7

Integrated Production Management System

Contents

7.1 Introduction

- This part of the manual is concerned with the use of computers to manage the production function. The subject has traditionally been referred to as production planning and control. This function has been practiced for many years.
- Attempts to use the computer in production planning date from the late 1950s and early 1960s. The early attempts were directed toward computerizing the same clerical procedures which had been done by hand for years.
- These procedures included preparation of schedules, shortage lists, inventory lists, and similar documents. During the late 1960s and early 1970s, a few individuals began to recognize the tremendous opportunities provided by the computer to make fundamental changes in the procedures and organization of production planning and control.
- Joseph Orlicky, George Plossl, and Oliver Wight stand out as some of the principal pioneers in these efforts to modernize and computerize the production management function. MRP (material requirements planning) was one of the first computerized procedures which significantly improved the way things were done.
- Since MRP was first implemented, many additional improvements in production planning and control have been introduced by taking advantage of the data processing and computational powers of the computer.
- Main objective in this experiment is to describe how computers are utilized to carry out the production management function in the CAD/CAM age.

7.2 Traditional Production Planning And Control

- At least a dozen separate functions can be identified as constituting the cycle of activities in traditional production planning and control.
- Organizationally, some of these functions are performed by departments in the firm other than the production control department. The functions are described in the following sections.

Forecasting

- The forecasting function is concerned with projecting or predicting the future sales activity of the firm's products.
- Sales forecasts are often classified according to the time horizon over which they attempt to estimate.
- Long-range forecasts look ahead five years or more and are used to guide decisions about plant construction and equipment acquisition.
- Intermediate-range forecasts estimate one or two years in advance and would be used to plan for long-lead-time materials and components.
- Short-term forecasts are concerned with a three- to six-month future. Decisions on personnel (e.g., new hiring), purchasing, and production scheduling would be based on the short-term forecast.

Production planning

- This is sometimes called aggregate production planning and its objective is to establish general production levels for product groups over the next year or so.
- It is based on the sales forecast and is used to raise or lower inventories, stabilize production over the planning horizon, and allow for the launching of new products into the company's product line.

Aggregate production planning is a function that precedes the detailed master production schedule.

Process planning

- Process planning involves determining the sequence of manufacturing operations required to produce a certain product and/or its components.
- Process planning has traditionally been carried out by manufactur¬ing engineers as a very manual and clerical procedure.
- The resulting document, prepared by hand, is called a route sheet and is a listing of the operations and machine tools through which the part or product must be routed.
- The term "rout¬ing" is sometimes applied to describe the process planning function.

Estimating

- For purposes of determining prices, predicting costs, and preparing schedules, the firm will determine estimates of the manufacturing lead times and production costs for its products.
- The manufacturing lead time is the total time required to process a work part through the factory. The production costs are the sum of the material costs, labor, and applicable overhead costs needed to produce the part.
- These esti¬mates of lead times and costs are based on data contained in the route sheets, pur¬chasing files, and accounting records.

Master scheduling

- The aggregate production plan must be translated into a master schedule which specifies how many units of each product are to be delivered and when.
- In turn, this master schedule must be converted into purchase orders for raw materials, ord¬ers for components from outside vendors, and production schedules for parts made in the shop.
- These events must be timed and coordinated to allow delivery of the final product according to the master schedule.
- Specifically, the master schedule or master production schedule is a listing of the products to be produced, when they are to be delivered, and in what quantities.
- The scheduling periods in the master schedule are typically months, weeks, or dates. The master schedule must be consistent with the plant's production capacity.
- It should not list more quantities of products than the plant is capable of producing with its given resources of machines and labor.

Requirements planning

- Based on the master schedule, the individual components and subassemblies that make up each product must be planned.
- Raw materials must be ordered to make the various components. Purchased parts must be ordered. And all of these items must be planned so that the components and assemblies are available when needed.
- This whole task is called requirements planning or material requirements planning. The term MRP (for material requirements planning) has come into common usage since the introduction of computerized procedures to perform the massive data processing required to accomplish this function.
- However, the function itself had to be accomplished manually by clerical workers before computers were used.

Purchasing

- The firm will elect to manufacture some components for its products in its own plants. Other components will be purchased.
- Deciding between these alternatives is the familiar "make-or-buy" decision. For the components made in-house, raw materials have to be acquired.
- Ordering the raw materials and purchased components is the function of the purchasing department. Materials will be ordered and the receipt of these items will be scheduled according to the timetable defined during the requirements planning procedure.

Machine loading and scheduling

- Also based on the requirements planning activity is production scheduling. This involves the assignment of start dates and due dates for the components to be processed through the factory. Several factors make scheduling complex.
- First, the number of individual parts and orders to be scheduled may run into the thousands. Second, each part has its own individual process routing to be followed. Some parts may have to be routed through dozens of separate machines.
- Third, the number of machines in the shop is limited, and the machines are different. They perform different operations and have different features and capacities.
- The total number of jobs to be processed through the factory will typically exceed the number of machines by a substantial margin.
- Accordingly, each machine, or work center, will have a queue of jobs waiting to be processed. Allocating the jobs to work centers is referred to as machine loading. Allocating the jobs to the entire shop is called shop loading.

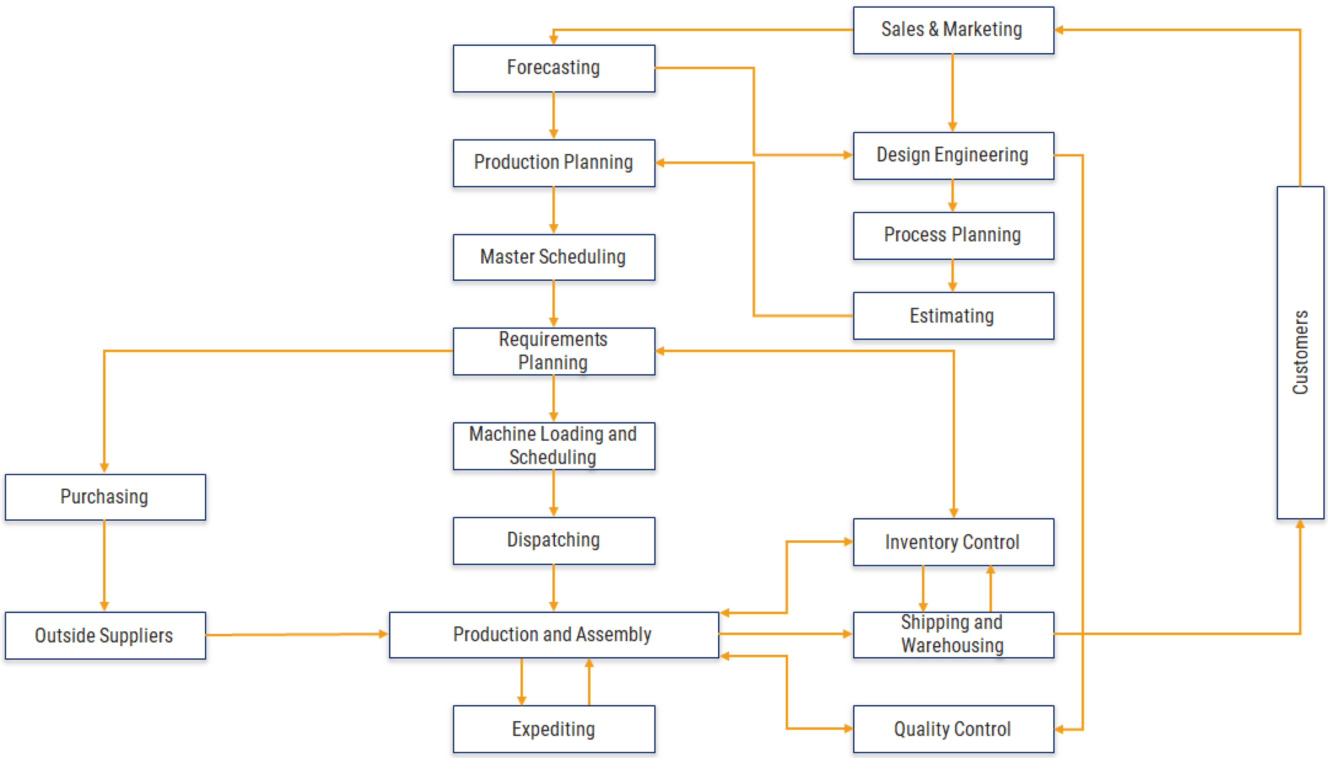

Fig.7.1 – Cycle of activities in a traditional production planning and control

Dispatching

- Based on the production schedule, the dispatching function is concerned with issu¬ing the individual orders to the machine operators.
- This involves giving out order tickets, route sheets, part drawings, and job instructions. The dispatching function in some shops is performed by the shop foremen, in other shops by a person called a dispatcher.

Expediting

- Even with the best plans and schedules, things go wrong. It is the expediter's job to compare the actual progress of the order against the production schedule.
- For ord¬ers that fall behind schedule, the expediter recommends corrective action. This may involve rearranging the sequence in which orders are to be done on a certain machine, coaxing the foreman to tear down one setup so that another order can be run, or hand-carrying parts from one department to the next just to keep production going.
- There are many reasons why things go wrong in production: parts-in-process have not yet arrived from the previous department, machine breakdowns, proper tooling not available, quality problems, and so forth.

Quality control

- The quality control department is responsible for assuring that the quality of the product and its components meets the standards specified by the designer.
- This function must be accomplished at various points throughout the manufacturing cycle. Materials and parts purchased from outside suppliers must be inspected when they are received. Parts fabricated inside the company must be inspected, usually several times during processing.
- Final inspection of the finished product is performed to test its overall functional and appearance quality.

Shipping and inventory control

- The final step in the production control cycle involves shipping the product directly to the customer or stocking the item in inventory.
- The purpose of inven¬tory control is to ensure that enough products of each type are available to satisfy customer demand.
- Competing with this objective is the desire that the company's financial investment in inventory be kept at a minimum.
- Inventory control interfaces with production control since there must be coordination between the various product's sales, production, and inventory level. Inventory control is often included within the production control department.
- The inventory control function applies not only to the company's final prod¬ucts. It also applies to raw materials, purchased components, and work-in-process within the factory.
- In each case, planning and control are required to achieve a bal¬ance between the danger of too little inventory (with possible stock outs) and the expense of too much inventory.
- The block diagram of Figure 7.1 depicts the relationships among the produc¬tion planning and control functions as well as various other functions of the firm, customers, and outside suppliers. In the diagram, the production planning and con¬trol functions are highlighted in bold blocks.

7.3 Problems With Traditional Production Planning And Control

- There are many problems that occur during the cycle of activities in the traditional approach to production planning and control. Many of these problems result directly from the inability of the traditional approach to deal with the complex and ever-changing nature of manufacturing. The types of problems commonly encountered in the planning and control of production are the following:

1. **Plant capacity problems**
- Production falls behind schedule due to a lack of labor and equipment. This results in excessive overtime, delays in meeting delivery schedules, customer complaints, backordering, and other similar problems.

2. **Suboptimal production scheduling.**
- The wrong jobs are scheduled because of a lack of clear order priorities, inefficient scheduling rules, and the ever-changing status of jobs in the shop. As a consequence, production runs are interrupted by jobs whose priorities have suddenly increased, machine setups are increased, and jobs that are on schedule fall behind.

3. **Long manufacturing lead times.**
- In an attempt to compensate for prob¬lems 1 and 2, production planners allow extra time to produce an order. The shop becomes overloaded, order priorities become confused, and the result is exces¬sively long manufacturing lead times.

4. **Inefficient inventory control.**
- At the same time that total inventories are too high for raw materials, work-in-progress, and finished products, there are stock outs that occur on individual items needed for production. High total inven¬tories mean high carrying costs, while raw material stock outs mean delays in meet¬ing production schedules.

5. **Low work center utilization.**
- This problem results in part from poor scheduling (excessive product changeovers and job interruptions), and from other factors over which plant management has limited control (e.g., equipment break¬downs, strikes, reduced demand for products).

6. **Process planning not followed.**
- This is the situation in which the regular planned routing is superseded by an ad hoc process sequence. It occurs, for instance, because of bottlenecks at work centers in the planned sequence. The consequences are longer setups, improper tooling, and less efficient processes.

7. **Errors in engineering and manufacturing records.**
- Bills of materials are not current, route sheets are not up to date with respect to the latest engineering changes, inventory records are inaccurate, and production piece counts are incorrect.

8. **Quality problems**.
- Quality defects are encountered in manufactured components and assembled products, resulting in rework or scrapped parts, thus causing delays in the shipping schedule.

7.4 Computer-Integrated Production Management System

- There have been several factors working over the last several decades to cause the evolution of a more modern and effective approach to the problems of production planning and control cited above.
- The most obvious of these factors was the development of the computer, a powerful tool to help accomplish the vast data pro¬cessing and routine decision-making chores in production planning that had previ¬ously been done by human beings.

- In addition to the computer, there were other factors which were perhaps less dramatic but equally important. One of these was the increase in the level of pro¬fessionalism brought to the field of production planning and control.
- Production planning has been gradually transformed from what was largely a clerical function into a recognized profession requiring specialized knowledge and academic training.
- Systems, methodologies, and even a terminology have developed to deal with the problems of this professional field.
- Important among the methodologies of production planning and control, and another significant factor in the development of the field, is operations research.
- The computer became the important tool in production planning, but many of the decision-making procedures and software programs were based on the analytical models provided by operations research.
- Linear programming, inventory models, queuing theory, and a host of other techniques have been effectively applied to problems in production planning and control.
- Another factor that has acted as a driving force in the development of better production planning is increased competition from abroad.
- Many American firms have lost their competitive edge in international and even domestic markets. Increasing U.S. productivity is seen as one important way to improve our competitive position. Better management of the production function is certainly a key element in productivity improvement.
- Finally, a fifth factor is the increase in the complexity of both the products manufactured and the markets that buy these products.
- The number of different products has proliferated, tolerances and specifications are more stringent and customers are more particular in their requirements and expectations.
- These changes have placed greater demands on manufacturing firms to manage their operations more efficiently and responsively.
- As a consequence of these factors, companies are gradually abandoning the traditional approach in favor of what we are calling computer-integrated production management systems.
- There are other terms which are used to describe these systems and their major components. IBM uses the term "communications oriented production information and control system—COPICS" to identify the group of system elements.
- George Plossl integrates the various system concepts under the name "manufacturing control". Computer-Aided Manufacturing International calls its development effort in this area the "factory management project".
- Oliver Wight refers to the use of MRPII, or manufacturing resource planning, to consolidate the manufacturing, engineering, and financial functions of the firm into one operating system. All of these terms refer to computerized information systems designed to integrate the various functions of production planning and control.
- Figure 7.2 presents a block diagram illustrating the functions and their relationships in a computer-integrated production management system.
- Many of these functions are nearly identical to their counterparts in-traditional production-planning and control. For example, forecasting, production planning, the development of the master schedule, purchasing, and other functions appear the same, in Figures 7.1 and 7.2.
- To be sure, modern computerized systems have been developed to perform these functions, but the functions themselves remain relatively unchanged.
- More significant changes have occurred in the organization and execution of production planning and control through the implementation of such schemes as MRP, capacity planning, and shop floor control. What follows is a brief description of some of the recently developed functions in a

CIPMS. We will neglect those func¬tions which are nearly the same as their conventional counterparts. The newer functions are highlighted in Figure 7.2 by bold blocks.

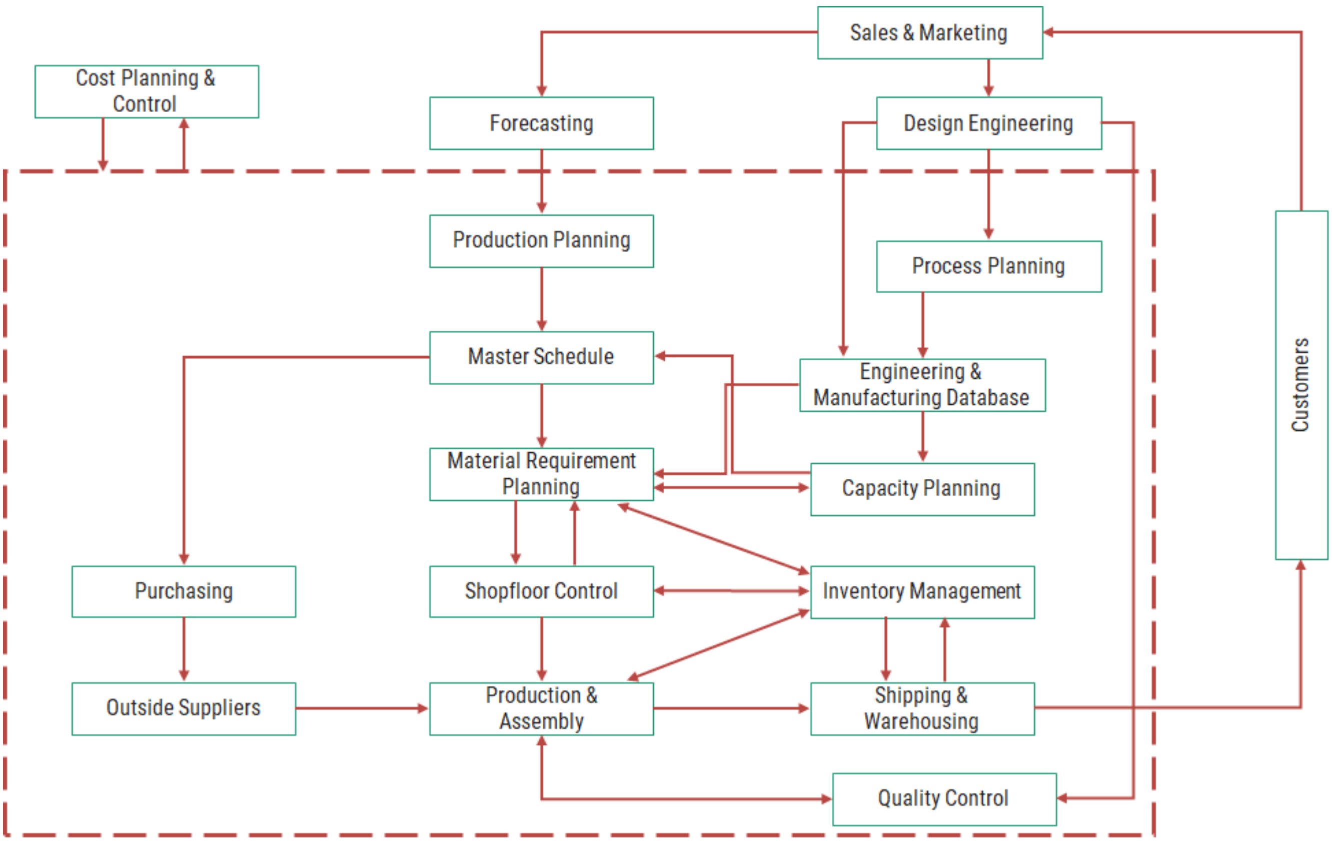

Fig.7.2 – Cycle of activities in a computer-integrated production management system

7.5 Material Requirements Planning

- Material requirements planning is a computational technique that converts the master schedule for end products into a detailed schedule for the raw material and components used in the end products. The detailed schedule identifies the quantities of each raw material and component item. It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products.
- MRP is often considered to be a subset of inventory control. While it is an effective tool for minimizing unnecessary inventory investment, MRP is also useful in production scheduling and purchasing of materials.
- The concept of MRP is relatively straightforward. What complicates the application of the technique is the sheer magnitude of the data to be processed. The master schedule provides the overall production plan for final products in terms of month-by-month or week-by-week delivery requirements. Each of the products may contain hundreds of individual components.
- These components are produced out of raw materials, some of which are common among the components. For example, several parts may be produced out of the same sheet steel. The components are assembled into simple subassemblies.
- Then these subassemblies are put together into more complex assemblies—and so forth, until the final product is assembled together. Each production and assembly step takes time. All of these factors must be incorporated into the MRP computations.

- Although each separate computation is uncomplicated, the magnitude of all the data to be processed is so large that the application of MRP is virtually impossible unless carried out on a digital computer.

7.6 Basic MRP Concepts

- Material requirements planning is based on several basic concepts which are impli¬cit in the preceding description but not explicitly defined. These concepts are:
  1. Independent versus dependent demand
  2. Lumpy demand
  3. Lead times
  4. Common use items

7.6.1 Independent versus dependent demand

- This distinction is fundamental to MRP. Independent demand means that demand for a product is unrelated to demand for other items. End products and spare parts are examples of items whose demand is independent. Independent demand patterns must usually be forecasted.
- Dependent demand means that demand for the item is related directly to the demand for some other product. The dependency usually derives from the fact that the item is a component of the other product. Not only component parts, but also raw materials and subassemblies, are examples of items that are subject to depen¬dent demand.
- Whereas demand for the firm's end products must often be forecasted, the raw materials and component parts should not be forecasted. Once the delivery schedule for the end products is established, the requirements for components and raw materials can be calculated directly. For example, even though the demand for automobiles in a given month can only be forecasted, once that quantity is esta¬blished we know that four regular tires will be needed to deliver the car plus one spare tire.
- MRP is the appropriate technique for determining quantities of dependent demand items. These items constitute the inventory of manufacturing: raw materi¬als, work-in-progress, component parts, and subassemblies. Accordingly, MRP is a very powerful tool in the planning and control of manufacturing inventories.

7.6.2 Lumpy demand

- In an order point system, the assumption is generally made that the demand for the item in inventory will occur at a gradual, continuous rate.
- This assumption is important for developing the mathematical model to derive the economic lot size formula. In a manufacturing situation, demand for the raw materials and com¬ponents of a product will occur in large increments rather than in small, almost continuous units.
- The large increments correspond to the quantities needed to make a certain batch of the final product. When the demand occurs in these large steps, it is referred to by the term “lumpy demand." MRP is the appropriate approach for dealing with inventory situations characterized by lumpy demand.

7.6.3 Lead times

- The lead time for a job is the time that must be allowed to complete the job from start to finish. In manufacturing there are two kinds of lead times: ordering lead times and manufacturing lead times.

- An ordering lead time for an item is the time required from initiation of the purchase requisition to receipt of the item from the vendor. If the item is a raw material that is stocked by the vendor, the ordering lead time should be relatively short, perhaps a few weeks.
- If the item must be fabricated by the vendor, the lead time may be substantial, perhaps several months.
- Manufacturing lead time is the time needed to process the part through the sequence of machines specified on the route sheet. It includes not only the operation times but also the nonproductive time that must be allowed.
- In MRP, lead times are used to determine starting dates for assembling final products and subassemblies, for producing component parts, and for ordering raw materials.

7.6.4 Common use items

- In manufacturing, the basic raw materials are often used to produce more than one component type. Also, a given component may be used on more than one final product.
- For example, the same type of steel rod stock may be used to produce screws on an automatic screw machine. Each of the screw types may then be used on several different products.
- MRP collects these common-use items from different products to effect economies in ordering the raw materials and manufacturing the components.

7.7 Inputs To MRP

- MRP converts the master production schedule into the detailed schedule into the detailed schedule for raw materials and components. For the MRP program to perform this function, it must operate on the data contained in the master schedule. However, this is only one of three sources of input data on which MRP relies. The three inputs to MRP are:
  1. The master production schedule and other order data
  2. The bill-of-materials file, which defines the product structure
  3. The inventory record file

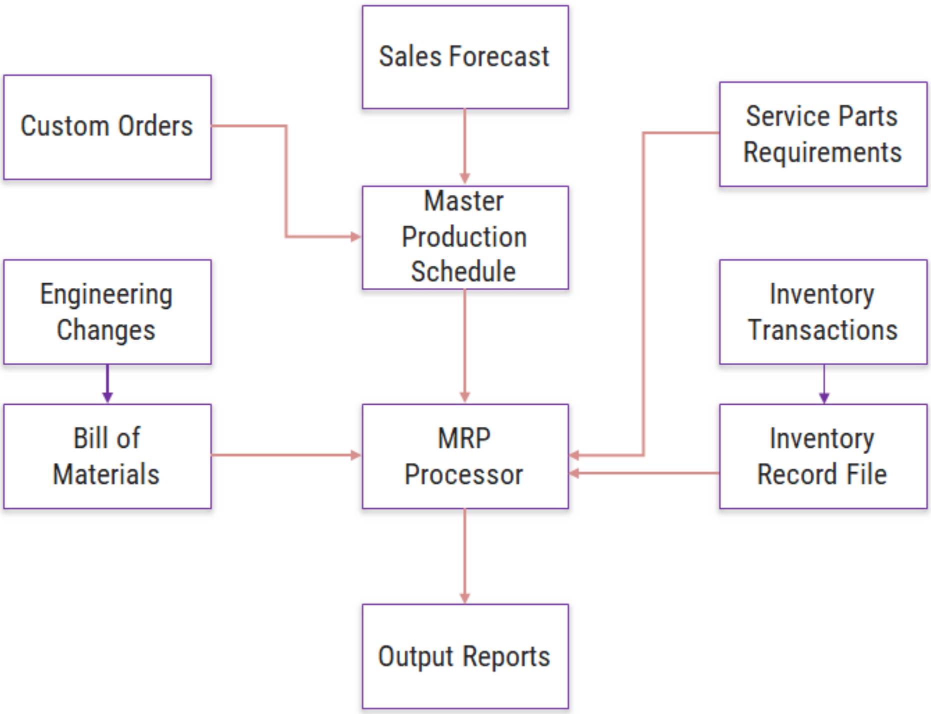

Fig.7.3 – Structure of a material requirements planning (MRP) system

- Figure 7.3 presents a diagram showing the flow of data into the MRP processor and its conversion into useful output reports. The three inputs are described in the sections below.

7.7.1 Master production schedule

- The master production schedule is a list of what end products are to be produced, how many of each product is to be produced, and when the products are to be ready for shipment. The general format of a master production schedule is illustrated in Figure 7.4.
- Manufacturing firms generally work toward monthly delivery schedules. However, in Figure 7.4, the master schedule uses weeks as the time periods. The master schedule must be based on an accurate estimate of demand for the firm's product, together with a realistic assessment of its produc¬tion capacity.
- Product demand that makes up the master schedule can be separated into three categories. The first consists of firm customer orders for specific products.
- These orders usually include a specific delivery date which has been promised to the customer by the sales department. The second category is forecasted demand. Based on statistical techniques applied to past demand, estimates provided by the sales staff, and
- other sources, the firm will generate a forecast of demand for its various product lines. This forecast may constitute the major portion of the master schedule.
- The third category is demand for individual component parts. These components will be used as repair parts and are stocked by the firm's service department. This third category is often excluded from the master schedule since it does not represent demand for end products.

Week number		6	7	8	9	10
Product P1				50		100
Product P2			70	80	25	
etc.						

Fig.7.4 – Master production schedule for products P1 and P2, showing week delivery quantities.

7.7.2 Bill of material file

- In order to compute the raw material and component requirements for end products listed in the master schedule, the product structure must be known. This is specified by the bill of materials, which is a listing of component parts and subassemblies that make up each product. Putting all these assembly lists together, we have the bill-of-materials file (BOM).
- The structure of an assembled product can be pictured as shown in Figure 6.6. This is a relatively simple product in which a group of individual components make up two subassemblies, which in turn make up the product.
- The product structure is in the form of a pyramid, with lower levels feeding into the levels above. We can envision one level below that shown in Figure 6.6. This would consist of the raw materials used to make the individual components.
- The items at each successively higher level are called the parents of the items in the level directly below. For example, subassembly S1 is the parent of components C1, C2, and C3. Product P1 is the parent of subassemblies S1 and S2.

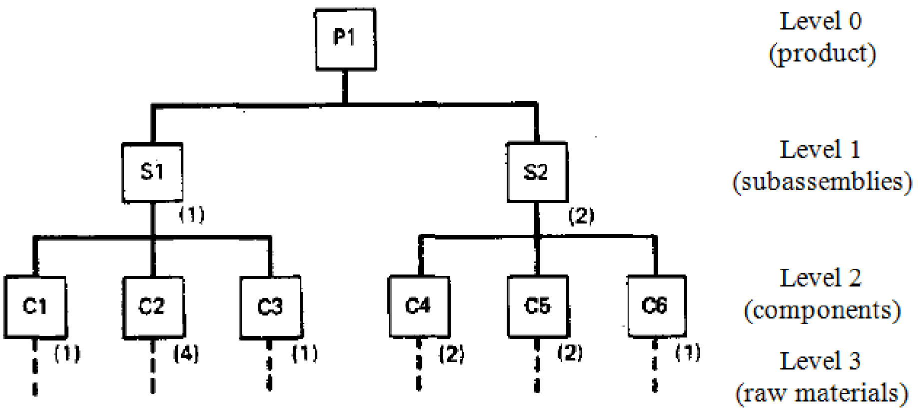

Fig.7.5 – Product structure for product P1

- The product structure must also specify how many of each item is included in its parent. This is accomplished in Figure 7.5 by the number in parentheses to the right and below each block. For example, subassembly S1 contains four of component C2 and one each of components C1 and C3.

7.7.3 Inventory record file

- It is mandatory in material requirements planning to have accurate current data on inventory status. This is accomplished by utilizing a computerized inventory sys¬tem which maintains the inventory record file or item master file.
- A definition of the lead time for the raw materials, components, and assem¬blies must be established in the inventory record file. The ordering lead time can be determined from purchasing records. The manufacturing lead time can be deter¬mined from the process route sheets (or routing file).
- It is important that the inputs to the MRP processor be kept current. The bill-of-materials file must be maintained by feeding any engineering changes that affect the product structure into the BOM. Similarly, the inventory record file is maintained by inputing the inventory transactions to the file.

7.8 MRP Output Reports

- The material requirements planning program generates a variety of outputs that can be used in the planning and management of plant operations. These outputs include:
  1. Order release notice, to place orders that have been planned by the MRP system
  2. Reports showing planned orders to be released in future periods
  3. Rescheduling notices, indicating changes in due dates for open orders
  4. Cancellation notices, indicating cancellation of open orders because of changes in the master schedule
  5. Reports on inventory status
- The outputs of the MRP system listed above are called primary outputs by Orlicky. In addition, secondary output reports can be generated by the MRP system at the user's option. These reports include:
  1. Performance reports of various types, indicating costs, item usage, actual versus planned lead times, and other measures of performance
  2. Exception reports, showing deviations from schedule, orders that are overdue, scrap, and so on
  3. Inventory forecasts, indicating projected inventory levels (both aggre¬gate inventory as well as item inventory) in future periods

7.9 Benefits Of MRP

- There are many advantages claimed for a well-designed, well-managed material requirements planning system. Among these benefits reported by MRP users are the following.
- Reduction in inventory. MRP mainly affects raw materials, purchased components, and work-in-process inventories. Users claim a 30 to 50% reduction in work-in-process.
- Improved customer service. Some MRP proponents claim that late orders are reduced 90%.
- Quicker response to changes in demand and in the master schedule.
- Greater productivity. Claims are that productivity can be increased by 5 to 30% through MRP. Labor requirements are reduced correspondingly.
- Reduced setup and product changeover costs.
- Better machine utilization.
- Increased sales and reductions in sales price. These are also claimed as MRP benefits by some users.

7.10 Manufacturing Resource Planning (MRP II)

- Manufacturing resource planning evolved from material requirements planning in the 1980s. It came to be abbreviated MRP II to distinguish it from the original abbreviation and to indicate that it was second generation, that is, more than just a material planning system.
- Manufacturing resource planning can be defined as a computer-based system for planning, scheduling, and controlling the materials, resources, and supporting activities needed to meet the master production schedule.
- MRP II is a closed-loop system that integrates and coordinates the major functions of the business involved in production. The term “closed-loop system” means that MRP II incorporates feedback of data on various aspects of operating performance so that corrective action can be taken in a timely manner; that is, MRP II includes a shop floor control system.
- MRP II can be considered to consist of three major modules: (1) material requirement planning, or MRP, (2) capacity planning, and (3) shop floor control. MRP accomplishes the planning functions for materials, parts, and assemblies, based on the master production schedule. In so doing it also provides a schedule for factory operations.
- The capacity planning module interacts with the MRP module to ensure that the schedules created by MRP are feasible. Finally, the shop floor control module performs the feedback control function using its factory data collection system to implement the three phases of order release, order scheduling, and order progress.
- Manufacturing resources planning represented an improvement over material requirements planning because it includes production capacity and shop floor feedback in its computations. But MRP II was limited to the manufacturing operations of the firm.
- As further enhancements were made to the MRP II systems, the trend was to consider all of the operations and functions of the enterprise rather than manufacturing.

7.11 Jit Applied To FMS

- The stockless production concept of just-in-time (JIT) manufacturing, originally pioneered by the Japanese, is about inventory, but it is much more than inventory reduction. It is about organizing the production process so that usable parts, both purchased and manufactured, are available on the shop floor when they are needed- not too late and not too soon.
- Throughout the text, emphasis is on material flow and part throughput inter¬nal and external to the cell or FMS.

- With FMS, sophisticated software handles the part scheduling for each work station, controls part movement from station to station, handles NC program download to each CNC unit, and performs a variety of other functions. Ideally, well-implemented and operational JIT techniques should be a prerequisite to FMS and be in place before a flexible cell or system is installed in order to follow the "simplify before you automate" rule.
- Unfor¬tunately, this is not the case in most companies, as adding cells and systems usually precedes major material flow and inventory reductions. JIT can be either a cause or an effect of FMS. However, it is difficult to implement FMS without JIT and achieve the true results of FMS.
- FMS forces operational and organizational change in a company. FMS is also a means to a just-in-time end and can be used in many cases to drive productivity improvement changes like JIT and group technology through the organization.
- The training, teamwork, cooperation, planning effort, and positive attitudes used to implement a cell or system can be carried over and broadened to undertake implementation of JIT techniques. Installing a cell or system first can provide a seedbed for planting and leveraging a JIT discipline.
- The installation of a cell or system provides the manufacturer with the flexibility to produce parts in lot sizes as small as one.
- With an FMS, it is no longer necessary to carry excessively large inventories or issue high economic order quantities in an attempt to satisfy anticipated customer demands.
- The accuracy of marketing's forecast would become less critical since the manufacturer would now have the option of producing to order. Consequently, the just-in-time philosophy advocated by a flexible manufacturing system would result in decreased lead times, less work in process on the shop floor, smaller finished parts inventories, and increased customer satisfaction.

7.12 GT Applied To FMS

- The classification and coding associated with GT provides a means by which parts may be easily selected to load a cell or FMS, if the part classification and coding system is available and operational at the time cell or system planning begins.
- In many instances, however, this is not the case and the part selection process is done manually. When planning for a cell or system, you are essentially doing a portion of group technology simply by determining equipment requirements, deciding which parts go into the cell or FMS, and grouping them accordingly.
- An FMS is, in fact, a grouping of machines to process a family of parts within a predefined range of part feature and characteristic requirements.
- As mentioned before, an FMS in many cases is referred to as a cell, depending on system size and how a particular company views its automation efforts.
- Given these considerations, it is apparent that an FMS can actually be considered a highly sophisticated GT manufacturing cell that can produce a wider range of parts and part families than the traditional GT manufacturing cell.

7.13References

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