1-1-1986

Materials management : Materials Requirement Planning and Just-In-Time

Joanne Shermulis

Materials Management:

Materials Requirement Planning
and
Just-In-Time

Submitted By: Joanne Shermulis
Submitted To: Dr. A. Rifai
BSA 499H
April 29, 1986

In a manufacturing firm, materials expenditures make up a good proportion of the capital investment. These expenditures are in the purchasing, handling, and storage of materials. Careful consideration must be given to decisions made in materials management, as the outcome affects the employees, the administration, the stockholders, and the customers of the firm.

Though there are many different methods of managing materials, two are gaining increasing importance: Materials Requirement Planning (MRP) and Just-In-Time (JIT). Materials Requirement Planning is a materials management system which attempts to minimize the total costs of materials purchasing and storage. Materials are purchased and produced in the most economical lot sizes, and arrive where they are needed prior to the time that they are needed. Just-In-Time is a total production and inventory management system which is based upon the timing of the flow of materials through the manufacturing process.

Materials Requirement Planning has been the recommended method of materials management by the American Production and Inventory Control Society (APICS) for many years. Many American firms have successfully implemented MRP systems. However, many members of APICS are now attributing JIT as a superior system. At this time, JIT is the primary method of materials management in Japan, with very limited applications in the United States.

It will be of great benefit to American manufacturing firms to study both of these systems to determine which of the two would better suit the needs of the firm. A comparison and contrast of MRP and JIT, and also of the American and Japanese manufacturing systems shall be addressed to help the readers to assess the proper method of materials management for a firm.

Materials Requirement Planning

MRP is an information system which attempts to facilitate the flow of materials in a manufacturing environment while minimizing the total cost of materials management. MRP is best suited for a repetitive manufacturing environment, with standard products and few variations, though it may also be applied to an intermittent process. Generally, MRP is most useful when end products are comprised of many subcomponents, when demand for the finished product is highly variable, and when dependent demand exists. Dependent demand is demand for a subcomponent in another assembly.

MRP is a "pull" system, which attempts to bring materials where they are needed, when they are needed. In this respect, MRP seeks to minimize inventory, though not necessarily to eliminate it. MRP makes use of the most economical lot sizing technique, such as the Economic Order Quantity formula. The Economic Order Quantity formula takes into account the fixed costs of procurement or of production set-ups, the variable costs of inventory handling and storage, and the demand incurred during the cycle period, to determine a lot size which will meet demand while minimizing costs.

The user of an MRP system may expect to spend an amount of time from several months to several years in implementation of the system. Once operating at top efficiency, an MRP system may be expected to increase operating efficiency by decreasing lost time due to materials shortages, and to reduce lead times in production and delivery.

An MRP system is driven by the master production schedule. The master production schedule (MPS) is based on independent demand forecasts of the finished product by the end user, and divides the overall production plan into specific end products. It identifies the quantity of end products needed, and the time at which they are needed. The MPS covers a planning horizon, generally a period from six months to one year. The planning horizon is comprised of "time buckets," or time intervals, generally one week each, in which each time bucket is assigned a forecasted production need. Figure 1 shows an example of a master production schedule.

A bill of materials supplements the master production schedule. A bill of materials identifies the specific parent/component relationships of all subcomponents of an end product. The bill of materials codes the level of each component. The level coding of parts is used to determine the

Figure 1

Master Production Schedule

	Time Buckets (in weeks)					
End Product	1	2	3	4	5	6
A	20	10	25	15	20	30
K	50	80	90	60	40	35
N	100	125	110	80	60	100

performed by determining total demand, incorporating inventory to determine total production needs, and then incorporating lead time to determine exactly when the material is needed.

Lead time and lot sizes must be known in order to perform the MPS explosion. Lead times may be classified as either procurement or production. A procurement lead time is the amount of time, measured in time buckets, elapsed between the request and receipt of materials from a supplier. A procurement lead time is necessary for raw materials or subcomponents received from a supplier and put directly into the production process. A production lead time is the amount of time, also measured in time buckets, elapsed between the request and receipt of subcomponents from other production departments of the firm.

Lot sizes are determined by various methods to find the most economical combination of reorder costs and inventory cost (for procurements), or of setup costs and inventory costs (for production). Each component may require a different lot size. The different lot sizes must be taken into account when scheduling production, as a lot of one component may be large enough to meet demand requirements for a month, while a lot of another component may only be large enough to meet demand requirements for a week.

Taking all of the forementioned components of an MPS into consideration, Figure 3 illustrates the MPS explosion. Beginning with the items with a low level code of zero, total demand per time bucket is summed. Taking into account beginning inventory, a planned order receipt is entered in each time bucket that

Figure 3

MPS Explosion

End product A
Lead time = 1 week
Lot size = 50 units

		1	2	3	4	5	6
Independent demand		20	10	25	15	20	30
Dependent demand		0	0	0	0	0	0
Total demand		20	10	25	15	20	30
Inventory	35	15	5	30	15	45	15
Planned order receipt				50		50	
Planned order release			50		50		

Component B
Lead time = 1 week
Lot size = 80 units

		1	2	3	4	5	6
Independent demand		10	10	10	10	10	10
Dependent demand		0	50	0	50	0	0
Total demand		10	60	10	60	10	10
Inventory	70	60	0	70	10	0	70
Planned order receipt				80			80
Planned order release			80			80	

Component C
Lead time = 0 weeks
Lot size = 225

		1	2	3	4	5	6
Independent demand		25	25	25	25	25	25
Dependent demand		0	180	0	100	80	0
Total demand		25	205	25	125	105	25
Inventory	200	175	195	170	45	165	140
Planned order receipt			225			225	
Planned order release			225			225	

Component D
Lead time = 2 weeks
Lot size = 220

		1	2	3	4	5	6
Independent demand		20	20	20	20	20	20
Dependent demand		0	160	0	0	160	0
Total demand		20	180	20	20	180	20
Inventory	200	180	0	200	180	0	200
Planned order receipt				220			220
Planned order release		220			220		

Figure 3 (cont.)

Dependent demand generations

Parent	Component	Qty	1	2	3	4	5	6
A	B	1		50		50		
	C	2		100		100		
B	C	1		80			80	
	D	2		160			160	
C	none							
D	none							

demand exceeds inventory. A planned order release is entered in the time bucket which reflects the lead time between release of an order and its receipt. The parent part is then entered on the dependent demand schedule to determine the timing and quantity of demand for the subcomponents. In the example, end item A has two subcomponents: part B and part C. For each end item A, one unit of B and two units of C are needed. This is reflected on the dependent demand schedule, as the quantity of B and C needed to meet the planned order releases of end item A are entered. The dependent demand schedule insures that all subcomponents will be available for production of a parent unit at the time when production is scheduled to begin.

Changes in demand forecasts may call for changes in the production plan, which requires a re-explosion of the MPS. This can become quite complicated, as an MRP is an ongoing system, and changes in the scheduling of jobs necessitates accurate knowledge of needs and a fair amount of time to allow for adjustments. It is for reasons such as this that experts on MRP systems believe that successful implementation of an MRP system amount of time equal to the sum of the actual processing times. This is quite an accomplishment, as in most manufacturing processes, the time spent in actual processsing of a product is approximately 10-20% of the total time spent in the production process. A JIT system may be expected to increase productivity and quality levels , and to reduce lead times.

A JIT system is driven by customer demand. Customer requirements are closely matched by the final assembly schedule. The final assembly schedule pulls material through the preceding stations in a chain of order, in the exact quantity needed. Each work center provides the following work center with only the amount it is ready to use. If the input material at a work center accumulates past a certain, set point, production at the preceding work center, which supplies the input, must stop. This type of bottleneck will happen very rarely in a JIT system which is functioning properly.

The amount of inventory between work stations is determined by a manual information system known as Kanban (the Japanese word for 'card'). A set of Kanban cards have two major functions in the JIT system: to provide the mechanism for short-range implementation of the system, given a prescribed number of cards; and to facilitate reductions of work-in-process inventory through a systematic removal of cards from the system (Peterson, p.526). Kanban cards are of two types: production cards and move cards. A production cards authorizes the production of one lot of a specific part at a specific work center. A move card authorizes the transfer of one lot from its producing work center to the

The employee removes the move card from the empty container and places it on the full container. The production card is removed from the full container and is placed in a box at work center B. The full container, with a move card attached, is transported to work center A, and the material is available for processing. At work center B, an employee picks up the production card from the box in which it was placed and attaches it to an empty container. This authorizes the production of one standard container (one lot) of parts at work center B. The removal of production cards from the system tightens the work-in-process inventory until each work center has only one production card. This is an ideal situation which can rarely be reached. However, reductions of work-in-process inventory of up to 75% are not uncommon.

While great gains may be made with a JIT system, it is certain that the system will not work without a deep commitment to success. Hewlett-Packard proposes nine elements of a successful JIT system.

1. Education and awareness of all persons affected by the system. This includes every employee in the firm, from top management on down. Work center employees must be skilled so as to be able to function at any work center which is falling behind in production. Others outside the firm must also be involved, such as customers, distributers, and suppliers.

2. Design of the flow process. Careful consideration must be given to the flow of materials. The JIT system will become more productive by more frequent transfers of materials from work station to work station. This requires placement of work

stations adjacent to each other. Transfers which require traveling a lengthy distance cannot be tolerated.

3. Total quality control. Every effort must be made to bring defects to near zero. This can only be accomplished by educating every employee on the issue of quality. Employees are made responsible for each piece of material which goes through their work station. All defects must be returned to the responsible party for rework. To keep this practice to a minimum, the idea is to correct the process, not just the product.

4. Level schedules. The production schedule must be leveled to keep a smooth flow of materials. It is not possible to speed up the production process, as it is assumed that the manufacturing line is always working at its highest level of productivity. It is possible, however, to increase production by putting additional lines into operation.

5. Demand pull production. It is necessary that production be stimulated by precise customer demands. If the final assembly department of a firm begins to accumulate inventory, the production process should be stopped.

6. Inventory reduction. Work-in-process inventory must be systematically be reduced, and finished goods inventory must be eliminated. Work-in-process reductions are accomplished with JIT through the use of Kanban cards. Removal of production cards from the system automatically reduces the work-in-process inventory. Finished goods must be distributed as soon as they have completed the manufacturing process. No build-up of finished goods is allowed.

7. Cooperative suppliers. Relationships must be established with suppliers so that the firm and its suppliers can work to their mutual benefit. Suppliers will be required to make deliveries daily or perhaps even several times each day. Reorder costs charged by suppliers must be minimal. Quality of the suppliers' parts must also be of nearly perfect quality, as acceptance of a defective lot can put a halt to the entire production process.

8. Improved production design. The production design must be streamlined to achieve the highest level of productivity. Unnecessary motions, movements, and transfers should be eliminated. Equipment changeovers must be analyzed and redesigned to be fast and inexpensive.

9. Commitment to the JIT philosophy. Everyone involved must believe in the value of JIT, and must be committed to striving for the success of the system. A refusal to cooperate by any one person involved can cause the failure of the entire system.

A Just-In-Time system is often compared to water in a river. When the water (inventory) is at a high level, dangerous rocks (obstacles to high productivity) are hidden. As the water (inventory) is lowered, rocks (obstacles) are exposed and removed, thus keeping the water flowing (high productivity) at a lower level.

Japanese Manufacturing Environment

The main thrust of why Just-In-Time production works so well for Japanese companies is the environment of the firm. The

Japanese approach to manufacturing is superior to the American approach, not technologically, but in a way that emphasizes education, quality, and trust. Elimination of waste is always stressed, and waste is considered to be any part of the manufacturing process which does not add value to the product. Inventory is considered waste, and even the transfer of a product from one work station to another is considered waste.

In a study by Gerhard Plenert, sixteen techniques of Japanese firms which are recommended for use in American firms have been outlined. These techniques are believed to be the reason why Japanese firms are operating so successfully today. The techniques are outlined in Figure 5 (Plenert, p. 122).

Figure 5

Sixteen Recommended Management Techniques

Facilities Planning Techniques
- Shared resources
- Smaller factories
- Technology specialization

Production Planning Techniques
- Product sequencing
- In-line quality control
- Just-in-time or Kanban
- Split shifts
- Lifetime vendors

Management Style Techniques
- Management circles
- Statistical management
- Long-run planning

Employee Relations Techniques
- Lifetime employment
- No nepotism
- Profit bonuses
- Morale programs
- Employee rotation

Under Facilities Planning, shared resources, smaller factories, and technology specialization are emphasized. Shared resources refers to separate firms sharing resources such as water supply, warehouses, power generation, service personnel, medical staff, etc. This practice is seldom done in the U.S. It is more applicable in Japan because of the smaller, "focused" factory. The Japanese produce a standard product, with few product variations, at each factory. This allows for technology specialization, with dedicated equipment designed for one particular purpose. This equipment is smaller and cheaper than the multipurpose equipment used by American firms.

Under Production Planning, product sequencing, in-line quality control, Just-In-Time, split shifts, and lifetime vendors are emphasized. Product sequencing supports the idea that a product should move to the next phase of production as soon as it is completed, not as a part of a batch. In-line quality control stresses that the quality of the product must be accounted for during the manufacturing process, not after. The responsibility for quality is placed with the people who are closest to the product, and who are able to recognize a problem with quality as soon as it arises. Quality control in the U.S. is usually exercised on finished goods by rejection of lots which fail to meet a statistical standard. Quality is therefore only the concern of one department of the firm. Split shifts is a concept which splits the workday into two periods. A gap of two to four hours between shifts is used for machine maintenance, changeovers, and inspections. By completing these tasks in the gap between shifts, idle time is cut for workers who would normally have to wait while the tasks were performed. The workers' time is spent more productively. Lifetime vendors are very common in Japan. A vendor is seen not as an adversary, but as an extension of the company. Vendors are not chosen by price, as many U.S. firms practice, but by an ability to be involved in the design and quality of the product, and to produce it as efficiently as possible.

Under Management Styles, management circles, statistical management, and long-run planning are emphasized. Management circles are a group of employees working together to develop a recommendation for top management. Very rarely are these recommendations rejected. Statistical management, or quality control, uses charts and statistics to aid in control and to keep the facilities operating with certain tolerances. This technique is already in wide use in the U.S. Long-range planning attempts to make gains in productivity in the long run, perhaps even at the cost of short range profitability. In many U.S. firms, this practice is unacceptable to the stockholddrs, and therefore, to management.

Under Employee Relations, lifetime employment, no nepotism, profit bonuses, morale programs, and employee rotation are emphasized. Lifetime employment for a company includes provisions for compensation, advancement, education, and retirement. It promotes loyalty and the good worker attitude conducive to productivity. No nepotism is practiced in Japan, so unqualified relatives are not found in the employee ranks. Profit bonuses are made to employees often, as a reward for good performance. Morale programs are designed to the interests of employees and their families. Employee rotation from one work station to another allows employees to become better educated of the production process and their part in it, and helps to alleviate the boredom of mass production techniques.

While some of these techniques are being applied by U.S. firms, all have the potential to become usable and desireable standards of management of U.S. firms.

A team of researchers at Ohio State University have made an intense study of the Japanese manufacturing environment. The results of this study are somewhat surprising. The research team accredits the environment of manufacturing as the succes of the Japanese. Simulations were conducted in which the environment was held constant and the system of materials management was changed. Just-In-Time and a Reorder Point system were compared. The results of the simulation concluded that while the results of the JIT system were exceptional, the results of the Reorder Point system were equally impressive. This lead the team to conclude that the success of the Japanese is attibutable to some key characteristics of their manufacturing environment (Ritzman, p.151).

The Japanese are able to establish a successful environment in manufacturing because they hold many of the same beliefs in their private lives as they do in their professional lives. Trust, cooperation, organization, flexibility, discipline, and a bias toward experimentation are all inherent to the Japanese people. Lifetime commitments are made and held by both parties.

Frivalties are not highly valued. Loyalty and honesty are practiced by most citizens. The Japanese people are able to incorporate these characteristics into their production process. These ideals have made the Japanese the most successful manufacturers in the world in recent years.

Benefit and Cost Comparison

As the ideals of both MRP and JIT are to reduce inventories and costs, it will be useful to know what type of reductions can be expected.

J. Orlicky, an early spokesman for MRP, suggests that successful MRP users will enjoy a reduction in inventory investment levels of 20% to 35%. Depending on the size of the firm and their original inventory investment level, this could potentially save a company hundreds of thousands of dollars annually. However, only about 50% (optimistically) of MRP installations are successful (Riggs, p.462). Many companies have sunk thousands of dollars into the implementation of MRP systems, only to have them fail miserably. This is usually due to poor forecasting or inaccurate record keeping. The adage, "garbage in, garbage out" applies here.

The benefits of a JIT system are potentially greater than those of an MRP system. A study of Japanese companies using JIT reports that inventories of firms in four industries have been reduced 55% to 84%, with further improvements expected (Nakane, p.89). Also, set up and reorder costs will become negligible, as necessitated by the structure of JIT. Though the exact figures are undocumented, the success rate of implementation of JIT in move strongly into the use of JIT systems (Crosby, p.21). Authorities in U.S. manufacturing have made strong recommendations both for and against the use of JIT in the U.S. The consulting division of Arthur Anderson and Co. has been educating American companies to the philosophy of JIT for over four years. Anderson executives have reported that their clients have achieved phenomenal results. According to Leroy Peterson, an Anderson partner, American manufacturers can reduce inventory and production lead times by approximately 90%, reduce set-up times by 75% and manufacturing and storage space by 50%, and improve the quality of manufacturing by 75% to 90% (Cook, p.66). With Anderson's help, the Harley-Davidson Co., on the brink of bankruptcy, was able to reduce its break-even point by 32% and increase its inventory turnover from three times per year to sixteen times per year.

Other proponents of JIT report similar results. The Ohio University research team performed a simulation of the application of JIT systems on typical U.S. manufacturing firms. Inventory levels have been reduced from an average of 41 weeks of supply to just above eight weeks of supply, and past due demand has decreassed from 2.1 to 0.2 weeks (Ritzman, p.151).

Apple Computer has won great praise for its application of JIT in the assembly of the Macintosh computer. They have set up a $20 million factory with a JIT system and are producing 6,000 Macintosh computers a week.

Despite the apparent success of many American firms, not all authorities are convinced of the applicability of JIT in the U.S.

Opponents claim that American firms should be extremely cautious about adopting a JIT system. The principle arguments against JIT are that the benefits of inventory reduction are outweighed by the potential costs of dirupted production due to a lack of crucial parts, and that Japanese firms are better suited for JIT because of a standardized product line. suppliers close to the home base, and an unusually cooperative work force. It is argued that American consumers demand a more varied product line, that the least expensive suppliers are usually geographically distant, and that crises will erupt frquently, causing management and employees to become frantic and burnt out.

Though praised for its success, Apple Computer has encountered some problems with its JIT system. A shipment of cathode ray tubes received from the far East which was defective was accepted for production. When discovered, management traveled to the Orient to discuss the problem with the maker. Meanwhile, the scant supply of computers was exhausted, and production stopped for over a week. When the CRT's finally arrived, extra workers and overtime were necessary to bring production back on schedule. Though the exact cost of this work stoppage has not been released by Apple, expenses incurred include the production line shutdown, overtime premiums, potential loss of customers who could not wait, cost of air fare and management time, air freight of the second CRT shipment, and potential quality loss due to catching up (Wilson, p.136). Disrupted production can be very expensive to a firm, especially if it occurs frequently. These costs must be considered before implementation of JIT.

Conclusion

It can be concluded that both MRP and JIT are useful systems for the management of materials. Figure 6 presents for the reader a summary of the main characteristics of the two systems. The benefits and costs of each system must be assessed by the individual manufacturing firm to determine which system will better serve their needs.

Figure 6

Summary

	MRP	JIT
Inventory	tolerated	eliminated
Demand	"pull" demand by customer needs	"pull" demand by customer needs
Suppliers	adversaries; multiple sources	extension of company; single source
Quality	statistical tolerances	must be near perfect
Lot Size	variable; determined by economic lot sizing techniques	usually small; ideal lot size is one unit
Lead Time	reduced	reduced
Implementation	complicated requires computer base	fairly simple, but may require redesign of facility layout