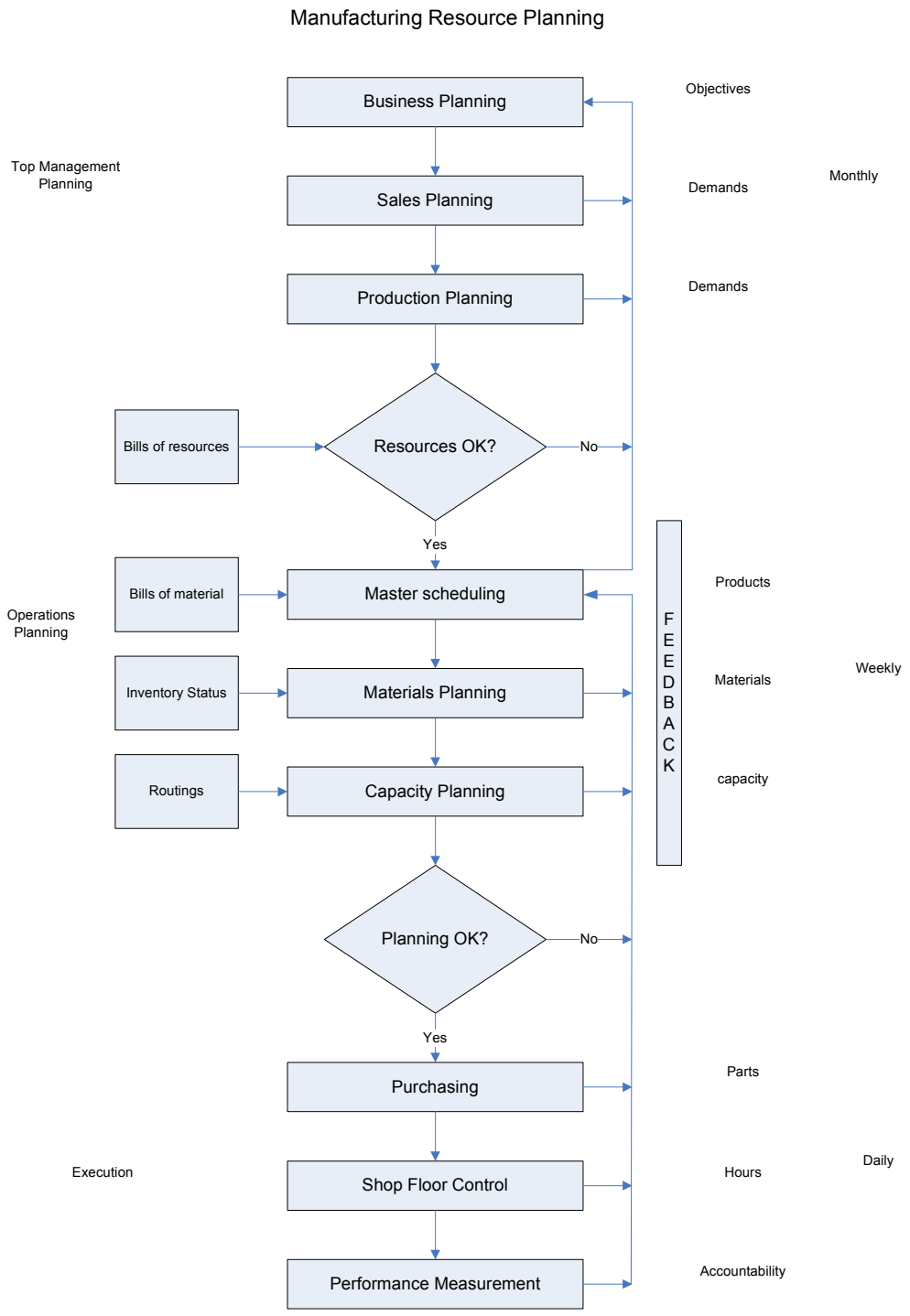

Figure 4.2 Framework of a MRPII system (Ip & Kam, 1998, p.249)

4.2 Master Production Scheduling (MPS)

The MPS is a statement of what the company plans to manufacture. It is the planned build schedule, by quantity and date, for top level items, either finished products or high level configurations of material (either physical configurations or pseudo configurations used solely for planning purposes.) The MPS module takes into account the sales forecast as well as considerations, such as backlog, availability of material, availability of capacity, management policy and company goals, etc. in determining the best manufacturing strategy.

The MPS drives MRP and thus the key input into the MRP process. Any errors within it, such as poor forecasts, etc. can not be compensated for by sophisticated MRP analysis as in lot sizing, calculation of safety stock or rescheduling. The MPS must be realistic in terms of the goals it sets for the manufacturing facility. It must not be merely a wish list of desirable production levels set by top management.

The accuracy of the MPS varies over the planning horizon. The planning data for the near term would tend to be more accurate since it is dominated by actual customer orders, distribution warehouse requirements and spare parts requirements. Change to the short term MPS should be treated as a series of firm planned orders.

Further out in the planning horizon, the MPS is likely to be less accurate and to be dominated by forecasts rather than actual orders. Forecasts may be based on analysis of historical trend, consideration of the state of the economy and market, and the actions of competitors. It may reflect the best guesses of those close to the market or it may involve the use of analytic forecasting and trend analysis techniques. Techniques, such as moving average analysis, exponential smoothing and regression analysis, may well be used to analyze past data in order to predict future data. The person or group responsible for the forecast must be aware of where each product in the company’s portfolio of products sits in terms of the preparing a forecast. This latter is particularly important today in industries, such as electronics and telecommunications, where product life cycles tend to be relatively short.

Typically the master schedule module software allows for a system generated forecast, a manually entered forecast, a schedule of actual customer orders received and a very simple procedure to combine the above in to a working estimate of demand. The user may specify a master production schedule. Each order is treated as a firm planned manufacturing order. There is a netting process very similar to MRP as the forecast demand is netted with the MPS and current inventory to generate a projection of inventory on-hand an available to promise. Projected inventory is based on initial inventory plus the firm planned orders less total demand. Available to promise is based on initial inventory plus the firm planned orders less actual orders.

The difference between the MPS module and the MRP procedure is that demand will only propagate from the scheduled MPS and not from the projected requirements. This means that the MPS will not influence manufacturing or purchasing orders without the intervention of the master planner (Tang & Grubbstrom, 2000).

It is important that there be a check on the feasibility of the proposed MPS before it is frozen and released to the manufacturing system for implementation. This feasibility check may be carried out through rough cut capacity planning. Master planning and rough cut capacity planning are thus two techniques that are employed in parallel. Actual MRP II systems vary somewhat in the support they give to these functions. Master planning systems often allow for planning at multiple levels and similar techniques to MPS and RCCP can be applied at more aggregate business planning and production planning levels.

4.3 Rough Cut Capacity Planning

Rough cut capacity planning involves a relatively quick check on a few key resources required to implement the master schedule in order to ensure that the MPS is feasible from a capacity point of view. The MPS and the rough cut capacity requirements plan are developed interactively.

In rough cut capacity planning, a bill of resource is attached to each of the master scheduled items. This bill of resource describes the capacity of various key facilities and/or people required to produce one unit of the item. Provision is made for using lead time offsets. No consideration is given to component inventories and the capacity requirements plan is driven solely by exploding the MPS against the bill of resource. The technique thus determines the impact of the master production schedule or the production plan on key or aggregate resources, such as man hours, machine hours, storage, and standard cost dollars, shipping dollars, inventory levels, etc.

In the RCCP exercise reveals that the MPS, as proposed, is infeasible then either or, alternatively, more resources must be acquired. Long term planning of overtime or subcontract is thus possible with the procedure.

4.4 Capacity Requirements Planning

The MRP system produces a set of planned orders for both manufactured and purchased items to meet the requirements of the master schedule. The MRP system has generated this material plan based on planned lead times for manufactured and purchased items. In doing so, the system has ignored any capacity constraints in the manufacturing facility.

MRP output can, however, be used for capacity requirements planning. This is done by exploding the manufacturing orders (planned and actual) through the routing specified in the production activity control system. This generates a detailed profile of what capacity is required in each work center.

Required capacity is then compared with available capacity and overload/under load conditions are identified.

A capacity requirement planning generates a more detailed capacity profile than that generated by RCCP. However, CRP is only performed after each MRP run and

these runs are typically performed only once a week. Therefore CRP does not facilitate interactive planning and is used primarily as a verification tool. In the days when the notion of closed loop MRP was popular, the CRP module was emphasized but, since then, its role seems to have diminished in importance compared to RCCP (Luscombe, 1994).

There are two common capacity planning methods, namely capacity planning based on forward scheduling and capacity planning based on backward scheduling. The principle of forward scheduling is illustrated in Figure (4.3). We identify the earliest start time for the operation in question through consideration of the planned order release date generated by MRP. We then use the lead time to calculate the completion date. If the completion time is prior to the due date then we have slack time available. If the completion time is after the due then we have a delay.

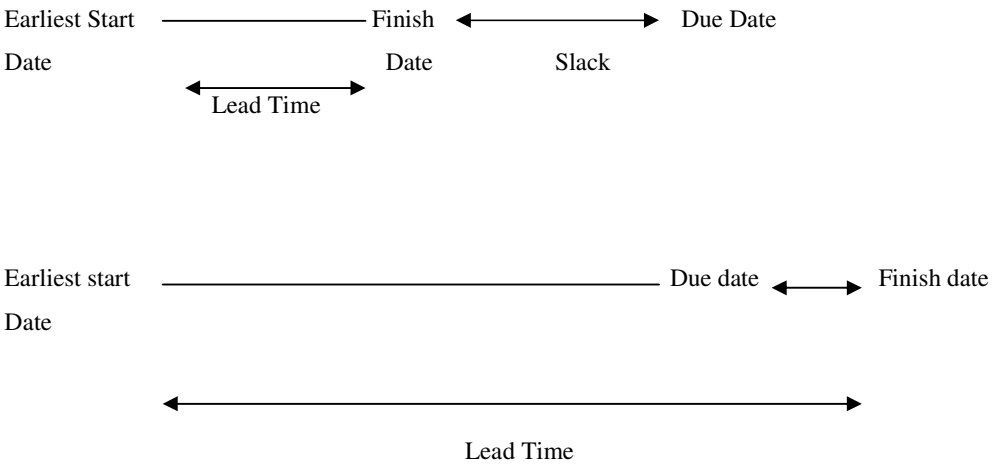

Figure 4.3 Forward Scheduling

In backward scheduling we identify the due date for the operation in question and use the operation lead time to calculate the latest operation start date. If the latest start time is after the earliest start date then we have slack time available. If the operation start time is prior to the earliest start date then we have negative slack. This is illustrated in Figure (4.4).

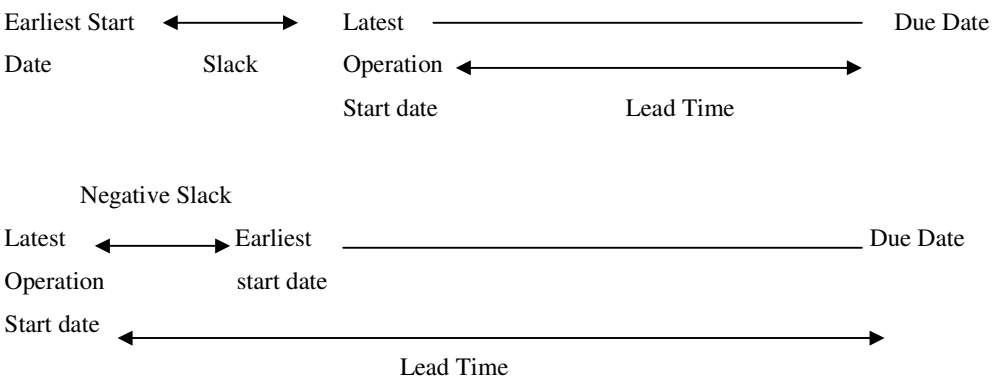

Figure 4.4 Backward Scheduling

From the production activity control system we have available the planned operation time for each operation in the manufacturing routing, as well as the details of the work center at which the work will be carried out. What CRP does is to develop a load profile for each work center which describes what capacity is required over the planning horizon and what capacity is available. Some CRP systems ignore operation lead times and use only the planning lead time for the order from MRP. In any case, the principle is the same.

The operation lead time referred to here is to be distinguished from the planning lead time used by MRP. The planned lead time, as used by MRP, is the average component or sub-assembly, painting and inspection, to complete the item. These operations lead times when added together make up the planning lead time for the component, as used by MRP.

The manufacturing lead time is the total time required to manufacture an item. Included here is order preparation time, queue time, set-up time, and run time, move time, inspection and put away time.

The purchasing lead time is the total time required to obtain a purchased item. Included here is procurement lead time, vendor lead time, and transportation time, and receiving, inspection and put away time.

Lead times must then be determined for both purchased and manufactured items. Lead times for purchased items are determined following discussions and negotiation between the purchasing people within a company and suppliers. Lead times for manufactured items, on the other hand, must be estimated based on past experience and through consideration of the various elements which together make up total lead time.

Within batch production systems, the lead time or throughput time for a batch through the shop floor is typically much greater than the processing time for the batch as shown in Figure (4.5). It is not unusual for the actual processing (including set up time) to represent less than 5% of the total throughput time. The throughput time or lead time is made up mainly of four major components-the set up time, the process time including inspection process time, the transport time and the queuing time. In real life this latter component is the largest, often representing in excess of 80% of total throughput time (Luscombe, 1994).

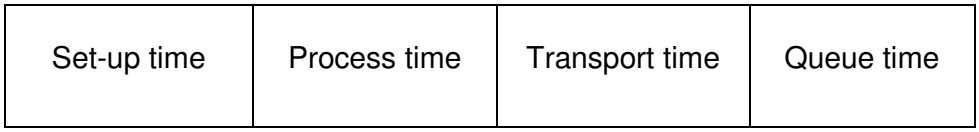

Figure 4.5 Breakdown of the lead time in a batch production system

In estimating lead times we must therefore pay particular attention to the calculation of the queuing element of the lead time. It is clear that this queuing time depends greatly on the load in front of a work center at a given point in time. Thus, if the machine is idle with no work queued in front of it, the queue time for an arriving job will be almost zero. If the machine is busy with a large queue time could be quite large. It is clear that the actual queuing time is variable and, consequently, the lead time is a variable also. For capacity planning purposes we use an average lead time based on our experience of the flow of work through the shop floor.

4.5 Production Activity Control

As the production activity control level, functions have been added to the basic MRP system which describe the process routing for fulfilling a manufacturing order (i.e. the sequence of steps a part goes through in its manufacturing process), as well as work center and standard time information. The routing information and work center information. The routing information and work center information of the PAC system have already been described in section 4.5.

The same operation scheduling procedures, which we saw in the CRP system, are used to set planned operation start times on dispatch lists. Work in progress tracking facilities the prioritizing of manufacturing orders on the dispatch list. There are a variety of techniques, including the use of critical ratio techniques, available for generating this priority. The critical ratio is calculated as the ratio of the time remaining until the due date, as compared with the sum of operation times remaining.

Capacity control, in the form of input output control, is provided in some systems. This reports on the planned workload that should flow into and out of each work center by week, as well as the actual workload inflow and outflow and finally, the cumulative deviation between plan and actual. This is useful in determining if a problem in a work center's output is caused by a capacity problem at that work center or, alternatively, by late input from upstream work centers.

Some of the inadequacies of PAC modules in MRPII systems are listed:

(1) Absence of the shelf interfaces to automatic data collection devices,
(2) Absence of quality management functionality,
(3) The routing control functionality of PAC modules in MRPII systems is typically rather naive. Only straight line flows are typically allowed and there is no support of multilevel tracking, i.e. tracking both the top level product and key sub-assemblies and components through parallel routings. In

addition, tracking is primarily by manufacturing order and support is rarely given for individual identification of units within a batch,

(4) Tooling control is rarely adequately provided for,

(5) Preventative maintenance and equipment tracking is rarely available.

4.6 Benefits of MRPII

From a management perspective, what benefits does MRPII offer (Jacobi, 1994)?

(1) Predictable financial and operating performance:

Variability in business performance is inefficient and costly. Planning and executing the plans, using information to support the business objective, means that the resulting day-to-day business operations occur by plan, not circumstance, and happen predictably. Predictable performance results in improved customer service, with time spent improving, rather than maintaining, the business at the current level. The need to expedite or excess inventory to cover inefficiency can be a past business practice.

(2) Better allocation of limited resources:

If you know where you stand, and know the cause and effect of the different elements of the business, you can allocate limited resources to root causes, not end effects. For example, high inventory is not an element existing alone, but caused by planning, scheduling, and other higher level problems.

(3) Agreement on problems:

If each functional area of a company understands the step-by-step process from plan to execution, and its effect on other elements, there will be better problem identification and prioritization. Problem solving will also focus on supporting business objectives versus departmental excellence. Facts take less time to manage

and don't leave room for lengthy discussion. People will be expected to create, not criticize.

(4) Management efficiency:

Commonly, 75 percent of management's time is spent identifying what the problem is and who is responsible, and 25 percent is spent on long-term solutions. This is very inefficient. With day-to-day operations monitored and executed as planned, due to understanding, planning, and communications, this ratio reverses.

(5) Common management objectives:

In most companies, departmental excellence does not equate to company excellence. Departments propose solutions based upon areas, not the total company needs. This is illustrated by "islands of automation" and functional versus flow layouts. With MRPII, people's eyes are opened to supporting company goals, not department goals, and understanding the role each of us plays in the company's success.

(6) Better and more beneficial communication; fact based communication:

The MRPII management process ties people together and allows them to communicate and work jointly. This is a result of a better understanding of the business process and its objectives. When you operate in an informal system, people are trying to discover what to do, not do it.

(7) Financial:

Companies that are successful in MRPII term the installation of the MRPII management process the most significant event in the company's history, more important than any new product or new machine or new management. Continuous examples show over a 250 percent return on investment. If you do not believe this

can occur in your business, think of the effect on your business if your main competitor was able to achieve a 95 percent level of performance in each of the areas that MRPII addresses, such as customer service, inventory accuracy, and master schedule performance.

4.7 The 10 Steps to Success

When you examine companies that have been successful in implementing the MRPII management process, they continually focus on the same issues. The issues, or "The ten steps to success," are a road map of how to be successful and maximize the benefits of MRPII (Jacobi, 1994).

(1) Step1-Education:

The first step in an effective MRPII implementation is management education. Leaders are setting objectives and then guiding people and other resources in achieving those objectives. Effective leadership in the transition to MRPII requires education on: "What is it?" "How does it work?" "How is it going to help me?" "What do we have to do?" "Where are we going with MRPII?" and "How is it going to affect my business?" Education provides this understanding and vision.

The most critical aspect is obtaining top management support, resources, and commitment. This is not a given, as often thought when management writes a check for the hardware and software system. This commitment is earned, and the most effective way to earn it is through applied education for strategic level management.

Courses specifically designed to address top management's needs will answer the question through team exercises of "Why commit limited management resources to the project?" and "Why should top management play an active role in MRPII's project success?" Education will allow management to discover for them that Class A MRPII can return more than 250 percent on the investment, and will be more

important financially than any other project being considered. This analysis will earn the right to utilize resources required.

Education for operation level areas will address the fundamental problem of "change creates discomfort." It will allow for an exchange of ideas that will internalize the process and develop subtask groups involved in activities applied toward change from the informal to formal system. It will tie individual departments and initiatives into a team. Through applied education, in which over 50 percent of the time is spent in discussion, the result is the team building and commitment. Getting the answer to "How can we apply this concept here?" through group discussion brings involvement, commitment, and ownership of the project to the project to the whole company, not just individuals. It gives an understanding of the MRPII principles and practices required to be successful.

(2) Step2-Industry Consultants:

Industry consultants provide guidance and structure to the project team and management. They are very beneficial in helping to set objectives, confirm direction, validate priorities, and review performance. The consultant acts as a quality check on the project.

By providing such items as sample project plans, step-by-step implementation methodology, and a perspective on how other companies solved problems, the consultant saves time by providing successful models for companies to adapt to their needs. This only slows the return on investment. Energies are spent on activity not analysis and chasing the (supposed) perfect plan.

(3) Step 3-Performance Measurement:

Finite performance measurement is the key to successful implementation of MRPII. Performance measurement defines objectives, goals, and targets; prioritizes needs; and increases understanding of cause-effect relationship. Without

performance measurement, a company will not know where it is and what needs to be done to improve performance. It forces accountability and peer pressure to work together to improve performance.

Performance measurement is an excellent way to increase communication of objectives and improve cooperation. People responsible for measures will work with others on whom their performance is dependent. This need to communicate breaks down departmental barriers and forces people to think company performance versus department performance.

(4) Step 4-Organizational accountability:

If performance is to be measured, someone must be individually responsible for improving the performance in these areas and working with others required to support these areas.

(5) Step 5-Handshake management:

Handshake management is in contrast to foxhole management. In foxhole management, people point fingers, play politics, and gather evidence to find blame. The objective is to find fault, not solutions, because it is easier to criticize than to create. People do not cooperate because they are looking for departmental and individual vindication rather than company wide excellence.

In handshake management, however, people work with mutual respect, trust, teamwork, and cooperation to get the job done. They deal with facts developed in the formal system. The attitude is to find solutions, not make themselves feel good by finding someone to blame for their situation. They agree with a mutual handshake on how to proceed and learn from mistakes, rather than hang from them.

(6) Step 6-Project team and leader:

The project leader is a full-time position reporting directly to the president. The project team should include members from each functional area of the business. If MRPII assists you in managing the total business, all departments must be represented. With the changes required, and realizing the benefits to be obtained, it is essential that a regular time must be allotted to make these changes. It may be difficult to have a vision of how you can replace these people in their normal day-to-day activities, but if the benefits are large, this is the best possible use of your people. Talking about success will not get the job done.

(7) Step 7-Cost justification:

If a company is to make an investment in time, effort, and capital to make MRPII work, there have to be benefits. Going through a cost justification with senior and operating management and developing the numbers is very revealing. When you yourself add up the benefits, you will realize quickly why it is so important to get this job done and to allocate your time to achieve this goal. Cost justification reveals these benefits to management resources, and serves as a continuous reminder of why we have to be successful.

(8) Step 8-Project plan:

A formal and dynamic project plan developed by the project team is critical. It sets direction, responsibility, goals, and changes required. The plan serves as a basis for input from others. It allows people to discuss their role in support of the plan and develops the basis of the teamwork required to succeed. A successful project plan is developed with everyone's input during the education process, and is a focus for discussion of "What should we do to improve?"

(9) Step 9-Database integrity:

Data accuracy and integrity is critical due to the integrated nature of MRPII. If inventory, routings, or bills of material are wrong, the problems are compounded and

people do not believe information. Seventy percent accurate inventory, routings, and bills do not translate to a 70 percent accurate master schedule. The computer does not think and create accuracy where there is none. Accurate information is critical to achieving usage of MRPII among individuals. In their effort to do a good job, an individual will revert to a manual process if they cannot get good information. Their MRPII project fails, and restarts are twice as difficult as people perceive. “MRPII does not work” is the belief, rather than they didn’t do it right the first time.

(10) Step 10-Software and hardware:

MRPII is a management process supported by an information system. Since it is a management process, people are the key. Information generated by hardware and software supports this process. It is not the process.

It could be said that, “We have good people, and they will figure out how to use the information” from the hardware and software. This is not a given. Simply because the information is available does not guarantee that management communicates, plans, and reaches common objectives using the output of the computer system. Nor does it guarantee that management operates the business on this information-decision-execution management system.

The specific pieces integrate very well in successful companies. People use the information generated to reach a consensus, communicate, and execute in a formal way throughout the organization. Those who fail recognize only the availability of information, not its use.

You can touch, feel, and test drive software. This is why many companies make this the first step rather than the last. It is easy to buy. It is not easy to improve business operations. It is looking in a mirror that is hard. Consequently, companies place far more emphasis on buying a solution through hardware and software than is justified by the benefits.

This is not to say that good hardware and software is not important. A software product that has a 90 percent fit to operating requirements, has good functionality, and is easy to use becomes a non issue because it does work. This allows people to focus on the real issue, the management process. But, with competition in this area, software brand choice will vary results only 5-10 percent (Demir & Gümüşoğlu, 1998).

In this section, the evolution from MRP to MRPII, Closed loop MRP, Master Production Scheduling, Rough Cut Capacity Planning, Capacity Requirements Planning are described and benefits of MRPII and implementation steps for being successful are examined.

In the next chapter, beyond MRPII, other production planning and control systems are described.

CHAPTER FIVE

OTHER MANUFACTURING TECHNIQUES

All respondents in the company of the automotive, machine tool, electrical, computing machinery, and other discrete and repetitive manufacturing industries implemented the set of manufacturing industries implemented the set of manufacturing philosophies and techniques in their companies over the years.

Prior to the 1960's, inventory was controlled by a manual system. Various techniques such as Economic Order Quantity, ABC classifications were used. Innovations were made and computerized inventory control systems have been appeared.

After World War II, Just in Time (JIT) philosophy that has the purposes of reduction of lead times, reduction of inventory, yielding a more competitive company, has appeared (Ptak, 1991, p.8).

Companies and software developers develop new ways of organizing and improving the operations. For example, MRPII that combines all functions of an organization has been developed as an extension of MRP. Distribution Requirements Planning (DRP), then a new concept, Enterprise Resource Planning (ERP) have developed to improve inventory management and planning functions, to provide controlling and managing all functions of an organization. Evaluation of manufacturing techniques is depicted in Figure (5.1).

In this chapter, Distribution Requirements Planning (DRP), Enterprise Resource Planning (ERP), and Just in Time (JIT) philosophies, relations with Manufacturing Resource Planning (MRPII) are examined.

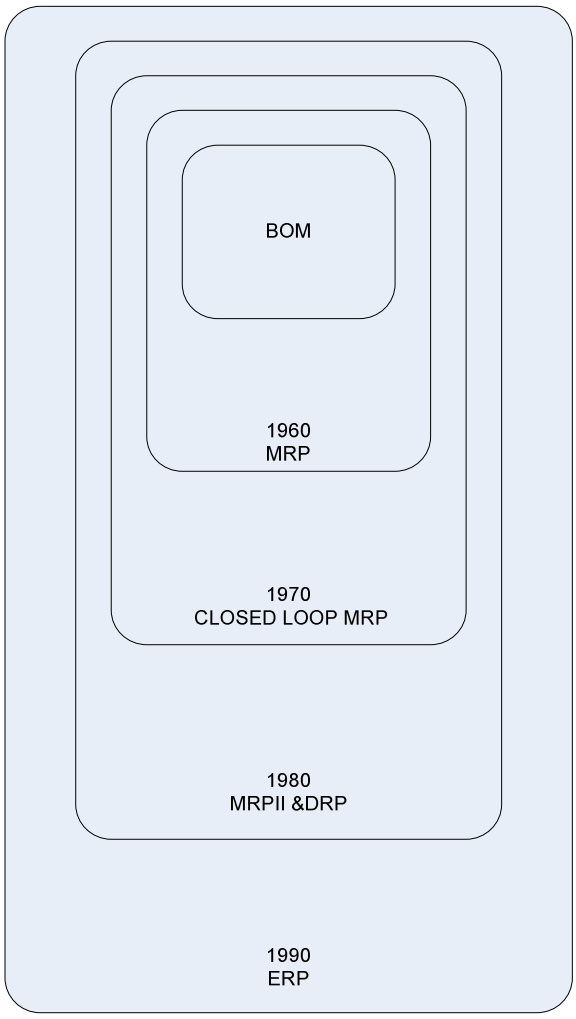

Figure 5.1 Evaluation of manufacturing techniques (Ptak, 1991)

5.1 Distribution Requirements Planning (DRP)

According to the literature (Vollmann & Berry & Whybark, 1992, p.752), (Martin, 1988, p.16), distribution Requirements Planning (DRP) is defined as follows;

Distribution Requirements Planning is a management process that integrates a number of critical activities necessary to manage and control distribution operations

and integrate their needs. DRP provides the basis for the physical distribution system to the manufacturing planning and control system.

Application of the Distribution Requirements Planning has the same logic of the Material Requirements Planning. In DRP, independent demand takes place only at the customer level; other levels in the distribution network have dependent demand.

Local distribution centers decide what is needed, from forecast at each local distribution centers, and then time phased net requirements are calculated. The calculation of the net requirements is the same as the one in MRP. Gross requirements, safety stocks, scheduled receipts, on-hand inventory are taken into account. Then, net requirements are located in planned order receipt date, and planned order release date is determined by using the lead times. Lead time expresses the time to receive order from central or upper side to the local center. The planned order release quantity becomes a gross requirement for the supply/central center.

Integrated system that combines DRP and MRP has a great advantage of managing entire organization for manufacturing organizations that produce and distribute products. Organizations can improve manufacturing and distribution function such as inventory, transportation, and warehousing by their own distribution network.

DRP and MRP are linked through the master production schedule and this link is presented in Figure (5.2). The accumulation of planned order releases for items from the master distribution center is a major input to the master production schedule. In a sense DRP drives the master production schedule (Tersine, 1994, p.466)

MRP process flows from the master production schedule to the detailed schedule of components or subassemblies, DRP process flows from the lowest levels of distribution network to the central distribution center. DRP manages final products in distribution, and MRP manages materials and in-processes for production. Integration between MRP and DRP provides exact control over resources from raw materials suppliers to the customers.

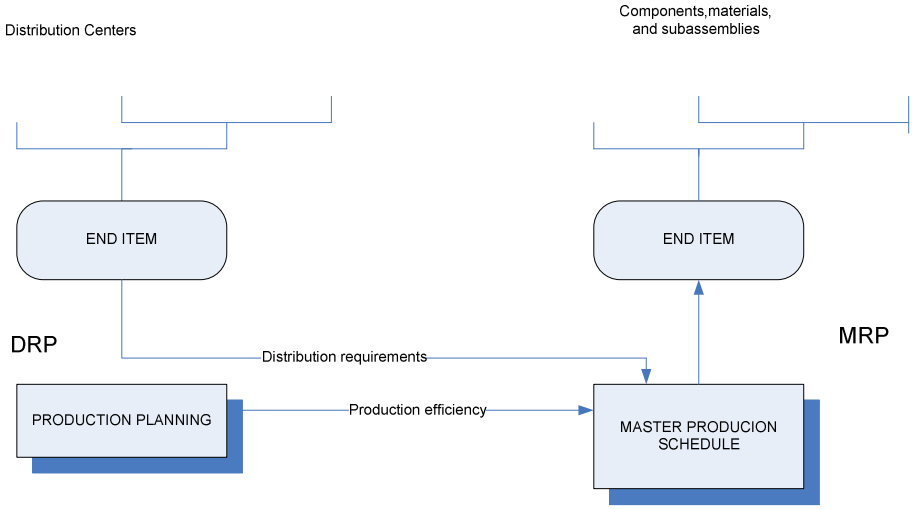

Figure 5.2 DRP and MRP integration (Tersine, 1994)

5.2 Enterprise resource Planning (ERP)

Enterprise resource planning (ERP) system is a business management system that comprises integrated sets of comprehensive software, which can be used, when successfully implemented, to manage and integrate all the business functions within an organization. These sets usually include a set of mature business applications and tools for financial and cost accounting, sales and distribution, materials management, human resource, production planning and computer integrated manufacturing, supply chain, and customer information. These packages have the ability to facilitate the flow of information between all supply chain processes (internal and external) in organization. Furthermore, an ERP system can be used as a tool to help improve performance level of a supply chain network by helping to reduce cycle times. However, it has traditionally been applied in capital-intensive industries such as manufacturing, construction, aerospace and defense. Recently, ERP systems have been expanded beyond manufacturing and introduced to the finance, health care, hotel chains, and education, insurance, retail and telecommunications sectors (Shebab, Supramaniam & Spedding, 2004).

Basically, ERP is an enterprise-wide planning and control system that will allow the manufacturing company to operate as one global business by coordinating

multisided operating units that are physically dispersed. It includes an advanced information technology such as graphical user interfaces, relational data bases, object oriented solutions (Jain, 1991, p. 34).

ERP packages touch many aspects of a company's internal and external operations. Consequently, successful deployment and use of ERP systems are critical to organizational performance and survival (Markus, 2000). Potential benefits include drastic declines in inventory, breakthrough reductions in working capital, abundant information about customer wants and needs, along with the ability to view and manage the extended enterprise of suppliers, alliances and customers as an integrated whole (Chen, 2001). In the manufacturing sector, ERP implementation has reduced inventories anywhere from 15 to 35 per cent (Gupta, 2000). Among the most important attributes of ERP (Nah, 2001; Soh, 2000) are its abilities to:

(1) Automate and integrate business processes across organizational functions and locations,
(2) Enable implementation of all variations of best business practices with a view towards enhancing productivity,
(3) Share common data and practices across the entire enterprise in order to reduce errors and
(4) Produce and access information in a real-time environment to facilitate rapid better decisions and cost reductions.

In a typical manufacturing environment, the master production schedule (MPS) specifies the quantity of each finished product required in each planning period; it is a set of time-phased requirements for end items. The firm, however, also needs a set of time-phased requirements for the parts and raw materials that make up those end items. Therefore, MRP is a production planning and control technique in which the MPS is used to create production and purchase orders for lower-level components. In the 1970s, manufacturers began to use techniques such as MRP in recognition of the importance of the distinction between independent and dependent demand items (Chen, 2001).

MRP is continually evolving and expanding to include more business functions. In the early 1980s, MRP expanded from material planning and control system to a company-wide system capable of planning and controlling virtually all the firm's resources. This expanded approach was so fundamentally different from the original concepts of MRP that Wight (1984) coined the term MRPII, which refers to manufacturing resource planning. A major purpose of MRPII is to integrate primary functions (i.e. production, marketing, and finance) and other functions such as personnel, engineering, and purchasing into the planning process. Since it is a company-wide system, MRPII often has a built-in simulation capability that allows the firm to ask "what-if" questions (Boykin, 2001).

In the 1990s, MRPII was further expanded into ERP, a term coined by the Gartner Group of Stamford, Connecticut, USA (Sriginidi, 2000). It is intended to improve resource planning by extending the scope of planning to include more of the supply chain than MRPII. Thus, a key difference between MRPII and ERP is that while MRPII has traditionally focused on the planning and scheduling of internal resources, ERP strives to plan and schedule supplier resources as well, based on the dynamic customer demands and schedules.

The popularity of ERP systems started to soar in 1994 when SAP, a German based company, released its next-generation software known as R/3. In the following years, companies began to pour billions into ERP systems offered by SAP and its major competitors such as Oracle, Baan, J.D. Edwards, etc. By the 1990s, industry prognosticators were forecasting that the ERP market would sustain and industry growth rate of 30 to 40 percent, and that the market would exceed $50 billion by 2002 (Chen, 2001).

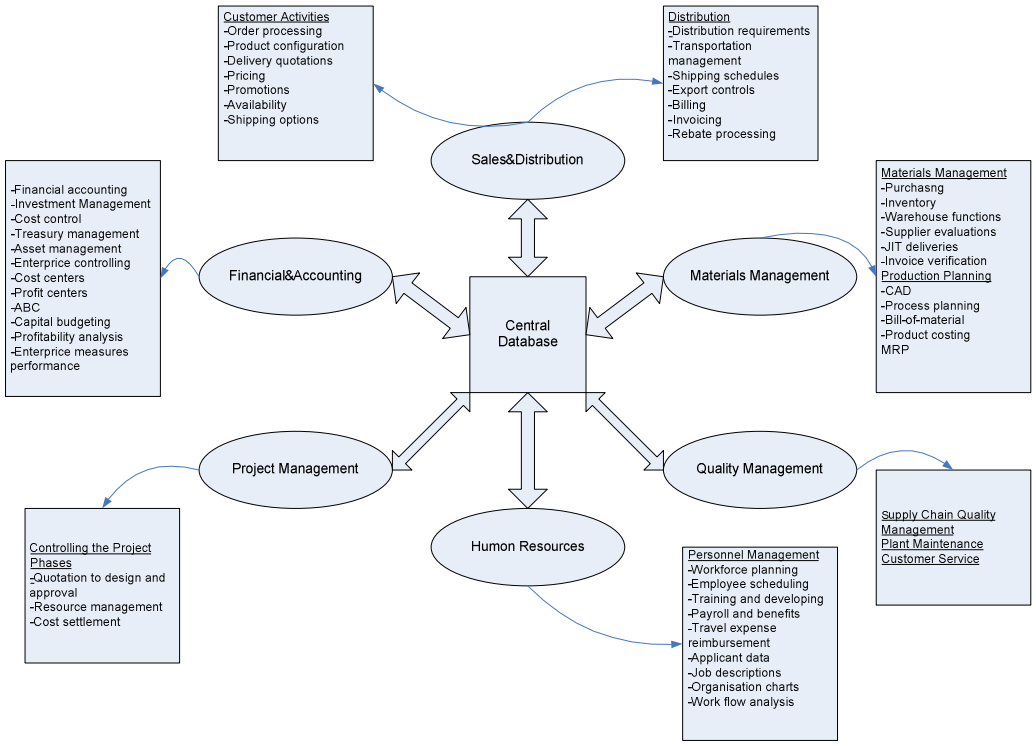

Figure 5.3 ERP system modules (Shebab, Supramaniam & Spedding, 2004, p.363)

An overview of ERP systems including some of the popular functions within each module is presented in Figure (5.3). While the names and numbers of modules in an ERP system provided by various software vendors may differ, a typical system integrates all these functions by allowing its modules to share and transfer information freely and centralizing all information in a single database accessible by all modules. The various modules of ERP include engineering data control (bill of materials, process plan and work centre data); sales, purchase and inventory (sales and distribution, inventory and purchase); material requirements planning (MRP); resource flow management (production scheduling, finance and human resources management); work documentation (work order, shop order release, material issue release and route cards for parts and assemblies); shopfloor control and magement and others like costing, maintenance management, logistics management. Also, the model of ERP includes areas such as finance (financial accounting, treasury management, enterprice control and asset management), logistics (production planning, materials management, plant maintenance, quality management, project systems, sales and distribution), human resources (personnel management, training

and development and skills inventory) and workflow (integrates the entire enterprice with flexible assignment of tasks and responsibilities to locations, positions, jobs, groups or individuals) (Shebab, Supramaniam & Spedding, 2004).

In summary, traditional MRP and MRPII applications may not be up to the challenge presented by manufacturers seeking to capitalize on the competitive advantage offered by an integrated supply chain. ERP, therefore, has evolved from its predecessors to play an integrated supporting role in the creation of a value chain.

5.3 Just In Time (JIT) with MRP

Just in time (JIT) is a manufacturing philosophy of eliminating waste in the total manufacturing process, from purchasing through distribution, and which leads to improve quality. JIT provides for the cost effective production and delivery only the necessary quality parts, in the right quantity, at the right time and place, while using a minimum of facilities, equipment, material and human resources (Bermudez, 1991). As part of JIT philosophy, there are three basic and equally important components for eliminating waste:

(1) Establishing balance and synchronization of flow in the manufacturing process. The essential element in eliminating waste is the identification of non-value adding activities,
(2) Company's attitude toward quality; the idea of "doing it right the first time,"
(3) Employee involvement.

Every member of the organization from the shop floor to senior management has a part to play in the elimination of waste and solving the manufacturing problems that cause waste.

The fundamental aim of JIT is to ensure the production is as close as possible to a continuous process. Some of the elements of this system are as follows:

(1) Uniform flow/layout,
(2) Set-up time reduction,
(3) Work in progress reduction,
(4) Organization in modules or cells,
(5) Kanban ("pull" system),
(6) Standardized containers (lot size reduction),
(7) Product simplification,
(8) Flexible workforce,
(9) JIT purchasing,
(10) Continuous improvement.

The relationship between MRP and JIT will be depicted on five points of MRP. These points are on-hand inventory, lot sizing, safety stock, lead time, gross requirements, and scheduled receipts/planned orders (Bose & Rao, 1998);

(1) On hand inventory: In JIT, inventory is waste and needs to be eliminated. Completed parts and subassemblies should be moved directly to the next higher level.
(2) Lot sizing: Lot sizing techniques are calculated by balancing inventory carrying cost with set-up cost to obtain optimal lot sizes. Set-up times are assumed to be fixed. In JIT, the objective is to continually reduce set-up time until a lot size of one unit.
(3) Safety stock: Under JIT, all reasons for safety stock need to removed, lead time, defects and machine breakdowns.
(4) Lead time: In JIT, continuous reduction of lead time for set-up, queues, reworks and material handling, have to be provided.
(5) Gross requirements: In JIT, production output at all levels needs to be synchronized with sales to avoid work in process. It focuses only what is needed, when I is needed. In many MRP calculations final assembly is scheduled based on the master schedule, requirements in other levels are often calculated by lot sizing techniques.

(6) Schedule receipts: MRP has difficulty in predicting when materials are receipt because of inaccurate lead times, unexpected scrap, and varying queue times. It is much easier to schedule receipts when there are less variability and more flexibility in the production process.

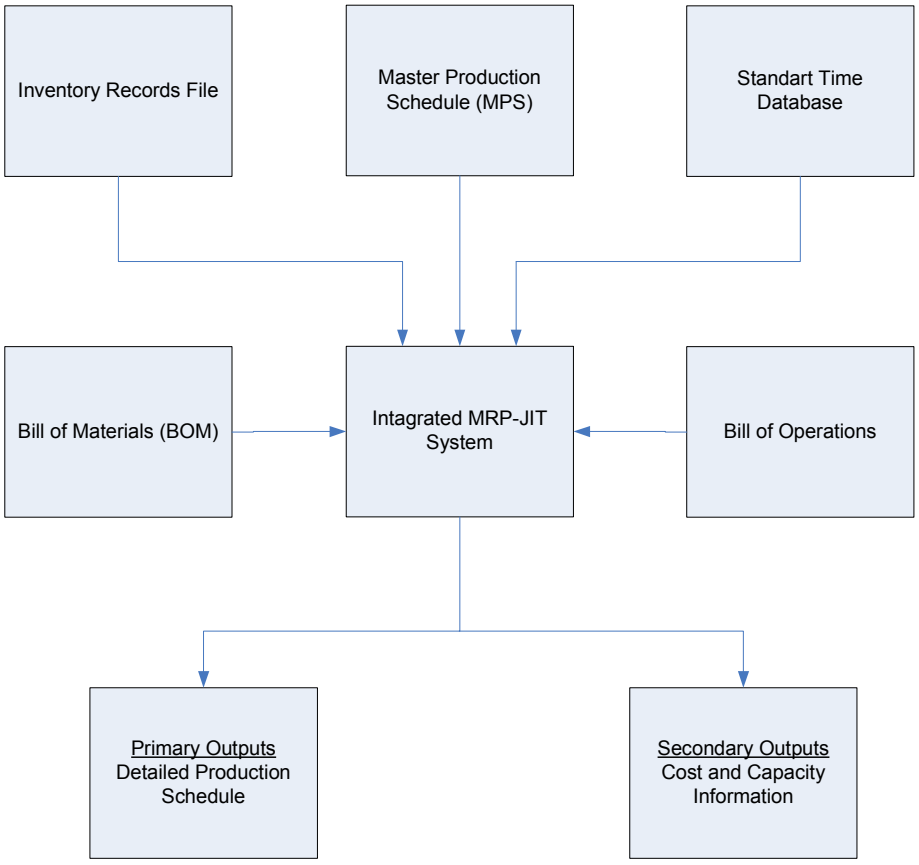

Figure 5.4 Basic structure of the integrated system (Ho & Chang, 2001).

The five major inputs of the integrated system are: MPS, BOM, inventory record file, bill of operations and standart time database. The first three inputs are the same as those in MRP. The MPS specifies the independent demand by period for each part. The BOM provides the parts and their quantities required to produce a product. The inventory record file provides the on-hand inventory and portion of fixed lead time for each part. The primary output of the integrated system is the detailed production schedule, which specifies for each work center which operation of which part is to be processed at what time period. The secondary outputs include the

detailed cost and capacity utilization report. Figure (5.4) illustrates the the basic structure of the integrated system (Ho& Chang, 2001).

MRP can be considered as a bridge to JIT. JIT is not a software system to replace MRP. Implementing JIT can greatly reduce the complexity of the scheduling problems.

In this chapter, Distribution Requirements Planning (DRP) which is a management process that integrates a number of critical activities necessary to manage and control distribution operations and integrate their needs, Enterprice Resource Planning (ERP) system which is a business management system that manage and integrate all the business functions within an organization and Just-in Time (JIT) which is a manufacturing philosophy of eliminating waste in the total manufacturing process from purchasing through distribution which leads to improve quality, are examined . The objective of this study is to concentrate on a Manufacturing Resource Planning (MRPII), but with this chapter the evaluation of manufacturing techniques is depicted too. ERP should not be considered as the final stage of this evaluation. There will always be a new frontier as long as the information technology continues to progress.

CHAPTER SIX

IDENTIFYING THE PROBLEMS IN THE ESTABLISHMENT

In this chapter; I will discuss the company Baran Ambalaj A.Ş. ,which will be introduced with a brief company profile, looking closely at those aspects of the company that make MRP system necessary; in other words, at the problems in the establishment. Particularly, I will tell how the decision for investing in completely new software and hardware, discarding the existing ones being used by the company, was made, and also which problems were identified in the system before the installation of the new software, what kind of solutions were formulated, the corrections made and precautions taken. Finally, I will try to ascertain whether or not the benefits expected from the new MRP system materialized.

The inventory management, purchasing management, and production management at the establishment will be examined and the problems and shortcomings experienced in these departments will be described. But firstly, general information will be given about the firm.

6.1 Information about the Firm

The MRPII software package is installed in a packaging company. The company was founded 25 years ago and is still located in Ataturk Industrial Estate (AOSB). Its' printing & forming plant, fully integrated within its 12500 m2 premises houses a workforce of 200, chemists, engineers, designers, electricians, and machine operators are among the many professionals collaborating to meet requests. All employees are committed to providing the most efficient packaging solutions to the problem of carrying products safely into the consumers' hands.

The firm provides solutions for small and medium size packaging (20 g to 20 kg according to products) requirements. The wide range of paper bags and complex laminated films are all suitable for food products. From flour to coffee, from pasta to

fruits, from plaster to chemicals, a large diversity of products find perfect protection within the wide assortment of packages. The firm's bags and films are developed to meet fully customers' product specifications and market requirements. All materials and products are tested in an integrated laboratory before, during and after the production. All orders are printed on one of the modern flexographic central drum presses in up to 8 colors. State of the art equipment and well trained staff assure that customers' artworks are perfectly respected and products are safely sent onto the shelves. The firm is committed to improving quality continuously. A careful selection of foreign and domestic suppliers, frequent inspections and strict quality and hygiene rules together with continuous staff training and education assure satisfaction of the most demanding clients.

The firm's products are:

(1) Chips, tacos and nuts packaging,
(2) Flour, sugar and salt packaging,
(3) Frozen food packaging,
(4) Legumes, pasta and macaroni packaging,
(5) Tea, coffee packaging,
(6) Tissue and detergent packaging,
(7) Pet food and pet products packaging
(8) Dry fruits packaging,
(9) Powder drinks packaging,
(10) Biscuits packaging,
(11) Carrier Bags.

6.2 Identified Problems in Inventory Management

Although there is limited computer support for the inventory management system, because of the loopholes and the weak points in the system on one hand, and the erroneous applications on the other hand, healthy inventory records can not be kept. As a result of reviewing the inventory management with a view to install MRP

system, the problems which can be grouped under the headings listed below have been identified:

(1) There are significant deviations between actual stock-takings figures and inventory records. These deviations in the inventory records make stock controls more difficult and cause production stoppages due to raw materials. This system in its' present state makes implementation of the MRP system definitely impossible.

(2) The physical borders of the stock areas have not been demarcated clearly. This makes the physical monitoring of the stocks difficult.

(3) There are mistakes arising from the fact that material entry and exit movements are handled also by employees other than the warehouse officers.

(4) As a result of incomplete or insufficient documentation for inventory movements, there are instances when the control of the material flow is lost.

(5) Erroneous entry and exit records are created because each and every inventory movement is not recorded separately and instantly.

(6) Erroneous entry and exit recordings are made because the warehouse officers are not adequately familiar with the materials.

(7) Since the materials are not grouped according to type in the warehouse, there are some materials which are wrongly identified and counted during stock counts and lead to erroneous records.

(8) Although there is a computer program used for inventory management, manual records and documents instead of computer generated ones are made for every inventory movement. These documents which are prepared manually are recorded in the system afterwards. This practice causes the records in the system not to be up-to-date and leads to erroneous records.

(9) A standard coding system does not exist for the stock records. This prevents proper classification of the materials and healthy inventory reports can not be obtained.

(10) There isn't any coding system for the semi-processed or finished products circulating in the production process. This makes the monitoring of the products in the system impossible.

(11) The material stocks related to the booked sales orders, idle stocks and the inventory items for which purchasing orders exist are monitored in excel files by the planning department. This leads to mistakes in the determination of net requirements. In order to avoid being out of stock, over stocking is preferred. This situation causes safety stock levels to exceed optimum levels and the funds tied up in stocks to increase.

6.3 Identified Problems in Purchasing Management

In the establishment, the procurement process for the inventory items is divided into two, as domestic purchasing and overseas purchasing.

The purchasing department obtains the necessary materials by issuing purchase orders in response to requisitions coming from the plant but the department can not receive any computer support for this process. Both the consolidation of the requisitions coming from various production units and subsequent grouping of requirements on basis of lead time, supplier, material type, requiring department etc. and issuance of purchasing orders and monitoring of the stock balances for ordered items are done entirely manually.

As a result the purchasing officers can neither handle the requisitions coming from the plant quickly and correctly nor monitor actual stock positions of required items. Additionally; there is no method other than relying on general experience and knowledge to control and verify the requirements of the plant.

The problems in the procurement process can be grouped under the headings listed below:

(1) As a result of non-use of a computer system in processing requisitions, problems arise in communication, monitoring and reporting.

(2) The planning department monitors the issued purchasing orders in excel files prepared themselves. The erroneous data recorded manually lead to excessive or insufficient supply problems.

(3) Lot sizing policies which determine ordering intervals and appropriate lot sizes do not exist. The purchasing orders are issued upon receipt of requisitions. This means LFL (lot for lot) technique is used in procurements. No study for comparison of the purchase cost evaluation of alternative ordering policies is undertaken.

(4) Because of problems in lead times of materials, excessive stocks are kept in various raw materials which increase stock keeping costs.

6.4 Identifying Problems in Production Management

There is no software used for the production process and reporting in the establishment. No statistics relating to production are available except for some efficiency and the cost analysis done on PCs.

Material tree charts do not exist for the produced goods and advance-ordering time-tables for various production phases (for these goods) are not recorded either.

In the company, production program are prepared in the weekly production meetings, in response to the requisitions coming from the sales department. This programming is done entirely on the basis of general information and experience, and from time to time, since all the details are not taken into consideration at the time

of planning; production plans are necessarily revised even after the production process is under way, reducing productivity.

The identified problems in production planning can be grouped under the following headings:

(1) Material tree charts and advance ordering time tables do not exist.

(2) Statistics which would help production planning, such as data on past production efficiency, waste quantities, reasons for work stoppages, idle times etc. are not available.

(3) Since computer support is not available, involuntary revisions in production programs reflecting changes in orders and/or supply sources can not be done in time and accurately.

(4) All the necessary data needed for making accurate production plans can not be obtained; and without computer support, processing what data available takes long time; therefore it is not possible to develop alternative scenarios and choose the best one.

(5) Since production data are not promptly recorded in the system, costs for production orders can not be correctly calculated.

(6) Realistic delivery dates can not be given to customers and this lowers customer satisfaction levels.

6.5 A General Evaluation on the Identified Problems

In spite of all the short-comings mentioned above, the company has an experienced and self-denying management team and using the advantages of operating in this sector for many years and having in-depth knowledge, manages to do its planning in the best way possible with the available resources.

Nevertheless, there is no doubt that a computer based MRP system, which will include the planning, production, finance and distribution modules, is necessary for providing the coordination and information flow between various departments and for the integration of the system. The lack of coordination and the flaws in information flow are the most prevalent and also the most serious problems in the current system of the company.

The company is operating in a highly competitive sector; so while raising the level of customer satisfaction which is an important factor in soliciting demand, considering today's economical conditions, it needs to keep the inventory reserves at minimum levels, in other words, to minimize the funds tied up in stocks; so comes naturally the answer to the question of how to solve the firm's problems. The cost of raw materials is the highest among all the costs incurred by the company (such as labor cost, factory overheads, etc.). It constitutes about 60 percent of total costs. Minimizing the funds tied up in stocks is only possible with reducing stock levels.

The firm, having decided to install the MRP system as a result of the above-mentioned conclusions, initiated studies within the framework of project to overcome the problems and these are explained in the following sections.

6.6 Solving the Problems of the Establishment

In this stage; we will tell the studies taken to solve the problems in the company. The following solutions to the problems were decided upon:

6.6.1 Changing the Current Hardware and Software

In order to solve the problems of the establishment, first of all, it is decided to improve the current computer system and the relevant other aspects of the general information flow/communication system to achieve company wide automation. QAD, which is a private consulting company, is hired to study the flaws and shortcomings of the general information system and troubles in the computer system.

A team of 6, chosen from among the employees of the company, including the author, is formed to co-operate with this private consulting company. Taking into consideration the previously identified problems, and the business volume, needs and plans for the future of the company, it was proposed to the management to purchase new hardware and software systems. As a result, the management decided to purchase the MRP/PRO software which is a MRPII system of U.S.A. origin. At the same time, the hardware would be replaced to reflect the latest advances in technology. The justifications for renewing the software and hardware systems and buying the software from abroad can be summarized as below:

(1) The current software and hardware are obsolete and fall way behind contemporary technology; and it is nearly impossible and very costly to upgrade the existing systems.

(2) Developing the software within the company is more costly and the company doesn't have time to lose before implementing MRP.

(3) There are not sufficient numbers of qualified employees in the company to develope MRP software.

(4) It is difficult to incorporate technological advances and new approaches rapidly if the software is developed within the company.

(5) The software to be purchased includes all the modules, ie. finance, distribution, planning and production.

Choosing the software package that is the most suitable for the needs of the company is an even more important point than the decision to install MRP system. The method used in choosing MRP/PRO software is explained below and can also serve as a guide for other companies:

(1) An evaluation committee consisting of managers of every department was formed.

(2) The developments in MRP field in both Turkey and the rest of the world were observed.

(3) The number of software companies offers of which which would be considered was limited to three.

(4) In order to make sure that the software (to be chosen) would be compatible with the domestic accounting regulations, an approval certificate from independent consulting companies was required.

(5) One-day presentations were received from the supplier companies. Also one-day visits were planned for the suppliers before presentations, in order to let them have information about the company. It was important that the presentation covered the critical points determined beforehand.

(6) While evaluating the offers of the companies providing MRP solutions; care was taken to see if the needs of the company would be satisfied with standard software package and the current version. A guarantee was asked from the supplier companies that in case the company's needs could not be fully satisfied with standard software; additional tailor-made software could be written or the needs could be satisfied with upgraded versions.

(7) Telephone calls were made to project managers of the companies which were in the reference list of the supplier companies. We spoke with the managers of those firms which had bought the software packages in question but implementation was not successful.

(8) The most important factor to consider is consultancy support. It was considered very important for supplier companies or the solution partners (at least two applications) to have experienced consulting teams.

After the selection of the software; a project was initiated to adapt it to the company. The project consisted of studies on solutions of the problems that we had identified earlier and on the modifications in the system to enable it to function efficiently. This project enjoyed full support of the senior management and assistant general manager was appointed as project manager.

The project management committee included one authorized representative from every department. Besides; work groups were formed to work on specific subjects and these groups were controlled and coordinated by upper level management.

The project management committee was meeting periodically to check if the targets determined according to the project plan that had been prepared and approved earlier were being reached and to make sure that activities being carried out within the project would be completed within the planned time-table. Also; in consideration of probable delays, the targets were reviewed and the plan was revised.

One of the main goals of the project was, apart from implementation of the new software, was to have this new system well-adopted and accepted by the whole company.

6.6.2 Installation of the Software

The main sections of the project and the activities performed in these sections correspond to the headlines under which the identified problems were grouped and described earlier.

6.6.2.1 Review of Inventory Management

(1) By going over all the inventory items, the product categories were grouped on basis of inventory class; and by including other detailed information, a new coding system was created for the finished products, semi-processed products and the raw materials.

(2) The physical borders of the stock areas, and the personnel responsible for the each area were determined.
(3) Studies were conducted for re-arranging storage of packages to allow for easier stock-taking and to develop new methods of storage that permit easier stock-taking.

(4) It is ensured that every stock movement was promptly recorded in the system by warehouse officials and all physical stock movements were accompanied by relevant documents produced by the system.

(5) By taking frequent stock counts on randomly selected items; the correspondence of stock-taking and recorded inventory figures was attempted to be maintained.

(6) The justification codes for accepting returns and rejecting supplies were separated and closely monitored.

(7) It was ensured that every stock movement between the warehouses and the production centers were duly recorded.

6.6.2.2 Review of Purchasing Management

In this phase, emphasis was placed on the software module which allows for internal requisitions to be consolidated on basis of buyers and then buyers' consolidating and grouping them according to various criteria and converting them to procurement orders.

Also, for every inventory item, information on details such as supplier, advance order time-table, order-lot size, minimum and maximum stock levels, etc. were collected and recorded. Price lists for all materials are updated. We can summarize these activities as follows:

(1) For every material, advance-order time tables and maximum and minimum

lot sizes, if any, were determined.

(2) It was ensured that for every material and service to be procured, requisitions were entered into the system. These requisitions were converted into procurement orders by buyers and the materials were taken delivery of and recorded into the system by the officers of the material-entry warehouse. By this way, all materials and services coming from outside were duly registered.

(3) Lot sizing policies, minimizing the purchasing costs of the raw materials, were incorporated into the system.

(4) The practice of issuing material purchase orders on basis of specific requirements determined by the system began.

6.6.2.3 Review of Production Management

The most comprehensive and most time consuming efforts were made on this subject. There was resistance to the new system by the production people because production people were not familiar with computers and they felt as if it was being imposed on to them and this slowed down the pace of reform. The activities undertaken can be summarized as follows:

(1) For each and every product manufactured at the plant, product recipes and production time requirements were determined.
(2) Work flow routes were drawn up.

(3) Waste rates were determined.

(4) Capacity constraints affecting production were identified.

(5) The lead times for the sales orders received began to be determined in accordance with capacity utilization reports produced by the system.

6.6.2.4 Training Programs

Among all the work performed within the framework of this project, the most important was telling everyone in the organization, beginning from top level directors to the lowest level operators, what MRP stood for, the aims and the logic of it, and getting MRP system accepted. Managers and the other users were informed about the inputs and the outputs of the system and explained why MRPII system should be implemented. Because it was imperative for the success of the project that the project was accepted and adopted by the people who would use the system and they were convinced of the necessity of it.

For this purpose, training sessions were organized at the firm's premises and MRPII system was attempted to be explained. From each department some staff members were selected and trained and then were used in training their own departments and getting the new system accepted by their departments. In this way, users were able to overcome simple problems by themselves and the upper level work groups and the project management committee could focus their energies to the overall implementation of the project.

From time to time, training sessions were held for audiences grouped on the basis of scope and level, but for general points, training sessions were held with wider participation.

6.7. Project Results

In this section, we will review the project work done for the new software, and will dwell upon the results of these activities. We will review the changes that occurred after the new software began to be implemented in inventory, purchasing and production management, the problems in which we had examined earlier and for the improvement of which the new system was implemented and will evaluate the results.

6.7.1. Results in Inventory Management

The most important aims of the work done on inventory management were making the physical stock-taking figures and inventory record figures match each other, making every material movement to be instantly traceable on the system; creating the storage conditions necessary for making stock-counts made at the end of each month, easier and reducing stock levels. The results of the implementation of the new software were:

(1) The deviation in stock figures, as calculated after the end-of-month stock-takings, was reduced by about 80%. But the aim is to bring the deviation down to zero. In a system in which all entries, exits and movements of stock are duly recorded, deviation in stock quantity figures can only be possible to to human error. Despite all the training provided, warehouse staffs do still make erroneous entries while recording stock movements into the system. In this case, what must be done is to detect and correct such kind of mistakes not in end-of- month stock counts but during daily spot controls while the production is underway. This will improve the reliability of the system.

(2) Every kind of material movement was recorded and traceable in the system. The physical inventory movements were being promptly recorded into the system therefore all the inventory reports produced by the system were up-to-date and correct. As a result of net requirements being determined by healthy inventory reports, uncessary raw material stock levels were lower and this reduced stock keeping costs. The main point here is that stock costs were reduced even while all the net requirements were supplied. This means that no out-of-stock cost is incurred. Comparing raw material stock levels before and after the implmenetation of the new software, we see on the average, an 11% decrease. (But no decline in production capacity during this period). With this decrease, the share of stock-keeping cost in total costs went down to 51%. But when we look at the achievements of other similar firms in the same industry using MRPII applications, we see that on the average 25% decline in their stock levels (Wong & Kleiner, 2001). So, the safety stock

levels determined for the materials in the establishment must be scrutinized again, and optimum safety stock levels must be determined and actual stock levels must be re-checked again and again to see if they come down to desirable levels. Of the approximately 918 tons of stock which the company has at present, 72% is related to orders. The remaining 28% is made up of safety stocks for various types of materials. The part that needs to be scrutinized is this.

Table 6.1 Comparing the average stock levels before and after the MRPII

	Raw Material Stock Level (film+paper)
Before MRPII	1036 ton
After MRPII	918 ton

6.7.2 Results in Purchasing Management

(1) Up-to-date supply information taken from suppliers were registered into the system by purchasing department, and as a result, the problems in supply lead times have declined. The practice of keeping unnecessary stocks in raw materials was given up and this reduced stocking costs. The aim is to be abe to supply required materials on time.

(2) Lot sizing policies were determined for raw materials and thus procurement costs were reduced. Appropriate lot sizes and ordering intervals began to be determined in accordance with these lot sizing policies. An example of the determination of lot sizing policies is provided in the next section.

6.7.3 Results in Production Management

(1) The production reports required by the senior management such as waste quantities, work stoppage reasons, productivity, the idle periods and production quantities can be obtained from the system daily, weekly and monthly.

(2) Production plans can be promptly revised reflecting changes in orders or sources. These changes may be in the form of postponing order dates, bringing forward or delaying delivery times, revisions in order quantities, or problems arising from materials or machines.

(3) While the rate of deliveries on the promised dates was 70-72% before the implementation of the new software; now this rate is approximately 85-90%: This means a 20% improvement (capacity and sales order quantities remain unchanged). This improvement has raised the level of customer satisfaction. One of the main factors causing this improvement is that order delivery dates began to be determined in consideration of the capacity utilization rates predicted by the MRPII capacity reports. Another important factor is the fact that as a result of planning the operations, material requirement dates, and job orders, by taking into account delivery dates of issued procurement orders, waiting times on the queue which was arising from manual planning got shorter. But again, looking at MRP applications of the other similar establishments in the same sector, it is seen that this rate of improvement reaches about 27% (Wong & Kleiner, 2001). In the establishment which operates in this highly competitive sector, production plans are often interfered for some special customers and some urgent orders are squeezed into plans. As a result of this practise, delays occur in the deliveries to other (normal) customers. Since it is not possible to obtain healthy requirements forecasts from customers, my suggestion is to reserve a certain production capacity for such kind of urgent and important requirements. This way, order delivery times will not be affected by interferences and the improvement rate can be further raised up from the level of 20%. Although it would seem that if those special, urgent orders did not materialize, the firm would be losing money (for keeping idle capacity), it is highly important to meet the urgent requirements of such kind of important customers in order to compete in this sector.

CHAPTER SEVEN

APPLICATION

The results achieved by a scientific method of ordering after the installation of the new software will be analyzed.

There are three lot sizing techniques in the software MFG/PRO that is used by the company. They are; Lot for Lot (LFL), Fix Order Quantity (FOQ) and Periodic Order Quantity (POQ) techniques. For this reason the selection will be made only from among these three ordering techniques. The aim is to reduce the purchasing costs with proper ordering techniques and to determine the appropriate order lot sizes and ordering intervals.

For the application to determine the proper lot sizing technique, Kerevitaş frozen food package orders, that have regularity, have been chosen. Below there is the master production schedule covering 16 weeks' orders.

Table 7.1 The master production schedule for Kerevitaş frozen food package

	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
PERIODS(weeks)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
QUANTITIES(kg)	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500

In Figure 7.1 and Table 7.2 the product structure tree for the frozen food package, unit input quantities and supply lead times of the finished products; semi-processed products and raw materials can be seen. In addition, bill of materials, which is taken from MFG/PRO, can be seen in appendix 1.

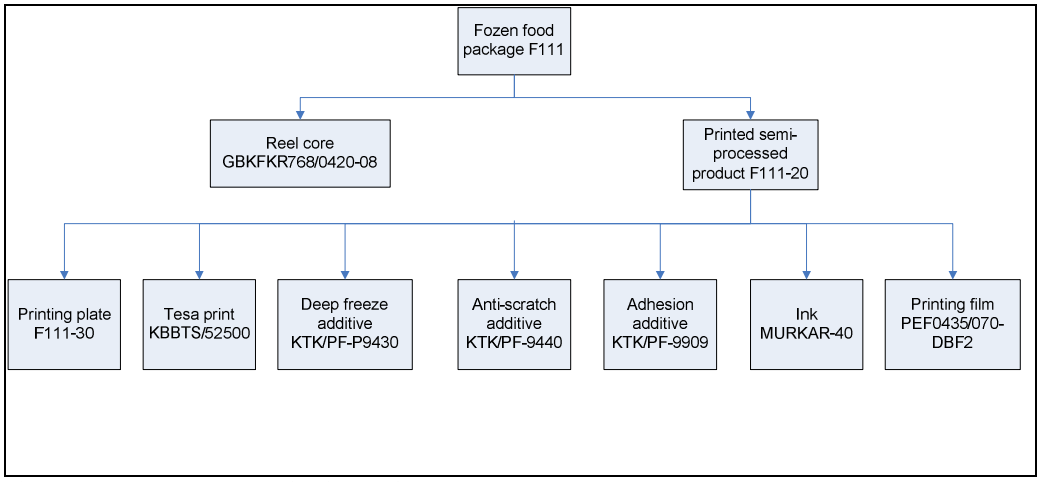

Figure 7.1 The product tree for frozen food package

Table 7.2 The bill of materials for frozen food package

Level	Item Name	Unit	Quantity	Lead Time	Source
0	Frozen food package F111	kg	1	2 Days	Manufacturing
1	Reel core GBKFKR768/0420	kg	0.023699	1 Week	Purchasing
1	Printed semi-processed product F111-20	kg	1	1 Day	Manufacturing
2	Printing plate F111-30	c2	1	2 Days	Manufacturing
2	Tesa Print KBBTS/52500	c2	4	2 Days	Purchasing
2	Deep Freeze additive KTK/PF-9430	kg	0.004034	1 Day	Purchasing
2	Anti-scratch additive KTK/PF-9440	kg	0.003026	1 Day	Purchasing
2	Adhesion additive KTK/PF-9909	kg	0.003026	1 Day	Purchasing
2	Ink MURKAR-40	kg	0.21685	2 Days	Purchasing
2	Printing film PEF0435/070-DBF2	kg	1,00998	4 Weeks	Purchasing

7.1 Determining the Appropriate Lot Sizes and Creating the MRP Tables for Components

The frozen food package, printing design for printed bobbin semi-processed products are determined by the customer before the start of each production run. In other words there is more than one design for this product and the production will be done according to the needs of a customer at the time. In such a case it is impossible

to keep stocks and only lot for lot technique can be applied for the finished product, printed semi-processed product, printing plate, tesa print and ink. These items are procured in the quantities and at the times required. Also the deep freeze additive KTK/PF-9430, anti-scratch additive KTK/PF-9440 and adhesion additive KTK/PF-9909 are flammable products that include alcohol and therefore they can not be stocked either. As required, they can be obtained from a supplier company located in AOSB. The most appropriate lot sizing techniques will be determined for the other items.

7.1.1. MRP Tables for the Kerevitaş Frozen Food Package, Semi-processed Products, Tesa Print and Ink

For finished products and semi-processed products, tesa print and ink, the MRP schedule prepared according to the lot for lot technique will be as seen in Table 7.3, Table 7.4, Table 7.5, Table 7.6 and Table 7.7.

Table 7.3 The MRP Schedule for Kerevitas frozen food package

	Source				Item				Lead time				Lot sizing policy			
	Manufacturing				Frozen food package				0 Week				Lot for Lot			
	PERIODS															
	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
On-hand quantity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled receipts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
Planned order receipts	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
Planned order releases	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500

At the beginning of each production run, there is a setup time for the items in net requirements that need to be produced in scheduled times. The setup cost to be incurred can be calculated using the following formula.

Setup cost = setup time x machine hour cost

Machine setup cost for the product = 0.5 hour x 90 YTL/hour = 45 YTL

Total setup cost for Kerevitaş frozen food package orders = 16x45 = 720 YTL

Table 7.4 The MRP Schedule for printed film semi-processed product F111-20

	Source				Item				Lead time				Lot sizing policy			
	Manufacturing				F111-20				0 Week				Lot for Lot			
	PERIODS															
	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
On-hand quantity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled receipts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
Planned order receipts	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
Planned order releases	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500

Machine setup cost for the printed bobbin semi-processed product = 3 hours x 130/hour YTL = 390 YTL

Total setup cost = 16x390=6.240 YTL

Table 7.5 The MRP Schedule for semi-processed product printing plate F111-30

	Source				Item				Lead time				Lot sizing policy			
	Manufacturing				F111-30				0 Week				Lot for Lot			
	PERIODS															
	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
On-hand quantity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled receipts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
Planned order receipts	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500
Planned order releases	500	2500	2000	2000	1300	1500	1500	500	500	500	1000	1000	1000	1000	500	2500

Set up cost for printing plate semi-processed product = 2 hours x 100 YTL/hour = 200 YTL

Total set up cost = 16x200 = 3.200 YTL

Table 7.6 The MRP Schedule for tesa print KBBTS/52500

	Source				Item				Lead time				Lot sizing policy			
	Purchasing				Tesa Print KBBTS/525				0 Week				Lot for Lot			
	PERIODS															
	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements	2000	10000	8000	8000	5200	6000	6000	2000	2000	2000	4000	4000	4000	4000	2000	10000
On-hand quantity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled receipts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements	2000	10000	8000	8000	5200	6000	6000	2000	2000	2000	4000	4000	4000	4000	2000	10000
Planned order receipts	2000	10000	8000	8000	5200	6000	6000	2000	2000	2000	4000	4000	4000	4000	2000	10000
Planned order releases	2000	10000	8000	8000	5200	6000	6000	2000	2000	2000	4000	4000	4000	4000	2000	10000

Tesa print is a material that can be obtained from domestic market. The ordering cost for the materials purchased locally will be calculated as follows:

Ordering cost = communication cost + cost of printed form = 2 YTL/order

The total cost for Lot for Lot technique = 16 x 2 =32 YTL

Table 7.7 The MRP Schedule for the printing ink

	Source				Item				Lead time				Lot sizing policy			
	Purchasing				printing ink				0 Week				Lot for Lot			
	PERIODS															
	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements	108	542	434	434	282	325	325	108	108	108	217	217	217	217	108	542
On-hand quantity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled receipts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements	108	542	434	434	282	325	325	108	108	108	217	217	217	217	108	542
Planned order receipts	108	542	434	434	282	325	325	108	108	108	217	217	217	217	108	542
Planned order releases	108	542	434	434	282	325	325	108	108	108	217	217	217	217	108	542

Total cost for Lot for Lot technique = 16x2=32 YTL

7.1.2 Determining Appropriate Lot Size and Producing the MRP Tables for the Printing Film PEF0435/070-DBF2

The net requirements for the printing film can be seen in Table 7.8. Also in Appendix No 2 there is a report of the net requirements for the film. The MRP Schedule will be prepared for the three different lot sizing techniques.

Table 7.8 The net requirements for printing film PEF0435/070

	Source				Item				Lead time							
	Purchasing				PEF0435/070-DBF2				4 Weeks							
	PERIODS															
	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements	505	2524	2019	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
On-hand quantity=3191kg	2686	162	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled receipts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements	0	0	1857	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524

(1) The MRP Schedule obtained as a result of orders given according to the Lot for Lot technique can been seen in Table 7.9.

The following formula will be used to calculate the ordering cost when ordering according to the Lot for Lot technique. This Formula is also valid for the imported materials.

Ordering cost = (the cost of establishing letter of credit) + (communication cost) + (acting order)

Ordering cost = 350 YTL/order (approximate importing charges)

Total cost for Lot for Lot technique = 14x350 =4.900 YTL

Table 7.9 The MRP Schedule for PEF0435/070-DBF2 as to the results of the LFL method

	Source				Item name								Lead Time				Lot sizing rule			
	Purchasing				PEF0435/070-DBF2								4 Weeks				Lot for Lot			
	PERIODS																			
	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements					505	2524	2019	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
On-hand quantity=3191 kg					2686	162	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled Receipts					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements					0	0	1857	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
Planned order receipts							1857	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
Planned order releases			1857	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524				

(2) Secondly, the MRP Schedule when ordering according to the Fix Order Quantity technique and the total sum of purchasing cost will be analyzed. In Table 7.10 the orders given according to this technique can be seen.

Fix order quantity determined for Fix Order Quantity technique is 5.000 kgs. While determining this quantity the material price and the total amount that will be paid at one time are taken into consideration.

The total cost of Fix Order Quantity technique = 4x350=1.400 YTL

Table 7.10 The MRP Schedule for PEF0435/070-DBF2 according to FOQ method

	Purchasing				PEF0435/070-DBF2								4 Weeks				FOQ			
	PERIODS																			
	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements					505	2524	2019	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
On-hand quantity=3191 kg					2686	162	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled Receipts					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements					0	0	1857	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
Planned order receipts							5000		5000						5000					5000
Planned order releases			5000		5000						5000					5000				

(3) For the third and last, the MRP Schedule when ordering according to the Periodic Order Quantity technique and the total sum of purchasing cost will be analyzed. In Table 7.11 the orders given according to this technique can be seen.

In order to find the ordering invertal to be used in Periodic Order Quantity technique first of all the Economic Order Quantity must be determined. The formula can be seen below;

Economic Order Quantity = $\sqrt{2KD/H}$

K: Ordering or setup cost (will be taken 350 YTL as calculated before)

D: The demand rate per unit time (the annual net required quantity for the material will be found)

D: 16785x52/14=62344 kgs (annual usage)

H: The holding cost per item per period (the following formula is being used for the holding cost calculation)

Monthly Holding Cost = A+B

A: The monthly cost ratio of the money invested in the Inventory

A= (Monthly rate of Interest of getting into dept) – (monthly rate of price increase)

B: Monthly Insurance Premium of the Inventory

A= (0.0192-0.0162) = 0.003

As stated by the company, the yearly insurance premium constitutes 1.572% of the total inventory cost. In this case, the monthly insurance premium of the inventory (B) will be equal to 0.01572/12.

(Monthly Holding Cost) = (0.003+0.01572/12)* unit cost

(Monthly Holding Cost)= (0.003+0.01572/12)*3.2 YTL=0.0138 YTL

Annual Holding Cost = 0.0138 x 1 2 = 0.1656

EOQ = √2x62344x350/0.1656=16233 kg= 16000 kg

Ordering interval can be found after finding Economic Order Quantity.

Orders per year =62433/16000=3.9

Ordering interval = 52/3.9=13.33 ≈ 13 weeks

Orders will be placed for the 13- week period requirements. In such case:

Total cost for Periodic Order Quantity technique = 2x350 YTL=700 YTL

Table 7.11 The MRP Schedule for PEF0435/070-DBF2 according to POQ method

	Source				Item name								Lead Time				Lot sizing rule			
	Purchasing				PEF0435/070-DBF2								4 Weeks				POQ			
	PERIODS																			
	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements					505	2524	2019	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
On-hand quantity=3191 kg					2686	162	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled Receipts					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements					0	0	1857	2019	1312	1514	1514	505	505	505	1009	1009	1009	1009	504	2524
Planned order receipts							12758											4037		
Planned order releases			12758											4037						

The applied 3 ordering techniques will be compared and the technique with lowest ordering cost calculation will be selected. The lot size and the ordering interval for the chosen technique will be accepted.

Table 7.12 Comparing the applied lot sizing techniques

Technique	Total cost (YTL)
Lot for Lot	4900
Fix order quantity	1400
Periodic order quantity	700

As it is seen in Table 7.12, the lowest cost is realized by POQ technique. Therefore the MRP program that is prepared according to this technique will be accepted. In Appendix 3 the stock planning information prepared by using the data calculated with this technique can be seen.

7.1.3. Determining Appropriate Lot Size and Producing the MRP Tables for the Reel Core GBKFKR768/0420

The net requirements for reel core can be seen in Table 7.13. For three different ordering policies the MRP program will be prepared in turn.

Table 7.13 The net requirements for GBKFKR768/0420

	Source				Item				Lead time							
	Purchasing				GBKFKR768/0420				1 Week							
	PERIODS															
	NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements	12	59	47	47	31	36	36	12	12	12	24	24	24	24	12	59
On-hand quantity=50 kg	12	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled receipts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements	0	21	47	47	31	36	36	12	12	12	24	24	24	24	12	59

(1) The MRP program when ordering according to Lot for Lot technique for reel core can be seen in Table 7.14.

Table 7.14 The MRP Schedule for GBKFKR768/0420 according to LFL method

	Source				Item name							Lead Time								Lot sizing rule			
	Purchasing				GBKFKR768/0420							1 Week								Lot for Lot			
	PERIODS																						
	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY						
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
Gross requirements					12	59	47	47	31	36	36	12	12	12	24	24	24	24	12	59			
On-hand quantity=50 kg					12	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Scheduled Receipts					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Net requirements					0	21	47	47	31	36	36	12	12	12	24	24	24	24	12	59			
Planned order receipts						21	47	47	31	36	36	12	12	12	24	24	24	24	12	59			
Planned order releases					21	47	47	31	36	36	12	12	12	24	24	24	24	12	59				

Reel core is a material that is procured from the domestic market. The ordering cost that is used for the materials purchased locally will be calculated as follows;

Ordering costs= communication costs + cost of printed form = 2 YTL/order

Total cost for Lot for Lot technique = 15X2 = 30 YTL

(2) Secondly, the MRP program for ordering according to Fix Order Quantity technique and the arising total purchasing cost will be analyzed. In Table 7.15 the orders given according to this technique can be seen.

Considering needlessness of overstocking due to supply lead time being short, the 50 kg of ordering lot is thought to be proper. At the same time for the supplier the rate of waste is getting higher in orders less than 50 kg.

Table 7.15 The MRP schedule for GBKFKR768/0420 according to FOQ method

	Source				Item name							Lead Time					Lot sizing rule			
	Purchasing				GBKFKR768/0420							1 Week					FOQ			
	PERIODS																			
	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements					12	59	47	47	31	36	36	12	12	12	24	24	24	24	12	59
On-hand quantity=50 kg					12	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled Receipts					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements					0	21	47	47	31	36	36	12	12	12	24	24	24	24	12	59
Planned order receipts						50	50	50		50	50			50		50			50	50
Planned order releases					50	50	50		50	50			50		50			50	50	

The total cost for Fix Order Quantity technique = 9x2 = 18 YTL

(3) As third and last technique, the MRP program for ordering according to Periodic Order Quantity technique and the total purchasing cost will be analyzed. In Table 7.16 the orders given according to this technique can be seen.

(Monthly holding cost)= (0.003 + 0.01572/12)* unit cost

(Monthly holding cost) = (0.003 + 0.01572/12)* 1 YTL= 0.000431 YTL

Annual holding cost = 0.000431*12 = 0.05172 YTL

D: 421 x 52/15 = 1460 Kg (annual usage)

EOQ = √2x1460x2/0.05172 = 336 kg

After finding the economical order quantity the ordering interval can be found.

Orders per year = 1460/336 = 4.34

Ordering interval = 52/4.34 = 11.96 ≈ 12 weeks

The orders will be given for 12 weekly periodical requirements. In such a case it appears that;

Total cost for Order Quantity technique = 2*2 YTL= 4 YTL.

Table 7.16 The MRP schedule for GBKFKR768/0420 according to POQ method

	Source				Item name							Lead Time				Lot sizing rule			
	Purchasing				GBKFKR768/0420							1 Week				POQ			
	PERIODS																		
	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gross requirements					12	59	47	47	31	36	36	12	12	12	24	24	24	24	12	59
On-hand quantity=50 kg					12	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scheduled Receipts					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net requirements					0	21	47	47	31	36	36	12	12	12	24	24	24	24	12	59
Planned order receipts						302											119			
Planned order releases					302											119				

The applied 3 order techniques will be compared and the technique with lowest ordering cost will be selected. The order lot size and the ordering interval for the chosen technique will be accepted.

Table 7.17 comparing the applied lot sizing techniques

Technique	Total cost (YTL)
Lot for Lot	30
Fix order quantity	18
Periodic order quantity	4

As it is seen in Table 7.17 the lowest cost has been obtained with POQ technique. In this case the MRP program prepared according to this technique will be accepted. In Appendix 4, the stock planning information prepared by using the data obtained according to this technique can be seen.

7.2 The Chosen Lot Sizing Techniques and Their Respective Costs

The chosen ordering techniques and their costs according to the above calculations are given at the following table.

Table 7.18 The chosen lot sizing techniques and their costs

Item	Technique	Total cost(YTL)
Frozen food package F-111	LFL	720
Reel Core GBKFKR768/0420	POQ	4
Printed film half product F111-20	LFL	6240
Printing plate half product F111-3	LFL	3200
Tesa Print KBBTS/52500	LFL	32
Ink MURKAR-40	LFL	32
Printing film PEF0435/070-DBF2	POQ	700

While the total cost obtained as a result of applying appropriate lot sizing techniques is 10.928 YTL, this amount before the implementation of the new system was 15.122 YTL. As it is seeen from this comparison, with the new MRPII system the ordering costs of the company are reduced, and the order lot sizes and ordering intervals begin to be determined in optimal manner.

CHAPTER EIGHT
CONCLUSIONS

Today's highly competitive and volatile business environment forces companies to search for ways to respond quickly and to adapt rapidly to changes and unexpected developments. In this competitive atmosphere, resources must be used efficiently, costs must be better controlled and product qualities must be improved. In order to achieve these, production must be very well organized.

The problems faced by the company where this system has been implemented and the methods for solutions found, actually are the phenomena that many companies have faced in the recent past or will be facing in the near future. In a period when domestic and foreign competition increase, expected quality and service levels rise, very strict quality management approaches are required in international markets, to avoid financial problems while adapting to the new conditions, to employ new technology and to train employees in every level will be possible only by increasing productivity through optimum use of resources.

The management of inventory, for which major part of the financial resources of many firms are allocated, becomes even more important under these conditions and forces establishments to use scientific methods.

Material requirements planning, with the support of computers in our age, both provides an excellent material management method and also puts unavoidably the company that decides to implement the system into rehabilitation while providing the necessary conditions for the installation of the system. Apart from the intrinsic advantages of MRP, during the installation stage, disciplining the company in many ways is one of its important benefits.

In a company, before starting the installation of MRP and MRPII systems, the requirements of these new software and the needs of the company must be very well analyzed. The manpower requirements during installation and the related expenses

must be known (in advance) by the management. The needs of the company must be clearly stated and how the new system will satisfy those needs must be considered. If necessary, changes in the organization chart must be made. Necessary trainings for all employees must be provided. In every stage during the installation and implementation of the new system, cooperation between all employees and managers must be ensured and support must be given to needing departments. During the transition period, the system's performance must be tested often, solutions for current problems must be searched and results must be evaluated.

In the company where the new system has been installed, the most important benefit expected from the new software was reduction of stock levels and this was realized. With the implementation of the new software, an 11% reduction in stock levels was realized. This was achieved by reducing oversized safety stocks through (better) control of inventory levels and procurement lead times. In order to further raise this rate of improvement, the inventory items for which safety stocks are kept and the optimum stock levels must be re-examined. Safety stocks in companies are helpful in hiding problems. For this reason they must be reduced step by step untill they come down to optimum levels.

Besides, the rate of sales order deliveries on promised dates (on-time delivery) rose from 70% to 85–90% and thus customer satisfaction increased. This was achieved with healthy capacity planning by using all the data provided by the new software. It can be possible to further raise this rate by amending the capacity plan to accomodate unexpected, urgent and important demands from clients.

For implementation, the production of Kerevitaş frozen food packages was taken as an example and the material requirement plans for the components (inputs) in the bills of material of this product were created. In this study, the 2006 data received from the company have been used. Three different lot sizing techniques in MFG/PRO were applied to determine appropriate order lot sizes and ordering intervals and the results have been compared in the light of their respective costs. The most cost effective ordering policy has been determined. The total ordering cost of the sample product and the components that were discussed in the implementation

report, has been reduced from 15,122 YTL to 10,928 YTL. The results achieved with the ordering process which employs scientific methods thanks to the implementation of the new software have been analyzed.

MRP and MRPII systems are very costly systems to install. Failure (in implementation) causes big problems for the companies. For this reason before deciding, the current system must be analyzed thoroughly and the shortcomings must be identified and if it is decided to buy new software, the selection of the software which will best fit the company becomes very important. This is a no-return decision. In this company, during the first year, the MRP concept and its' advantages were not fully understood and the necessary organizational reforms were not made at the necessary pace. This prevented the implementation of MFG/PRO effectively. But in the course of time changes were made (changes in the organization, addition of new reports and modules) and at present the software is used efficiently. But every change means extra cost and wasted time.

MRPII systems aim for every activity to be performed and managed in every detail and in integration. All the working processes will be created on the software. This complicates the implementation of the software. Software that will work as soon as it is installed should not be expected. It is a considerably difficult and time consuming operation to adapt the working processes of the company to the software.. At this stage I have some suggestions that I think are very important for successful implementation:

(1) Top management' support and determination must be secured,

(2) All department managers must believe in and support the new system fully,

(3) One qualified staff from every unit must be assigned to the implementation project,

(4) The company's employee must be prepared for changes and the importance of teamwork must be stressed,

(5) Support of qualified consultants must be received,

(6) The Project manager must be selected from among those with experience in implementation of MRP.

Finally, if we summarize the whole study;

In the first chapter, MRP systems have been introduced and information has been given about its' development and history dating back to 1960's. The operating logic and the organizational requirements of MRP system have been explained.

In the second chapter, the benefits to be expected from MRP system, the aims of the implementation of the system and the complications to arise during installation have been explained. The inputs and outputs of MRP system have been told.

In the third chapter, the Lot Sizing techniques used for determining purchasing costs, ordering intervals and appropriate order lot sizes have been explained. Three of these techniques have been applied in the company in order to reduce purchasing costs.

In the fourth chapter, detailed information about the MRPII system, which is our main topic, has been given, the development process from MRP to MRPII has been told and the steps that must be taken for a successful MPRII implementation have been explained. These steps are like a roadmap followed by the many companies that have been successful in MRP implementation.

Although the focus of the study was on MRPII softwares, in the fifth chapter the latest advances have been noted and information about new production planning and control systems have been given.

In the sixth chapter, the problems that led the application company to buy new MRPII software, the suggestions for a healthy implementation and the results obtained with implementation have been evaluated. How the investment decision to

discard the existing hardware and software systems and to renew all systems was made, what kind of problems in the system had been identified before the installation of new software and what sort of solutions had been proposed, the corrective and precautionary measures taken have all been explained. Finally, whether or not the benefits expected from the MRP system had been realized was discussed.

In the implementation section, the results achieved with the new purchasing process which employs scientific methods owing to the implementation of the new software have been analyzed. A company producing packaging product has been used as an case study and by applying a number of techniques, to a chosen product and its components, appropriate order lot size have been determined and a material requirements plan has been formulated. By comparing different lot sizing techniques, cost wise, the most suitable technique has been determined.

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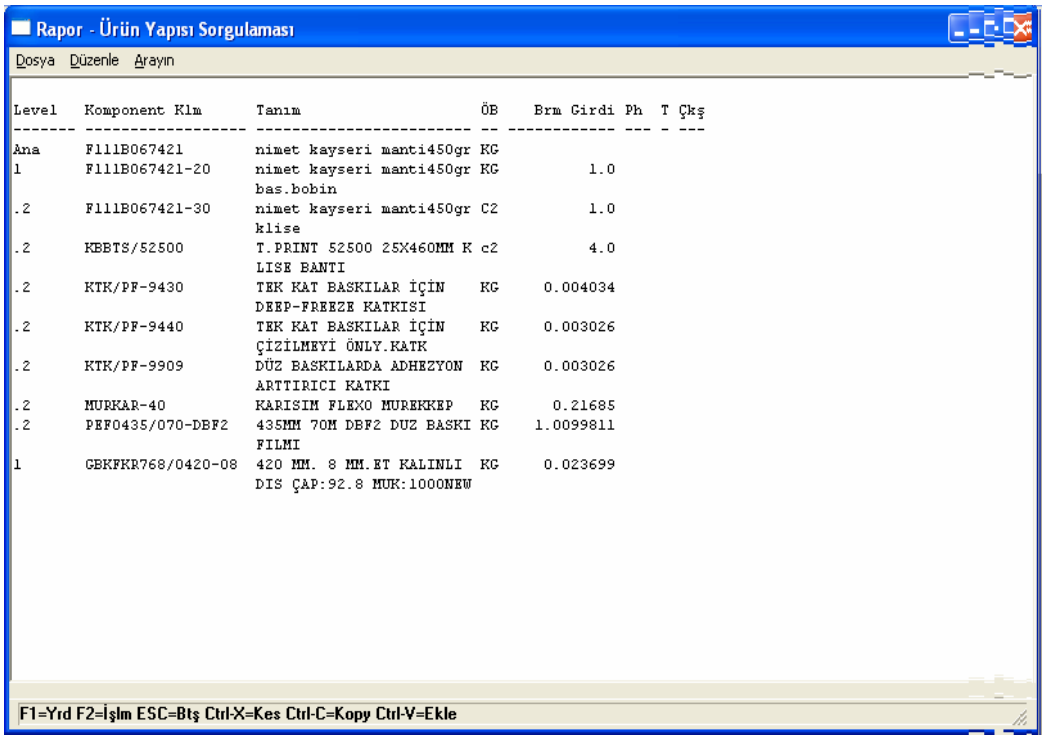
APPENDIX 1



Rapor - Ürün Yapısı Sorgulaması

Dosya Düzenle Arayın

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Ana	F111B067421	nimet kayseri manti450gr	KG				
1	F111B067421-20	nimet kayseri manti450gr bas.bobin	KG	1.0			
.2	F111B067421-30	nimet kayseri manti450gr klise	C2	1.0			
.2	KBBTS/52500	T.PRINT 52500 25X460MM K LISE BANTI	c2	4.0			
.2	KTK/PF-9430	TEK KAT BASKILAR İÇİN DEEP-FREEZE KATKISI	KG	0.004034			
.2	KTK/PF-9440	TEK KAT BASKILAR İÇİN ÇİZİLMEYİ ÖNLY.KATK	KG	0.003026			
.2	KTK/PF-9909	DÜZ BASKILARDA ADHEZYON ARTTIRICI KATKI	KG	0.003026			
.2	MURKAR-40	KARISIM FLEXO MUREKKEP	KG	0.21685			
.2	PEF0435/070-DBF2	435MM 70M DBF2 DUZ BASKI FILMI	KG	1.0099811			
1	GBKFKR768/0420-08	420 MM. 8 MM.ET KALINLI DIS ÇAP:92.8 MUK:1000NEW	KG	0.023699			

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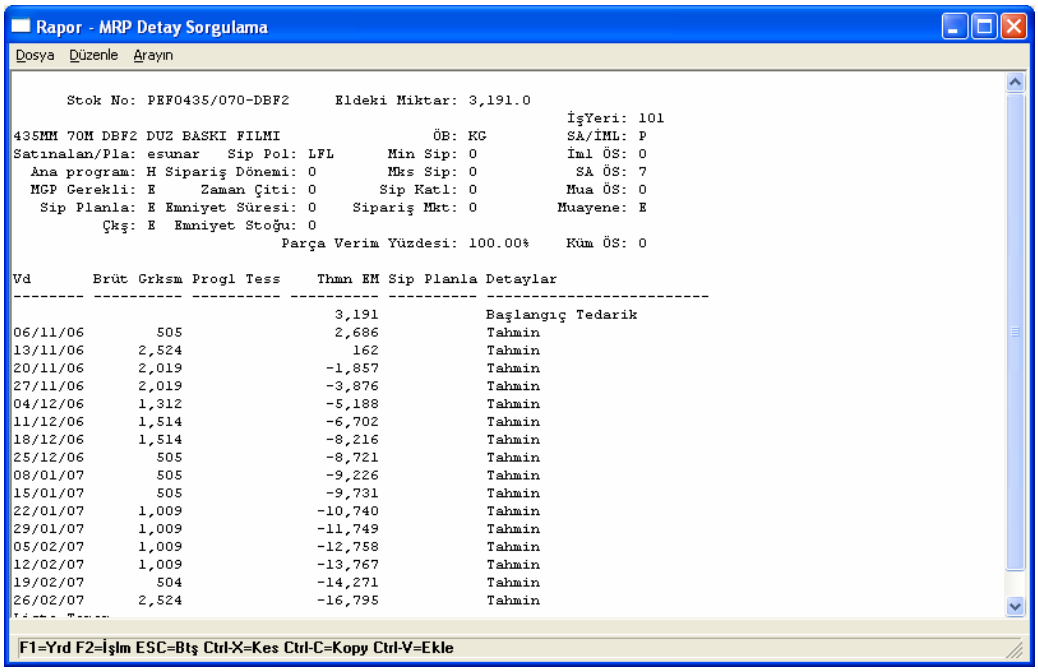
APPENDIX 2



Rapor - MRP Detay Sorgulama

Dosya Düzenle Arayın

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Satınalan/Pla: esunar   Sip Pol: LFL      Min Sip: 0       İml ÖS: 0
  Ana program: H Sipariş Dönemi: 0        Mks Sip: 0        SA ÖS: 7
  MGP Gerekli: E     Zaman Çiti: 0       Sip Katl: 0       Mua ÖS: 0
   Sip Planla: E Emniyet Süresi: 0    Sipariş Mkt: 0      Muayene: E
         Çkş: E  Emniyet Stoğu: 0
                              Parça Verim Yüzdesi: 100.00%    Küm ÖS: 0

Vd       Brüt Grksm Progl Tess    Thmn EM Sip Planla Detaylar
-------- ---------- ---------- ---------- ---------- -------------------------
                                    3,191            Başlangıç Tedarik
06/11/06        505                 2,686            Tahmin
13/11/06      2,524                   162            Tahmin
20/11/06      2,019                -1,857            Tahmin
27/11/06      2,019                -3,876            Tahmin
04/12/06      1,312                -5,188            Tahmin
11/12/06      1,514                -6,702            Tahmin
18/12/06      1,514                -8,216            Tahmin
25/12/06        505                -8,721            Tahmin
08/01/07        505                -9,226            Tahmin
15/01/07        505                -9,731            Tahmin
22/01/07      1,009               -10,740            Tahmin
29/01/07      1,009               -11,749            Tahmin
05/02/07      1,009               -12,758            Tahmin
12/02/07      1,009               -13,767            Tahmin
19/02/07        504               -14,271            Tahmin
26/02/07      2,524               -16,795            Tahmin
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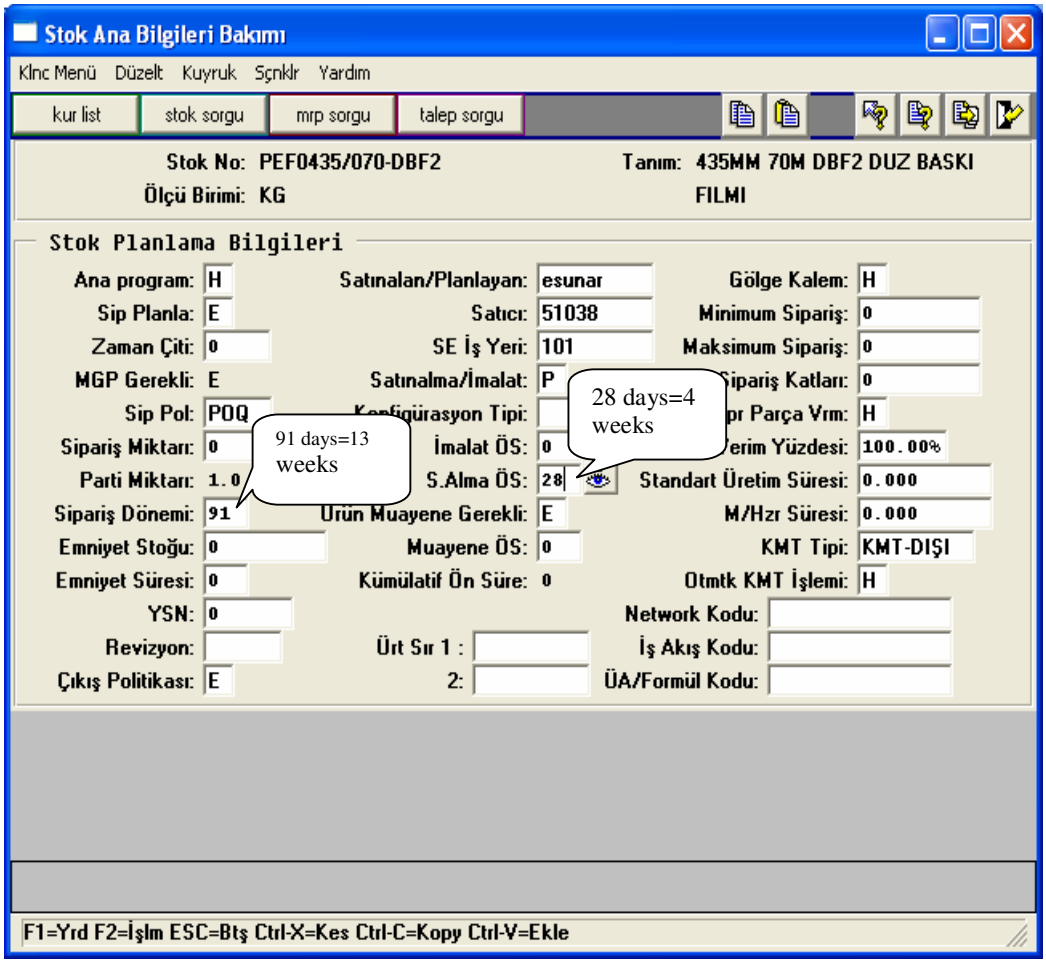
F1=Yrd F2=İşlm ESC=Btş Ctrl-X=Kes Ctrl-C=Kopy Ctrl-V=Ekle

APPENDIX 3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Klnc Menü Düzelt Kuyruk Sçnklr Yardım
kur list
stok sorgu
mrp sorgu
talep sorgu
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Tanım: 435MM 70M DBF2 DUZ BASKI
Ölçü Birimi: KG
FILMI
Stok Planlama Bilgileri
Ana program: H
Satınalan/Planlayan: esunar
Gölge Kalem: H
Sip Planla: E
Satıcı: 51038
Minimum Sipariş: 0
Zaman Çiti: 0
SE İş Yeri: 101
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Satınalma/İmalat: P
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Sip Pol: POQ
pr Parça Vrm: H
Sipariş Miktarı: 0
İmalat ÖS: 0
erim Yüzdesi: 100.00%
Parti Miktarı: 1.0
S.Alma ÖS: 28
Standart Üretim Süresi: 0.000
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Ürün Muayene Gerekli: E
M/Hzr Süresi: 0.000
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Muayene ÖS: 0
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Otmtk KMT İşlemi: H
YSN: 0
Network Kodu:
Revizyon:
Ürt Sır 1 :
İş Akış Kodu:
Çıkış Politikası: E
2:
ÜA/Formül Kodu:
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28 days=4 weeks
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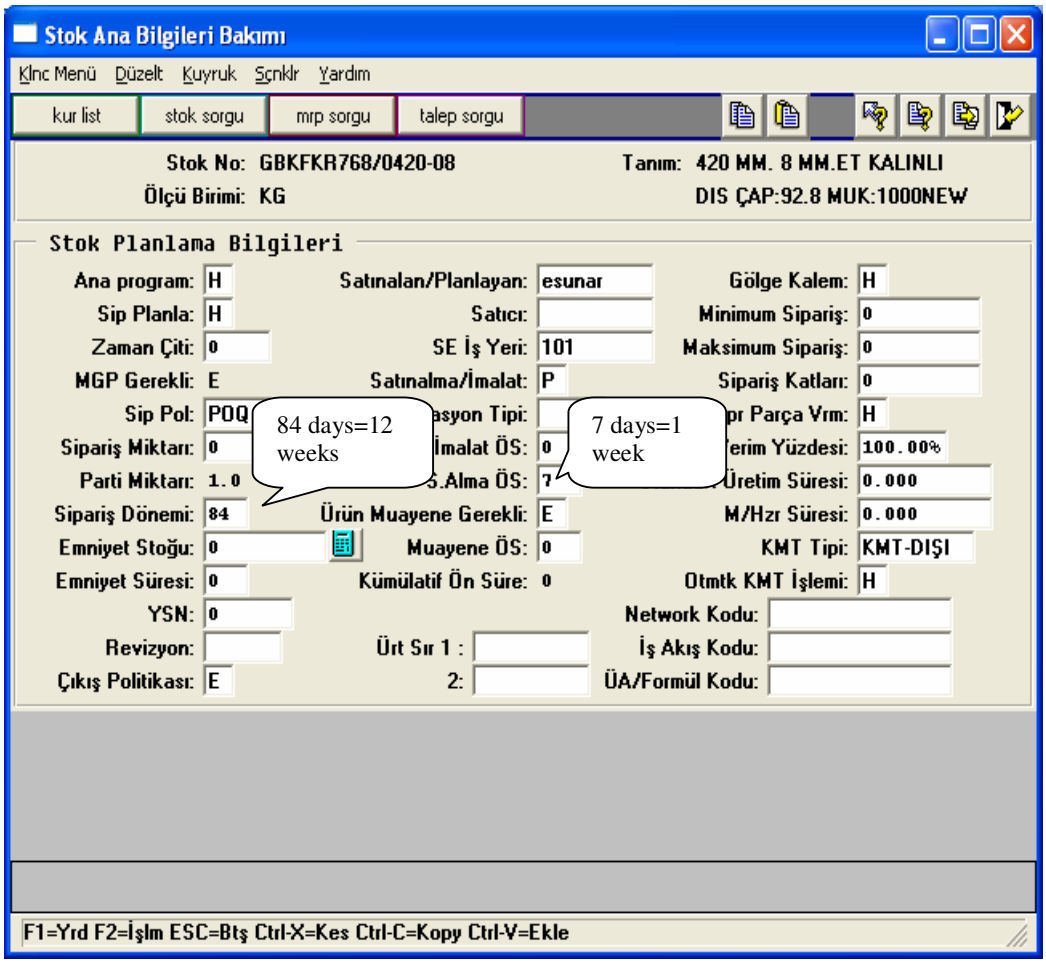
APPENDIX 4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kur list
stok sorgu
mrp sorgu
talep sorgu
Stok No: GBKFKR768/0420-08
Tanım: 420 MM. 8 MM.ET KALINLI
Ölçü Birimi: KG
DIS ÇAP:92.8 MUK:1000NEW
Stok Planlama Bilgileri
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Satınalan/Planlayan: esunar
Gölge Kalem: H
Sip Planla: H
Satıcı:
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SE İş Yeri: 101
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Sipariş Katları: 0
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YSN: 0
Revizyon:
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ÜA/Formül Kodu:
Ürt Sır 1 :
2:
84 days=12 weeks
7 days=1 week
F1=Yrd F2=İşlm ESC=Btş Ctrl-X=Kes Ctrl-C=Kopy Ctrl-V=Ekle