

## **A COMPARATIVE STUDY OF EXISTING MANUFACTURING PLANING AND CONTROL APPROACHES**

**O.Torkul, I.H.Cedimoğlu & M.S.Aksoy**  
Sakarya University Engineering Faculty  
Industrial Engineering Department  
Esentepe, Adapazarı- Turkey

### **ABSTRACT**

During the 1980s various approaches to batch-type manufacturing environments were implemented. The most popular of these were Material Requirements Planning (MRP), Group Technology (GT) and Just-In-Time (JIT). However few successful implementations of any of these approaches were achieved [1] [2] [3]. This paper compares the various approaches of GT, MRP, JIT along with the integrated approaches such as MRP/GT and MRP/JIT.

### **1. INTRODUCTION**

At present manufacturing industry suffers from economic recession and rapid changes of product design as well as from production planning and scheduling problems. The literature still lacks theories for making practical effective and flexible multi-product batch-type manufacturing systems [4] [5] [6].

Some effective approaches to the batch-type manufacturing systems have been developed:

1. Material Requirements Planning(MRP) which is used for manufacturing control in American industry.
2. Group Technology(GT) is a manufacturing philosophy which is widely used in British manufacturing.
3. The Japanese approach of Just-In-Time(JIT) production.

Recently some research has been carried out on integration of GT/JIT and GT/MRP. Today, in an increasingly competitive manufacturing environment, higher levels of customer service (short and reliable delivery times) are required, inventory costs have to be kept low and productivity has to be high. Market demands change quickly so that manufacturers can no longer operate in a steady state using long term fixed schedules. However existing systems are failing to provide the improvements required. They must move to a transient style similar to a JIT/MRP type manufacturing system: keeping stocks at a minimum, low work-in-progress and shorter lead times as well as responding quickly to changing demands.

## 2. GROUP TECHNOLOGY

Group Technology (GT) is a technique for identifying and bringing together related or similar components in a production process in order to take advantage of their similarities, for example by making the use of the inherent economies of flow-production methods [7]. Adoption of group technology involves some steps [8]. First, classification and coding of the similarities between parts is used to develop formal families of parts based on design and/or manufacturing similarities. Some of these classification and coding schemes are very formal and are perceived as synonymous with "group technology". A second step involves using the concept of part families to guide the physical rearrangement of the production facility. Groups (cells) of different machines are identified and dedicated to the production of a part-family or a set of part-families. These dedicated machines are placed together to form a manufacturing cell. This is usually referred to as cellular manufacturing [9].

The Group Technology literature has claimed several advantages for the group technology layout over the functional layout [8] [10]. Some of the benefits that may be expected are: lower work-in-progress inventories, lower material handling costs, lower costs of preparation and tooling, a significant reduction in the amount of time spent setting up (or changing over) machines between batches of parts. Reducing set up times allows you to reduce the batch size required. This should lead to more flexibility in both scheduling and processing. The combination of lower set up time and lower material handling time, has implications for improving customer service and due-date performance.

On the other hand, a growing amount of literature is critical of group technology. Suresh [2] has pointed out that few group technology implementations can be considered successes, despite the large body of literature describing group technology's advantages.

A number of authors have discussed changes, to factory other than the layout, that must be made to a system before a group technology implementation will be successful [2] [10]. These include controlling orders so that they are issued at regular intervals of less than two weeks, carefully planning a loading sequence that minimizes setup and idle time and purchasing new equipment. Others have suggested improved production planning and control as well as improvements in organisation and scheduling [11] [12].

Various industry reports indicate that implementation of GT concepts leads to remarkable improvements in efficiency. It has been noted [13] that there has been considerable delay between these claims based on information from the industry, and the start experimental work to test the reports.

Simulation experiments that have been performed [9] seem to yield results that do not completely support the industry reports. For example, shops with process layout were shown to have significantly shorter average flow times and lower work-in-progress inventories. The shops that used GT layout were shown to have shorter setup times, lower machine utilization and shorter distances travelled, on average. The results



suggested that a well-organized traditional job shop may be able to achieve overall performance that is at least comparable to that of the same shop using GT layout.

### 3. MATERIAL REQUIREMENTS PLANNING

Material Requirements Planning (MRP) is basically a procedure used to determine the quantity and timing of replenishment order releases, for manufactured and bought-out items including raw materials, and to decide on the priority of jobs competing for limited resources in the workshop[14]. This approach to materials management applies to large job-shop situations in which many products are manufactured in periodic lots in several processing steps.

Time-phased part requirements are deduced from a master production schedule using a bill of materials and routings with standard throughput times and yields. Processing requirements are determined by comparing part requirements against available inventory. The procedure operates under the assumption of infinite capacity ignoring the practical capacity limitation of the workshop to execute the production plans generated by the procedure. The procedure uses fixed manufacturing lead times to determine the planned schedule of order releases to meet the requirements at higher level. MRP methods are computer-based, and many software companies offer products variously labelled "MRP", "Closed-Loop MRP" or "MRP II".

The implementation of MRP, posed some problems particularly, with capacity shortages. The MRP procedure was therefore incorporated into an "overall system" called closed loop MRP. In this "improved" system, some important elements missing from the original MRP, such as capacity requirements planning and shop scheduling are allowed for.

Closed-loop MRP closes small loops within the operations department. The operations department also fits into a grand loop that includes capacity planning, marketing, financial planning and overall business planning [15]. Because of this, the concept of closed loop MRP systems is extended into manufacturing resource planning known as MRP II.

MRP II is designed to allow a feedback system to adjust the master production schedule depending on conditions monitored in the purchasing/production environment. MRP is the heart of the MRP II system but feedback is the key to its success [16].

MRP II leaves the scheduling decisions within each work centre to the supervisor in charge. Some MRP II programs have simulation capabilities to allow managers to ask "what-if" questions [17]. They also allow better scheduling by smoothing production levels. Obviously, MRP II will be effective only if feedback information is timely and accurate.

The use of MRP systems is so widespread in the U.S.A that many managers have come to think of them as a necessary part of manufacturing, along with buildings, machines

and workers [17], but the concept of MRP and the extended system MRP II have been criticised lately. The main reason for the criticism is the fact that few implementations are successful. Most of the critics [18] [19] blame the system failure on two main drawbacks :

1. MRP systems require a higher level of data accuracy than most users are able to provide.
2. MRP systems require a high level of commitment from management and the users.

The dynamic nature of the manufacturing environment makes it difficult to maintain accurate information and this has been called "the fundamental problem of manufacturing" [20].

Some principle weaknesses in the systems are [21]:

- 1) the systems are too complex to implement,
- 2) the systems can not respond quickly to environmental changes.

MRP systems develop time-phased requirements for all component parts and sub-assemblies. If a time bucket is one week long, the system assumes that a lead time of one day is equal to that of one week. This would allow materials to be delivered several days earlier than the day on which the material is required for operation. This is serious deficiency of the system which makes it inappropriate as a "Just-in-time" tool and it undermines the potential benefits of time-phasing of requirements.

#### **4. REAL-TIME MRP SYSTEM**

Sinulingga [21] has claimed that the forecasted master production schedule is one of the sources of complexity of MRP systems. He also suggested the use of actual customers' orders instead of forecasted master production schedules and the applications of an effective loading procedure(e.g. forward loading to finite capacity), in which the system is operated in "real-time". In addition, stocked component replenishment is processed on an order to order basis. Spare capacity, if available, can be utilised to replenish orders for stocked manufactured items.

Some of the benefits gained through Real-Time MRP are described as follows [21]:

- it detects the critical events and project the impact of such events on production;
- it responds quickly to affect the impact;
- it improves performance of the MRP system.

Naji [22] has discussed the performance of Real-Time MRP Systems subjected to some adverse effects caused by inaccuracies. He suggested that if the adaptive loading model is operated in Real-Time mode before processing each new order, then this will ensure the presence of up-to-date information regarding capacity availability.



## 5. AN INTEGRATED GT/MRP SYSTEM

The major problem in the production of assembled products is usually the coordinated delivery of components to meet assembly schedules. Where functional organisation is used for component production it is impossible to plan effectively because of complex interactions between jobs. Typically some 80% of the total throughput time is spent in queuing [23]. This can be reduced significantly by the introduction of group organisation.

The problems of such production processes are almost always associated with the interface between component production and the assembly of products or sub-assemblies. Almost all delays in such systems are caused by unbalanced supplies of components to meet current assembly programmes either through production delays on the former or changes to the latter. The desirable characteristics of component production can be summarised as [23] :

- short, reliable lead times
- high degree of flexibility
- production of balanced sets of components

Because of the above reasons and the GT and MRP problems mentioned earlier, some authors [2] [4] [8] [23] suggest that these problems can be alleviated by developing an approach to integrating manufacturing-based GT concepts with MRP systems. They present a framework of such a system [2] [4] [8] [23].

Let us examine what they suggested to achieve this:

New [23], proposed a component in MRP that calculates demand and short cycle planning and control of order input, and the use of a planned loading sequence together with group organization of the production facilities. He claimed that GT cannot be used without MRP because:

- a) it is very sensitive to component shortages, and
- b) total load input for the cells need to be carefully controlled.

Also MRP alone is not enough because with batch control :

- a) realistic planning is almost impossible
- b) planned sequencing is difficult, and
- c) long lead times are perpetuated.

He believes that the combination of these two philosophies provides the key to effective control over what is currently an uncontrolled and inherently uncontrollable system.

GT and MRP have been found to have several drawbacks in practice. It has been proposed that such drawbacks may be substantially alleviated via a fairly straight forward combination of both GT and MRP [24]. Authors have also shown the results obtained through actual case study [24].

The difference between the integrated approach and MRP alone is a reduction of about 5% for total flow time. In [24] the authors believe that when the integrated approach is used more reduction of flow time can be expected .

Suresh [2] has described the operation of an MRP system in a group technology framework in which the implementation of GT involves primarily,

1. the changeover from process to a group layout,
2. establishing a Production Planning and Inventory Control system which would be compatible and optimal for operations based on a group layout (and which is achieved through MRP), and
3. a scheduling and machine loading approach based on the GT concepts of tooling and material families.

In [2] the author claims that the system can provide some improvements such as much shorter and more predictable manufacturing lead times compared to functional layouts. Moreover the system can get benefits from reduced WIP in shopfloor and finished goods inventories and simplified materials movement and control, which remain a problem in functional layout-based MRP systems.

Hyer and Wemmerlov [8] have stated that " MRP is a system for order scheduling and, as such, is not concerned with how the orders are completed. Group technology (cellular manufacturing), however, is a way of making production more efficient and is therefore not directly concerned with the timing of jobs that pass through the system". They discussed whether an MRP system is compatible with the production planning and control requirements of production cells. They suggest that a combination of MRP and GT system is viable. The problems that arise are especially in the areas of lot-sizing and sequencing/scheduling.

As a result, they claimed that MRP systems can accommodate GT cell production planning and control but that certain issues need careful analysis. Gupta and Darrow[25] have suggested that many of the production economies of GT can be realized in the job shop by better production planning, without uprooting machines to form machine cells. They have worked on a case study of gear manufacturing at Black & Decker's industrial products division where the shop is a classical functional job shop and managed as a well established MRP system. Components for the production have been classified into GT part families. The results showed that the optimal group scheduling method reduces the setup and carrying costs by 23.3% on average when compared to the optimal policy for scheduling independent part requirements. The results of their research suggest that more benefits can be realized before the large capital expenditures are made to reorganize existing machining centres by developing an approach to integrating manufacturing-based GT concepts with MRP systems.



## 6. JUST-IN-TIME(JIT)

Just-In-Time production techniques were pioneered by the Toyota Motor Company. The JIT philosophy is to make only the minimum of necessary parts in the smallest possible quantities at the latest possible time [26]. JIT affects every aspect of manufacturing. Major opportunity areas include quality control, work methods, physical layout, supplier relationships and production scheduling and control.

Like MRP, JIT plans component parts needed to meet a known master schedule. A key difference is this: MRP feeds a component scheduling system, while JIT provides for component production and deliveries to be triggered by a visual or audible signal instead of schedules. JIT manufacturers commonly maintain the master schedule, bills of materials and inventory records in computer files—principally for calculating requirements for purchased items.

The first principle involved in the JIT production approach is the elimination of waste. This simple approach means using the absolute minimum of equipment, labour, materials, space and time that is necessary to add measurable value to the product.

The second principle of JIT production involves the management of people. The JIT philosophy assumes that people are able and willing to take on more responsibility. It departs from the path of specialization and allows the worker to be more flexible. The workers are encouraged to develop their general skills and cross train in as many disciplines and technologies as possible [27].

The following are examples of the other means employed by Japanese companies in developing their production system [28].

- Product and cellular layout arranged in a U shape
- The use of mixed model production and assembly lines
- Operators stand at work stations to facilitate easy movement and production flow.
- When human operation is more efficient and effective than machines, the Japanese will employ human effort.
- In assembly situations, jobs are kept together in kits.

Based on statistics which have been published by various sources, some of the benefits which have been realized though JIT are; an average reduction in inventory, a reduction in manufacturing leadtimes, reduction in setup times, reduction of work-in-process, space reduction and quality improvements.

However JIT is not the answer to all the manufacturing problems [26] [29]. It can be seen that the concept of JIT would not allow the production of parts if they are not immediately required because such production is considered as wasting resources. To some extent this view may be correct if the spare capacity of expensive machinery is utilised by producing some parts to be used later on. This view is undoubtedly

questionable. Furthermore leaving spare capacity unutilized is certainly wasting resources [21].

## **7. MRP/JIT**

MRP II systems that were the standards in the early 1980s will not be standards for the 1990s. The reason is that MRP II systems do not have the functional and technical tools needed to meet the information requirements of current and future manufacturing operations as pointed out earlier. As a result the evolution of manufacturing systems has taken us from MRP II systems to the current day capabilities of JIT. This evolution has caused some problems. The problems have occurred when changes in manufacturing processes have ignored the overall impact on the manufacturing systems environment that run these processes.

Many companies have realized some benefit from the application of JIT techniques as mentioned earlier. However, they have not gained the full benefits of such changes [3]. For this reason some researchers [29] [30] [31] and [32] have proposed an integrated MRP/JIT system.

Schultz[30] has claimed that a company's manufacturing strategies must support the long-term objectives of the business to survive, profit and grow. They must be developed to keep supply and demand in balance for each major product/market relationship. These strategies include: MRP II, JIT and CIM(Computer Integrated Manufacturing).

It has been claimed by Bermudez [31] that JIT and MRP, as a hybrid solution, provides a more comprehensive management system for the manufacturer. The hybrid MRP/JIT manufacturing management system combines the planning and control concepts of MRP II with the streamlined execution concepts of JIT.

## **8. CONCLUSION**

Existing systems are failing to achieve the objectives of manufacturing. Results have shown that the manufacturing systems designed in the early 1980s are not the answer to today's manufacturing environment requirements[3].

Many companies which have applied JIT techniques have not gained the full benefits of such changes. Today these systems can be grouped together under several manufacturing strategies to help achieve the objectives of business[30].

General requirements for today's manufacturing environment can be specified as:

- Manufacturing processes should be simplified.
- Existing systems should be grouped together under several manufacturing strategies.
- It should provide fully integrated communication between both environments in the planning and in the shopfloor.



- Human intervention should be necessary to resolve conflicts and this role can be carried out by expert systems.
- System should be operated in both "Push" and "Pull" environments.

## REFERENCES

1. Cervený, R.P., Scott, L.W., "Survey of MRP Implementation", *Production And Inventory Management Journal*- Third Quarter, 1989, pp:31-34.
2. Suresh, N.C., "Optimizing Intermittent Production Systems Through Group Technology and an MRP System", *Production And Inventory Management*, Fourth Quarter, 1979, pp:76-84.
3. Wejman, J.M., "The New Generation in Manufacturing Systems", *Autofact' 89*, Conference Proceedings, Detroit, Michigan, October 30- November 2, 1989.
4. Ham, I., Hitomi, K., Yoshida, T., *Group Technology: Application to Production Management*, Boston, 1985.
5. Walker, W.M., "The Usage of Computer-Integrated Manufacturing Technology Within Manufacturing Organizations in The North East of England", *Int. J. of Operations & Management*, Vol.9, No. 7, 1989, pp: 45-57.
6. Warwick, A.M., Walters H.M.J., "A Rule Based Planning and Scheduling System for Manufacturing Industries", *Proceeding of International Conference On Expert Planning Systems*, Brighton, June 1990.
7. Gallagher, C., Knight, W.A., *Group Technology*, Butterworth & Co.(Publishers) Ltd., 1973.
8. Hyer, N.L., Wemmerlov, U., "MRP/GT: A Framework For Production Planning And Control Of Cellular Manufacturing", *The Journal For The American Institute For Decision Sciences*, Vol.13, No.4, October, 1982, pp:681-701.
9. Flynn, B.B., Jacobs, F.R., "An Experimental Comparison of Cellular(Group Technology) Layout With Process Layout", *The Journal For The American Institute For Decision Sciences*, Vol.18, No.4, Fall 1987 pp:562-587.
10. Burbidge, J.L., *The Introduction of Group Technology*, New York:Wiley, 1975.
11. Harvey, R., "How the Machining Cell Makes Flexibility Go", *Iron Age*, 1983, 226, pp 57-61
12. Spencer, M.S., "Scheduling Components for Group Technology Lines (A new application for MRP). " *Production and Inventory Management*, 1980, 20(4), pp:43-47.
13. Shambu, g., Ramesh, R., Rao, H.R., "A Rule-Based System for Scheduling in a Hybrid Group Technology Environment", *Expert system and leading edge in production and operations management proceedings of the third international conference.*, 21-24 May 1989, USA, pp. 357-367.
14. Orlicky, J., "The New Way of Life in Production and Inventory Management", New York, 1975.
15. Schonberger, R.J., Knod, E.M., *Operations Management: Improving Customer Serve*, Forth Edition, 1991
16. Bedworth, D.D., Bailey, J.E., *Integrated Production Systems*, John Wiley & Sons Inc., 1987.

17. Baudin, M., *Manufacturing Systems Analysis, with Application to Production Scheduling*, Prentice Hall Inc., 1990.
18. Krupp, J.A.G., "Why MRP Systems Fail", *Production And Inventory Management*, Third Quarter, 1984, pp:48-53.
19. Fisher, K.R., "How to Implement MRP Successfully", *Production And Inventory Management*, Fourth Quarter, 1981,
20. Galgut, P.E., *Effective Production Planning and Control*, Cranfield Institute of Technology, England.
21. Sinulingga, Unpublished Ph.D. Dissertation, Cranfield Institute of Technology, England, 1988.
22. Naji, Z., Unpublished Ph.D. Dissertation, Cranfield Institute of Technology, England, 1991.
23. New, C., "MRP & GT, New Strategy for Component Production.", *Production And Inventory Management*, Third Quarter, 1977, pp:50-62.
24. Sato, N., Innizio, J.P., Ham, i., "Group Technology and Material Requirements Planning: an integrated methodology for production control", *Annals of the CIRP*, vol. 27, No.4, 1978, pp:471-473.
25. Darrow, W.P., Gupta, J.N.D., "Integrating Group Technology And MRP Systems Through Lot Sizing And Scheduling", *Computers Industrial Engineering*, Vol. 16, No.2, 1989, pp: 287-296.
26. Sohal, A., Howard, K., "Trends in Materials Management", *International Journal Of Physical Distribution & Material Management*, Vol. 17, No. 5, 1987, pp: 3-41.
27. Musolf, J.V., "Resource Management: the long goal of Just-In-time", *Autofact' 89 Conference Proceedings*, October 30- November 2, Detroit, Michigan, 1989.
28. Dale, B.G., "Japanese Manufacturing Efficiency: a study in the electronics industry", *IEE Proceedings*, Vol. 137, No.5, September 1990,
29. Piciacchia, F.R., "Plant Operations Control: A Vital Necessity For Executing The JIT Schedule In a CIM Plant", *Autofact'89 Conference Proceedings*, October 30- November 2, 1989 Detroit, Michigan.
30. Schultz, T.R., "MRP-JIT-CIM: Choosing the 'right' strategy", *Proceedings of the AMS' 86 Exposition and Conference*, Chicago, USA, 24-26 June 1986.
31. Bermudez, J., "Using MRP System To Implement JIT In Continuous Improvement Effort", *Industrial Engineering*, Vol. 23, No. 11, November 1991, pp: 37-40.
32. Rao, A., "A Survey of MRP-II Software Suppliers' Trends in Support of Just-In-Time", *Production And Inventory Management Journal*-Third Quarter, 1989, pp:14-17.