MRP AND INVENTORY AND PRODUCTION CONTROL IN PROCESS INDUSTRIES*

Nancy S. Nelson, *Kimberly-Clark Corp. Neenah, WI.*

Introduction

A process industry is one in which many products are made from a few materials. Assembly and fabrication industries do the opposite: make a few products from many parts. Examples of process companies include food, paper, and chemical manufacturers. Due to the nature of their operations, process industries face inventory and production control problems that are different from those of other types of manufacturers. Because of this, managers of many process firms do not consider computerized Material Requirements Planning (MRP) an applicable tool. Examination of some of those planning and control problems and analysis of possible solutions reveal that MRP can be used, and indeed has been successfully applied in many process situations. Complementary systems that provide input to and/or use output from MRP systems are also helpful.

Process Industry Problems

Unlike manufacturing firms that have factories with unique machinery for making particular products, paper and chemical companies may have several mills or plants capable of making many of the same products. Raw materials rather than machines are the key to the end product. Such firms must decide not only how much product to make at what time but also where to produce. Similarly, the raw materials and other components must not only be available on time and in the correct quantitites but must also be at the right plant.

Another production problem is scheduling jobs among multiple paper machines or processing equipment located at one plant. For example, paper mills often have several machines that can produce the same paper but have ". . . different production widths, different operating speeds, and different manufacturing costs" [9, p. 13]. The different widths are important since one customer may order twenty-inch rolls and another twenty- five-inch rolls of the same material. Two machines may produce sixty-five and seventy-inch rolls, respectively. The scheduler must allocate production of specified paper product and roll size among the machines in order to minimize trim losses, total production hours and total variable production costs [9]. Such a situation is similar to the disposition of by-products obtained as the result of some chemical manufacturing methods.

The effect of batch quality on process industries is different than on assembly operations. An example of this situation might occur when a chemical company wants to make 5,000 pounds of some product. If the batch is bad, all 5,000 pounds must be scrapped or reprocessed [4]. If an assembly plant was making 5,000 units of a product, a portion might be rejected by quality control but it is unlikely that the entire 5,000 would be rejected.

Keeping accurate inventory records at a reasonable cost seems to be another process inventory problem. A liquid raw material might be packaged in fifty-gallon drums and used in small amounts for a particular batch process. It would be expensive to repackage the material in units for production for inventory status purposes. A similar situation might occur where partial rolls of material are converted to other products.

Advantages of MRP

The advantages of installing an MRP system in a process industry are essentially the same as those for a hard goods manufacturer. John Anderson and Roger Schroeder conducted a survey, in about 1978, of 326 industrial firms, including process ones, to obtain data about MRP systems in use [1]. Their findings included an analysis of benefits as perceived by the users. Quantitatively measured benefits included higher inventory turnover, shorter delivery lead time, higher percentage of meeting delivery times, smaller percentage of split orders caused by unavailable materials, and a lower number of expediters. Improved competitive position, improved customer satisfaction, better production scheduling, and improved plant efficiency were the most important overall subjective benefits, as ranked by the survey respondents. The researchers found that different types of improvements were significant in different types of companies so the specific ranking of benefits could be different for process firms as compared to job shops. All of the above factors are general business objectives that are applicable to any kind of manufacturing.

Although process industries may strive for the aforementioned benefits, the uniqueness of process industry inventory and production problems may seem to preclude use of MRP as a tool for attaining them. But analysis of those situations indicates that MRP can be adapted for continuous process planning and control. Thomas Kochalka argues that no business is completely unique. He says that the theory and principles, if not the details, at *one company* probably apply to others and that "no business is easy to plan in" [6, p. 17].

Solutions to P&IC Problems for MRP Implementation

One problem mentioned above is allocating production among plants. Constraints such as capacity, available warehousing, individual mill operating costs, and transportation costs are among the important considerations when making the allocation decision. International Paper uses a simulation model as a tool in developing its strategic, tactical, and operational plans. The production plan from this overall plan is used as input into its master production schedule [2].

Machine assignment and capacity utilization at each location must be considered [7]. This problem was illustrated by the paper scheduling situation. Like location allocation, this concern falls within production scheduling. Existing scheduling procedures may already address this problem, as it is not created by MRP implementation. For instance, a company may already use a production scheduling—computer system that incorporates simulation techniques in order to come up with a good schedule [14].

Economical use of byproducts resulting from many chemical processes and from cuts of rolls in such industries as paper manufacturing must also be considered [7]. This situation should again be included at the master production scheduling level. The output from a scheduling simulation system could indicate the quantities of byproducts that will be produced. Output from the MRP system itself would provide feedback for scheduling by listing gross requirements for byproducts that are used as components in another process.

Another area of concern is the inventory status integrity of certain items. Some, such as the raw material packaged in fifty-gallon drums, may be stored on the shop floor, with five gallons drawn off as needed for a certain process. This chemical may be used again soon at the same location so it would be impractical to move it back and forth between the stockroom and the production area. Yet, the storeroom inventory would show that fifty gallons were used while actually forty-five gallons are still on hand for use. One solution is to establish a work-in-process or floor inventory bucket as well as a stores inventory bucket [10]. Multiple floor buckets could be used for more than one production location. The fifty gallons of material would be issued from the stores inventory to the floor inventory. Five gallons would then be issued for the manufacturing order being processed. Thus, the on-hand quantity in the inventory record would be the correct amount, forty-five gallons.

A key assumption of MRP is that, within the planning horizon, production schedules are know with some certainty. The problem of batch quality discussed above can upset the schedule by causing a "rerun" or a shortage for the next processing step when a batch is bad. This possibility can be planned for by maintaining safety stock, where most economical, based on storage costs, shelf life, etc., or by increasing lead time [7].

Another specific implementation problem is defining units of end product for the master production schedule and units of components for the bill of materials. The end product could be expressed in gallons, square yards, linear feet, tank cars, barrels, rolls, etc. In other words, the units can be the same as those used in customer orders [6]. These units would necessarily vary from firm to firm. The bills of materials should be structured to fit the process as well as the end product. If one of the components, for example, is fed by pipeline into the production area, the feed per end unit would be expressed in the bill. The bill of materials could be viewed as a recipe in many situations and calculated algebraically to yield the end product unit. If one end product unit is a tank car of product X and another is a barrel of X, different bills of material could be prepared by the MRP software since the proportions of the components needed would be constant.

Portions of processing output are often sold to outside companies or transferred to other manufacturing plants. Such transactions occur at various points in the production process. This situation could be handled by treating production up to the sale point similar to the subassembly of a service part. Demand for the product at this point could be treated as a combination of independent, the outside sales and transfers, and dependent, where the product will be used as a component for further processing. This demand would then be reflected in the production schedules. Interplant transfers can also be considered within the MRP processing. For example, the identification number associated with the subassembly could concatenate a location identification with the product number. When the MRP system run at the receiving plant indicates a planned order for the product using the component, a gross requirement could be generated at the sending plant [6].

Another problem in process industries is based on the nature of the components and raw materials. The standard batch needed for processing might be different from the purchase quantity in an amount that increases costs relating to handling, shelf life deterioration, storage, etc. The manufacturing process might require 180M pounds of a material available only in 200M pound tank cars. The excess would have to be drummed off or otherwise stored or shipped elsewhere. The overhead cost of such events should be obtained from historical information and factored into the planning lot sizes [6].

The above discussion includes some of the most common obstacles to MRP implementation in a process environment. All of these problems can be solved in a manner compatible with MRP. Indeed, in some cases, MRP output actually provides information for the solutions. The relationships between those problem situations and MRP are summarized in Table 1.

Other Considerations for MRP Implementation

Many of the factors which must be considered when implementing an MRP system are similar for any industry. Extensive advance planning is one of the most important aspects [3]. Organizational procedures and resources must be assessed in depth, preferably by top management.

TABLE 1
Process P&IC Problems and MRP

Process Shop Situation	*Interface with MRP*
Allocation of production among various plants and machines.	Use simulation model output as input to master production schedule.
Economical use of byproducts.	Time-phased gross requirements generated for byproducts used as components or to be sold provide planning information for scheduling the processes that produce the byproducts.
Components (liquids, rolls, etc.) stored on shop floor.	Provide floor bucket as well as storeroom bucket in inventory record to maintain inventory status integrity.
Poor batch quality resulting in entire run scrapped.	Maintain safety stock at economical point or increase lead time to keep schedules valid.
Definitions of units for master production schedule and bills of materials.	Use same units as customer order.
Portions of output sold or transferred at various points in production process.	Treat demand for output like service part demand in standard MRP.
Nature of materials regarding handling costs, shelf life, storage, etc.	Determine overhead costs of such factors based on historical data and factor into planning lot sizes.

Personnel who will be affected by the MRP system must be trained and made aware of the objectives of the system. The technical parts of the system must be developed. These elements include the master production schedule, bills of materials, an inventory file, a capacity planning and control system, and shop floor control [3]. Procedures must be established for the maintenance of the above items.

The role of the computer is important. Because of the number of computations involved in exploding bills of material, etc., a computer is a necessity. It is a mistake to consider "MRP as a computer system rather than a people system made possible by the computer" [13, p. 96]. The people involved with the system, from top management to the shop floor foremen, must understand how the MRP system will affect their jobs. The nature of some jobs will change, inventory planners and buyers, for example, will be involved with preventing future shortages instead of fixing existing ones. Personnel must realize that MRP is a tool for them to use in performing better.

A related problem when installing a computerized production and inventory control system such as MRP is to expect the computer to do too much without human intervention. Traditional electronic data processing systems such as those used for accounts payable and payroll automate clerical functions. Manufacturing systems, on the other hand, extend farther into the decision-making process. Standard system analysis procedures often do not include methods for the ". . . higher degree of efficient integration of the human element . . ." [5, p. 15] needed in an MRP system. Thus, it is very important that development of such a system include active participation by production and inventory control people as well as data processing personnel. Anderson and Schroeder found that hardware and software problems encountered during implementation were generally secondary to people problems [1].

One alternative MRP implementation program for process companies is to put only part of their production on the system. A company that makes materials that require special curing is an example of a candidate for this. The time of curing is not precise, so the procedure is more an art than a science. In addition, the entire process has a high probability of failure. One such company put the production with known scrap levels on an MRP system and will try to add others such as the curing production later. Special processes like that might always require special human planning attention [12].

Successful MRP in a Process Firm

The Dow Corning Corporation, a chemical company, is an example of a process firm that has experienced success with its MRP system [4]. They run a weekly regeneration system. MRP was installed during the end of 1974 and beginning of 1975. One of the company's objectives was to improve on-time deliveries to customers. In 1973, sixty-five per cent of deliveries were on time; in 1974, seventy-four per cent; and in 1975, eighty-five per cent. Their raw materials inventory in 1978 was at ninety-five per cent of the 1974 level. Production had increased twenty-five per cent over the same time period.

The company's operations incorporate many of the process firms' factors discussed above. They sell some of the output at various stages in the manufacturing process in varying units. They transfer products to other plants. They use some of the products from one process for further work in another operation within the plant. They experience batch failures.

One of Dow Corning's main problems with MRP was providing a good master production schedule. Inventories increased to a high level during the first year of using the MRP system. Consequently, the company discovered that there was not actually a forecast on which to base the schedule. They developed a quarterly, formal production planning process at the top management level in order to set better production levels. Education and training also became a critical area. People were sufficiently trained at the time of installation. However, with personnel changes it became evident that the firm needed a continuing education program. Neither of these problems is particularly related to Dow Corning being a process firm. Dow Corning's solution to its master production schedule problem is the action proposed by Joseph Orlicky for any firm using MRP. He suggests that this schedule ". . . represents the main point of management entry into the overall system" [8, p. 256]. Similarly, most companies experience personnel changes that would necessitate continuous or periodic MRP training programs.

MRP in Process and other Industries

Much recent effort by APICS and others has been expended to formulate a production and inventory control model using MRP for process industries. That model is basically the same as the job shop model with modifications, as discussed above. This conclusion is supported by the findings of an APICS workshop dealing with process industry production and inventory planning [11]. Another interesting result of recent examinations of how process industries are using MRP is that ". . . many nonprocess industries are viewing themselves as having process industry characteristics" [10, p. 35]. The nature of the material flow rather than the nature of the product is the key point. Many mass production lines share with traditional process manufacturing such traits as repetition, fixed routine of work through the plant, higher unit volume and lower cost, and emphasis on output rates instead of units per job or manufacturing orders [10]. Companies that make standard consumer products for stock might fall into this category.

MRP can indeed be a useful tool for production and inventory control and planning in process industries. Adapting the MRP system to fit the particular situations and needs of an individual company is extremely important. Anderson and Schroeder found that a variety of MRP designs do exist, which indicates that many types of companies, not just process ones, must adapt the classical MRP approach to their own situations [1].

References

1. Anderson, John and Roger Scroeder, "A Survey of MRP Implementation and Practice", *Proceedings of the Material Requirements Planning Implementation Conference September 24, 25, & 26, 1978*, APICS and University of Minnesota pp. 6-42.

2. Bender, Paul S. and others, "Practical Modeling for Resource Management", *Harvard Business Review*, Vol. 59, March-April, 1981, pp. 163-173.

3. Donovan, Michael, "Are you Ready for MRP? *Management Review*, Vol. 66, October, 1977, pp. 46-50.

4. Hayes, Dan, Jr., "A Case Study of MRP Implementation in a Process Firm", *Proceedings of the Material Requirements Planning Implementation Conference: September 24, 25, & 26, 1978*,