UNIT 10 MATERIAL PLANNING FOR CIM SYSTEM

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10.1 INTRODUCTION

The three important determinants of market share and profitability of any organization are the cost of manufacturing products and their quality and lead time. The manufacturing planning and control functions are solution to achieve the goals of minimum cost, high quality, and minimum lead time. That is why the understanding of basics of material planning and control are important.

Objectives
After studying this unit, you should be able to
- understand the principles of production and inventory control for CIM,
- describe the conditions under which MRP is most appropriate,
- discuss the inputs, outputs and nature of MRP processing, and
- explain MRP II and how it relates to MRP.

10.2 PRINCIPLES OF PRODUCTION AND INVENTORY CONTROL FOR CIM SYSTEM

10.2.1 Production Control

The production control is known as the heart of manufacturing system. Figure 10.1 gives the detail of production control of CIM. An estimate of the demand for each type of product sold is provided by demand forecasting. Long-term forecasting is done with enough lead time, for adjusting capacities that involves constructing new buildings, buying new equipment, and hiring people and usually takes 1 to 5 years. Short-term forecasting takes the time around 1 to 12 months to manufacture the required products.

The main objective of the aggregate production plan is to rationalize the differences between demand and existing production capacity within a planning horizon. Since
demand and the associated production requirements are present in the terms of some aggregate unit like direct labour hours, the production plan is better known as the aggregate production plan. The aggregate production plan is prepared after knowing the demand. Existing capacity is being compared to this aggregate measure which is expressed in the aggregate units, for each interval, usually a month, in the planning horizon.

After the development of the aggregate plan, it is to be disaggregated into a master production schedule. This plan identifies the types of the end product that must be produced in each period in the planning horizon. After finalizing this plan, all organizations should agree to the quantities available for sale in each interval of the planning horizon.

Production requirements can be planned at this point. Final product usually consists of several detailed parts, generally represented as a bill of materials, and inventories usually exist for some if not all of these parts. Consequently, master production plan cannot be used for detailed production plan without some modifications.

The material requirements plan will exceed capacity regularly for one or more of the detailed parts. A detailed capacity analysis of the material requirements plan determines this. Several ways, such as working overtime or subcontracting help in resolving capacity limitations. The material requirements plan and possibly the master production schedule are to be modified, if the capacity limitations can be resolved. Thus, developing master production schedule and a material requirements plan can be an iterative process.
10.2.2 Inventory Control

For inventory control, quantities to be deposited or withdrawn are specified by production control. The monitoring of the planned and actual quantities, as well as planned and actual deadlines from the operational data collection, generate adjustment impulses to regulate the machines or control the system responsible for the divergence. A perpetual inventory system needs to have the ability to be adjusted. An inventory control is important in answering the questions like what the amount should be ordered and when the order should be placed. A type of inventory is decided after knowing the demand item. Items for which demand is influenced by market conditions and is not related to the inventory decisions for any other item held in the stock. For these types of items, independent demand inventory is used. This inventory includes wholesale and retail merchandise, service industry inventory such as stamps and mailing labels for post offices, end-item and replacement-part distribution inventories and maintenance. The inventory control is being shown in Figure 10.2.

![Inventory Control Flow Diagram](image)

**Figure 10.2 : Inventory Control Flow**

Inventories receive its data from the physical transactions in the manufacturing execution systems (MES) that track the movement of each item. MES is an on-line, integrated, computerized system that is the accumulation of methods and tools used to accomplish production. In many manufacturing systems, the system itself creates the material usage transactions using a technique known as backflushing. In this system, the manufacturing system computes how much of each direct component should have been consumed for a quantity of parent items that is being reported on the floor or is entering the stock room. Since on-hand inventory balances are the starting point for MPS and MRP planning and for customer order promising, these must be absolutely accurate. Inventory affects the following functions:

- **MPS** – inventory provides the starting balance for the MPS calculations for each item.
- **MRP** – inventory provides the starting balance for the MRP calculations for each item.
- **Customer Order Promising** – some manufacturers promise shipment based on-hand inventories of finished goods.
- **General Ledger** – inventory provides the on-hand balance and standard cost for general ledger to calculate inventory asset value.
- **P and L** – inventory provides the standard cost for the items being adjusted.
SAQ 1

(a) What is the basic principal of production control for CIM system?
(b) Give the inventory control flow for the CIM system.
(c) Why the control of the CIM system is necessary?

10.3 MATERIAL REQUIREMENT PLANNING (MRP)

The system which is essentially an information system consisting of logical procedures for managing inventories of component assemblies, subassemblies, parts, and raw materials in a manufacturing environment is known as Material Requirement Planning (MRP). Generally, the product which is to be manufactured consists of many components that may be produced from different engineering materials. The materials have to be ordered with sufficient lead time for meeting the completion date for a product. Accurate calculations are to be done for meeting the due dates set by marketing. For calculating the lead time of raw material, a considerable amount of experience is needed. The planner must be acquainted with the material, component suppliers, and production capabilities of the company. The determination of actual production requirement is a tedious task and is difficult in the firms that have thousands of finished goods assembled from many subassemblies and piece parts. A technique called MRP combined with a computer has simplified this process.

The process of developing the detailed production plan is called MRP. Information on the right quality, right parts, and the correct timing for production, raw material, and components are given by the MRP. The basic structure of MRP is shown in Figure 10.3.
10.3.1 Input of MRP

The inputs of MRP are as follows:

The Master Production Schedule (MPS)

This is anticipated to build schedule for selected (independent demand) items by quantity per planning period. Products that are demanded by the market are the selected items. The MPS combines two following types of requirements for independent demand items:

- Based on firm customer orders
- Based on forecasts

The MPS represents the management’s commitment and its authorization to order from vendors or manufacturer because it drives the material requirement process. The management of the MPS is very important and it includes the trade off between make to stock and make to order, the use of inventories to level production considering the time when the demand is seasonal or random and the order promising process to customers.

The MPS integrates firm customer orders and demand forecasts. The important question is not only that when to promise delivery to a customer but also whether to accept a potential customer order or not. Constrained by capacity limitations and the availability of materials, the order fulfillment process management team needs marketing, manufacturing, purchasing and cost information to develop a MPS that serves the process best.

For MPS, the time frame is important. The minimum planning time period known as time buckets indicates the accuracy of the planning process. The number of time period used by MPS spells out the length of the planning horizon. The total time required for purchasing raw materials and component parts to manufacture and assemble the independent demand item is equal to the minimum length of planning horizon.

The MPS is updated continuously. With the completion of current time, the next period becomes the current one and a new period enters the planning horizon. This process keeps the MPS current and updated and is known as rolling planning horizon.

The Bill of Material (BOM)

The source of information about the structure of each independent demand item is known as bill of material (BOM). It is possible to coordinate the requirements for independent demand items with the requirements for subassemblies, components and raw material through BOM. This is done by assigning an identification number to each component part, raw material, subassembly or product. Unique identification is possible by consistently using the same numbers throughout the MRP system. BOM can be divided in two following types:

- **Single Level BOM**: This shows only immediately required components of each part type number. These relationships are same as father-son connections. By linking the single level BOM of different part numbers, information about the components is maintained.

- **Indented BOM**: It shows all the required components for each independent demand item including components of raw materials.

The bill of material (BOM) file is often called the product structure file or product tree because it shows how a product is put together. It contains the information to identify each item and the quantity used per unit of the item of which it is a part.

To illustrate this, let us consider the case as BOM. Product A is made of two units of Part B and three units of Part C. Part B is made of one unit of Part D and four units of Part E. Part C is made of two units of Part F, five units of Part G, and four units of Part H. Figure 10.4 shows the product structure tree of the above Bill of Materials.
Example 10.1

Assume that product Z is made of two units of A and four units of B. A is made of three units of C and four D. D is made of two units of E. Show the bill of materials (Product-Structure Tree).

Solution

The Inventory Records

MRP system compares the gross requirements for each part number to its current inventory for functioning properly. Only if the gross requirements exceed the current inventory, an order for that part number should be issued. The current inventory includes inventories in the stock rooms, in-process inventories and inventories of parts and material already ordered from suppliers but not yet delivered. Inventory records contain information on stock on hand, in-process inventories and pipeline inventories and the anticipated arrivals dates to the factory.

10.3.2 Output of MRP

MRP creates two major outputs:

Full MRP Report

This projects the on-hand inventory status of each item to the end of the planning horizon. This MRP report can be reduced as planning and vertical format shown in Table 10.1. The planning grid shows six time periods that can be days or weeks, plus an on-hand (OH) that shows actual on-hand inventory quantity for this item when the grid is calculated.

<table>
<thead>
<tr>
<th>Table 10.1: MRP Report</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OH</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Gross Requirements</td>
</tr>
<tr>
<td>Scheduled Receipts</td>
</tr>
<tr>
<td>Projected Available</td>
</tr>
<tr>
<td>Net Requirements</td>
</tr>
<tr>
<td>Planned Order Receipts</td>
</tr>
<tr>
<td>Planned Order Releases</td>
</tr>
</tbody>
</table>
The rows in the grid are explained below:

*Gross Requirements*

It is the total demand for this item for this period. Both internal and external demands are included in this demand.

*Scheduled Receipts*

It is the total open or committed, supply orders for this item that includes both manufactured and purchased orders.

*Projected Available*

The projected on-hand inventory for this item at the end of each period is shown by this output. This is calculated by MRP by starting with the projected value available at the end of the previous period, then subtracting the gross requirements for the period being planned and adding the scheduled receipts for the period being planned. The calculation for this period gets completed when the resulting projected available is greater than the specified safety level.

*Net Requirements*

It is the projected shortage, after subtracting gross requirements and subsequently adding scheduled receipts for a period. The basic quantity for Planned Order Receipts is formed by this output. All Net requirements are filled by MRP for eliminating all potential shortages.

*Planned Order Receipts*

These are the quantity that is expected to be received into the stockroom during the period that is the Planned Order Release quantity less any yield or shrinkage.

*Planned Order Release*

The Planned Order Release quantity is calculated by MRP by increasing the Net Requirements to compensate for yield losses, then comparing that quantity to the minimum order quantity for this item, and further increasing the quantity again to a multiple of the Order Multiple quantity for this item.

**MRP Action Report**

This contains the exceptions that materials planners must take action on, including rescheduling existing orders and releasing new orders. One such example is shown below in Table 10.2.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Action</th>
<th>Order</th>
<th>Quantity</th>
<th>Date from</th>
<th>Date to</th>
</tr>
</thead>
<tbody>
<tr>
<td>35129</td>
<td>Bike wheels 27”</td>
<td>Rel/Exp</td>
<td>WO 3631</td>
<td>70</td>
<td>6/30</td>
<td>7/2</td>
</tr>
<tr>
<td>22193</td>
<td>Seat-touring</td>
<td>Release</td>
<td>PO 3899</td>
<td>100</td>
<td>6/24</td>
<td>7/2</td>
</tr>
</tbody>
</table>

**10.3.3 Different Logics in MRP System**

The material management function in the order fulfillment process is supported by MRP. The main aim is that the same logic can be used for ordering purchased materials or parts, manufactured components and assembled products. The MPS is the basis of information on gross requirements for independent demand items. Basic MRP logic takes this information as input and translates it into time phased net requirements. Logic of the basic MRP record is presented in Table 10.3.
Table 10.3 : Basic MRP Logic

<table>
<thead>
<tr>
<th>Week</th>
<th>Gross Requirement</th>
<th>Projected Available Balance</th>
<th>Planned Order Released</th>
</tr>
</thead>
</table>

The first row indicates the planning time periods and the Gross requirements are summarized in the second row. For independent demand items, these requirements are taken from the MPS record. From MPS record, these requirements are taken for independent demand items. Gross requirements for dependent demand items are based on the planned order release information in the MRP records of their parents in the BOM.

The scheduled receipt information in the third row is related to pipeline and in-process inventories. A work order or a purchase order was issued for these inventories.

The basic MRP logic is modified to accommodate special situations. Lot sizing policy is one such modification. The lot for lot, lot-sizing logic does not take set up or order cost into account. A minimum batch size is calculated while these costs are relatively high and each time an order its size is set equal to or larger than the minimum batch size. The Economic Order Quantity logic is frequently used for calculating this minimum order size. The same logic applies to purchase parts when economy to scale is available, i.e. the cost per unit decreases as the order size increases.

Another modification of the basic MRP logic is to buffer against uncertainty. Two following types of buffers are commonly used:

**Buffer Stock**
A minimum inventory level target is set in this case. By setting the minimum inventory target to a level that covers the expected fluctuations in the demand for a part number, a buffer against uncertainty is created.

**Buffer Lead Time**
It is designed to protect the system from fluctuations in supply lead-time. It is based on increasing the lead-time of a part number by a predetermined amount to protect the system against uncertainty in actual delivery dates. Its impact is that on an average all shipments arrive earlier than needed and the average inventory in the system increases. But at same time, the probability of shortages that delay assembly, production or delivery to customer is reduced.

10.3.4 Manufacturing Resource Planning (MRP-II)

MRP systems that deal with resource capacities are known as MRP II. MRP II system consists of the basic MRP I modules plus the RCCP (Rough Cut Capacity Planning), CRP (Capacity Requirement Planning) and SFC (Shop Floor Control) modules. This is shown in Figure 10.6.

A closed loop MRP system is one that includes detailed capacity analysis. Some MRP II systems include the business plan in this closed loop system. This module implements logic that is known as Input-Output analysis. This logic monitors the actual queue of work orders in front of each work center in its simplest form. By measuring the length of queue in terms of number of hours required for completing all the work orders waiting for processing in front of each work center and comparing this load to the available capacity of the work center, the time required to complete the current queue can be estimated. The lead time for the work center is estimated by this calculated time. The analogy between the queue in front of a work center and a reservoir proves the input-output MRP logic. The input rate to the reservoir is analog to the input of work orders to the queue generated by the MRP logic, while the output rate is analog to the
rate at which work orders are executed. Keeping the input rate under control, the order fulfillment team can control the level of the reservoir.

Figure 10.6: MRP II Structure

SAQ 2
(a) How does an increase in quantity in the MPS gross requirements affect the MRP output? Use the gross to net and time phasing logic in your explanation.
(b) How will you implement MRP in any industry?

SAQ 3
Product A consists of two units of subassembly B, three units of C, and one unit of D. B is composed of four units of E and three units of F. C is made of two units of H and three units of D. H is made of five units of E and two units of G.

(i) Construct a simple bill of material (Product Structure Tree).
(ii) Construct a product structure tree using low-level coding.
(iii) Construct an indented parts list.
(iv) To produce 100 units of A, determine the members of units of B, C, D, E, F, G and H required.
10.4 RECENT TRENDS IN ENTERPRISE INTEGRATION

Globalization of market has put up a great impetus and marvelous pressure on manufacturing enterprises to cope up with market requirements. A new paradigm in manufacturing arena known as agile manufacturing has emerged to become adaptive with the competitive market. For a system to be called agile, the system must be flexible, reconfigurable and responsive. The main aim of the agile manufacturing is to facilitate manufacturing enterprise to be competitive by dynamically reconfiguring software, equipment, and organization structures. Some of the characteristics of agile manufacturing are as follows:

- Greater product customization
- Rapid introduction of new or modified products
- Advanced inter-enterprise networking technology
- Upgradable products
- Increased emphasis on knowledgeable, highly trained, empowered workers
- Interactive customer relationships
- Dynamic reconfiguration of production processes
- Greater use of flexible production technologies
- Rapid prototyping
- An open systems information environment
- Innovative and flexible management structures
- Product pricing based on value to the customer
- Commitment to environmentally benign operations and product designs

Manufacturers are being driven by the pressures such as increasing e-business and make-to-order for integrating business processes across the entire value chain. The need of the hour for the manufacturers in the present e-manufacturing environment is to communicate with the global marketplace, collaborate with strategic supply chain partners, and compete with market based on speed, agility, and knowledge.

Manufacturing has undergone drastic change over the last two decades, still the intensity of change has not decreased. In the last decade, IT revolution has changed the business trends. Business trends point to changing industry structures, new approaches and newer business models brought about by the global, e-business paradigm that thrusts new challenges and drive a different thinking. The new goal is to achieve synchronization of business processes amongst the constituents of the value chain such as suppliers, partners’ collaborators and customers. Internet is the means of achieving this integration because of its easy reach and ubiquity. The internet allows communication flow and commerce to happen over a network that spans different business across the globe constituting a value chain.

SAQ 4

(a) What is meant by the term enterprise integration?

(b) What are the recent developments in the enterprise integration that have reduced the lead time and enhanced the quality of manufacturing of a product?
For manufacturers, e-business is a phenomenon that makes traditional industry structures and business paradigms stand on their head, spawning new business models and allowing industrial business “new spaces” for improving effectiveness. E-business for e-manufacturing is an entire change from the traditional values that defined manufacturing till date. It is changed from being vertical integration driven single entities to a collaborative commerce driven extended enterprise. E-business is today driving the supply chain and the supply chain is in turn driving manufacturing.

It is a fact that no matter how well orders can be taken, or how well slick is the distribution system, the shop floor has to be optimized. The manufacturing plants form the critical center in the supply chain. It deals with customers by focusing on sales orders, their status, and shipment. In dealing with suppliers, the plant mainly focuses on material order, their status and deliveries. Both sides can be served business to business (B2B). Tired supply chains and contract manufacturing are forcing companies to manage the plant in the context of as virtual or extended enterprise that requires internet enabled applications.

The distribution and supplier interfaces have often been managed by maintaining buffer inventories within the plant which are expensive. By cutting excess inventory, the plants have become much more responsive. The effect is felt all the way up and down the chain. Manufacturers have to become much more active in managing both upstream and downstream activities.

**Figure 10.7 : Need of Manufacturing System in E-Business Era**

Due to the fact that e-business increases the demand for information on visibility, the situation has been aggravated and changes the competitive dynamics. Quantity of the available information about orders in production influences purchasing decisions. Skills
in new web based methods must be developed by companies for dealing with suppliers and customers in addition to manufacturing excellence. This led to a situation in which a system is put in the place to synchronize the manufacturing operations with both customer orders and supplier deliveries. This progresses towards developing B2B communities.

A dynamic, recombinant supply chain network is modeled instead of rigid chain. Instead of a system that lends itself to long-range planning and forecasting, a system is developed that requires short term scheduling, component level WIP tracking, and much greater information visibility than ever before in the production nodes. Manufacturers must raise the visibility of manufacturing information for optimizing performance, enhancing responsiveness and managing costs to survive in this competitive world. The manufacturing system needs in the e-business era is being shown in Figure 10.7.

**SAQ 5**

What do you understand by extended enterprise and what role internet has played in it?

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**10.6 SUMMARY**

Material Requirements Planning (MRP) is an information system used to handle ordering of dependent-demand items (i.e. components of assembled products). The main features of MRP are the time-placing of requirements, calculating component requirement, and planned-order releases. To be successful, MRP requires a computer program and accurate master production schedule, bill of material and inventory data. Firms that have not had reasonably accurate records or schedules have experienced major difficulties in trying to implement MRP.

MRP-II is a second-generation approach to planning which incorporates MRP but adds a broader scope to manufacturing resource planning because it links business planning, production planning and the master production schedule.

The main aim of manufacturing planning and control is to manufacture the right product types in the right quantities, at the right time, at minimum cost and meet the quality standards. Manufacturing planning and control is the heart of the manufacturing firms. Moreover, the market barriers are coming down and now the demand of the market is steered towards shorter product life cycles, high quality, and low costs. It is not inevitable but essential to have an integrated manufacturing planning and control to survive in this competitive market. The development and manufacture of high-quality customized products at low cost with reduced lead time have empowered the enterprise-wide integration systems and CIM systems indispensable in any industry.

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**10.7 KEY WORDS**

**MRP**: Material requirements planning (MRP) is a viable method of assuring that items are available at their times of need; material requirements planning consists of a set of logically related procedures, decision rules, and records designed to translate the master production schedule into time-phased net requirements, for each inventory item needed to implement this schedule.
Material Planning for CIM System

MRP II

: MRP systems that deal with resource capacities are known as MRP-II. MRP-II system consists of the basic MRP-I modules plus the Rough Cut Capacity Planning (RCCP), Capacity Requirement Planning (CRP) and Shop Floor Control (SFC) modulus.

10.8 ANSWERS TO SAQs

SAQ 3

(c) A

B (2)

E (4)

F (4)

C (3)

D (3)

H (2)

E (5)

G (2)

D (1)

(d) Level 0  100 units of A

Level 1  200 units of B

300 units of C

Level 2  600 units of F

600 units of H

1000 units of D

Level 3  3800 units of E

1200 units of G
FURTHER READINGS


Mejabi, O. O. (1994), *Private Communications*, Department of Industrial and Manufacturing Engineering, Wayne State University, Detroit, Michigan.


Li, Y. (1992), *A Feature Recognition Algorithm for Polyhedral Parts*, Unpublished Master’s Thesis, Department of Industrial Engineering, University of Windsor (Canada).
Globalised markets and growth in computers have changed the role of manufacturing management. The manufacturers have to automate their manufacturing processes, otherwise reaching the targets, customers satisfaction, total quality and cost reduction have become major problems to manufacturers. To overcome these problems, manufacturers have chosen the automation of their factories. CIM is one of the topic in automation. CIM concept promises lower cost, higher quality and shorter lead time.

CIM is used for integration of various manufacturing activities in a factory. CIM applications are unique to the specific company and its requirements. CIM increases the value of the product. CIM helps achieve the factory of future whereby personnel on paper are all but eliminated as far as possible.

This block, comprising three units, is on CIM Modelling and Operations.

Unit 8 discusses the characteristics of operational aspect of CIM. It also explains the simulation aspects of flexible manufacturing system. Further, it emphasizes on simulation modelling of FMS problems.

Unit 9 deals with the computer aided process planning (CAPP). CAPP is used for preparing production schedule for components. CAPP contains sequence of operations and the corresponding machines required for that operation. In this unit, we will differentiate the variation in approaches to general process planning and computer aided process planning. A few existing knowledge based CAPP systems are reviewed. And finally, focuses are made on recent trends in CAPP.

Unit 10 concentrates on material planning for CIM system. It also discusses the principles production and inventory for the CIM system. It also elaborates the new planning concepts, MRP, MRP-II and recent trends in enterprise integration.