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A Hybrid MRP-JIT Production Planning and Control System

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ABSTRACT: *Over the years, production systems have largely been controlled by either MRP (Material Requirements Planning, JIT (Just in Time) or OPT (Optimized Production Technology) paradigm. As should be expected each of these paradigms has its limiting conditions for operational effectiveness. A hybrid production planning and scheduling framework is developed to address the multi-stage, production-inventory system problem by integrating MRP and JIT production. A combined MRP and JIT system can be more effective manufacturing system that utilizes the best attributes of each production paradigm to accommodate the best planning features of MRP and the best execution features of JIT to address the changing needs of industry. The objective is to find detailed shop-floor schedules, which specify the quantity of an operation to be processed, at what time, and by which machine, so as to minimize total production cost. The integrated production system eliminates some inherent problems in MRP & JIT and focuses on orchestrating objectives, actions and tasks of an entire organization to build up competitive manufacturing capabilities, achieve manufacturing excellence, and sustain a reasonable level of growth.*
KEYWORDS: *MRP, JIT, push & pull type, production system*

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I. INTRODUCTION

A new production planning and scheduling framework is developed to address the multi-stage, production-inventory system problem by integrating Material Requirements Planning (MRP) and Just-in-Time (JIT) production. The objective is to find detailed shop-floor schedules, which specify the quantity of an operation to be processed, at what time, and by which machine, so as to minimize total production cost. The integrated system gets rid of the major problems existing in MRP and JIT. First of all, the proposed integrated system incorporates both the scheduling and capacity planning aspects, simultaneously. Secondly, the integrated system eliminates the need to specify planned lead time. Thirdly, the integrated system, unlike MRP, provides detailed shop-floor schedules. Lastly, the integrated system does not have to operate in the level schedule case as in JIT, so it can handle a very general production environment [1].

A combined MRP and JIT system can be more effective manufacturing system which utilizes the best attributes of each manufacturing system need to accommodate the best planning features of MRP and the best execution features of JIT to address the changing needs of industry. When MRP and JIT involve in any production system than its balance the all entire production and minimize their limitation by work together. The main theme of MRP- JIT is "getting the right materials to the right place at the right time". But JIT and MRP work on opposite type. MRP and JIT each have benefits. The question is, can they work together successfully and how would one go about combining them? Most major manufacturing firms use MRP. Of the firms using MRP, many in repetitive manufacturing also use JIT techniques. Although JIT is best suited to repetitive manufacturing, MRP is used in everything from custom job shops to assembly-line production. A challenge arises in integrating the shop-floor improvement approaches of JIT with an MRP-based planning and control system. The MRP/JIT combination creates what might be considered a hybrid manufacturing system. This hybrid system is commonly found in any assemble-to-order environment. In this environment, raw material can be transformed into common semi-finished products at a point where next downstream operations are controlled by customer orders. Therefore, the production of the earlier upstream stations is controlled by push-type production, while the production of the later downstream stations is controlled by pull-type production [2].

II. OVERVIEW OF MRP

A material requirement planning is a technique that uses the bill of material, inventory data and a master schedule to calculate requirements for material. It also takes into account the combination of the bill of material structure and assembly lead times. The result of an MRP plan is a material plan for each item found in the bill of material structure which indicates the amount of new material required, the date on which it is required. The new schedule dates for material that is currently on order. If routings, with defined labor requirements are available, a capacity plan will be created concurrently with the MRP material plan. The MRP plan can be run for any number entities (which could be physically separated inventories) and can include distributor inventories, if the system has access to this type of information. MRP tries to strike the best balance possible between optimizing the service level and minimizing costs and capital lockup [3].

The basic function of MRP – plan material requirements. MRP used to coordinate orders within the plant and from outside. Outside orders is called purchase orders, and within orders called jobs. MRP focuses on scheduling purchase orders and jobs to satisfy material requirements generated by external demand. MRP dealing with two basic dimensions of production control: quantities and timing. The system determines suitable production quantities of all types of items, from final products that are sold to inputs purchased as raw materials. Production timing must also be determined, to ensure meeting order due dates [4].

III. OBJECTIVES OF MRP

Table 1 describes the clear specification of the MRP objectives in two three main subjects, namely: inventory, priorities and capacity [5].

Table 1: Objectives of MRP

INVENTORY	• To order the right part. • To order right quantity. • To order at right time.
PRIORITIES	• To order with in the due date. • To keep the due date valid.
CAPACITY	• To plan for a complete load. • To plan for a accurate load. • To plan for an adequate time to view future load.

IV. COMPONENTS OF MRP

Inputs for MRP- As shown in figure 1 [5], MRP process is triggered by the Master Production Schedule (MPS) which indicates the production volume of finished products on weekly basis. MPS is the primary input. Therefore, for a successful run of the MRP, MSP must have a time schedule that is greater than the total lead time of the finished product. Bill of Materials (BOM) which is a detailed item wise requirement document is the second input for MPR. It may contain multistage type of products that may require several stages of a number of components to be fitted or converted into leading to the making of the final or finished product. Inventory record file (IRF) is the third input for MRP. It contains the status of an inventory item. It indicates the current stock position, the past timing and sizes of all orders, including the open orders for the item, the lead time for each item. IRF basically happens to be the past experience and serves as a good reference point for planning for the future MRP [6].

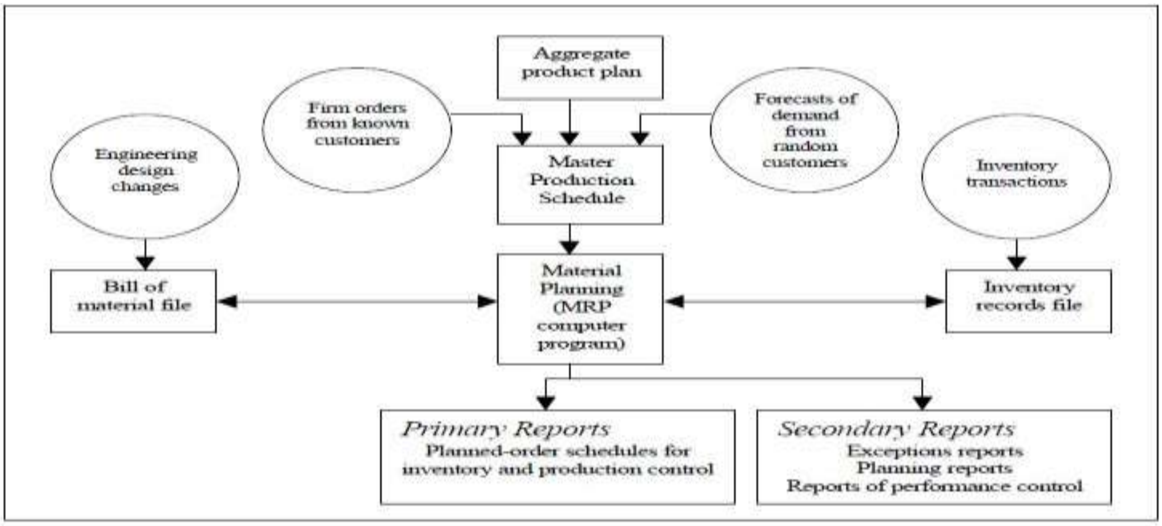

Figure 1: Components of MRP

Outputs of MRP- The MRP processing produces the net requirements for each partin each period. From that, much information can be reported: 1. Primary reports: schedule of the planned orders, changes in due dates, inventory status reports, and so on. 2. Secondary reports: performance reports, late order reports, scrap reports, aged inventory reports, and so on. In this program, the MRP report for each item includes the followinginformation for each planning period [7]:

- Gross Requirement: derived from the parent item
- Schedule Receipt: from inventory records
- Projected on Hand
- Net Requirement
- Planned Order Receipt
- Planned Order Release

V. HOW DOES MRP WORK?

There are two important questions to ask here. How much of an item is needed? When is an item needed to complete a specified number of units, in a specified period of time? The MRP process involves the following steps:

- Determine the gross requirements for a item.
- Determine the net requirements and when orders will be released for fabrication orsubassembly.

Net Requirements = Total Requirements – Available Inventory

NR = TR – AI ……………..… (1)

Net Requirements = (Gross Requirements + Allocations) – (On Hand) + Scheduled Receipts

NR = (GR + AL) – (OH) + SR……………….. (2)

- Develop a master production schedule for the end item (this is the output of the aggregate /production planning).

The MPS is adjusted accordingly, as follows:

- Create schedules identifying the specific parts and materials required to produce the end items.

The bill of materials will be useful here.

- Determines the exact numbers needed.
- Determines the dates when orders for those materials should be released, based on lead times [6].

VI. BENEFITS OF MRP

The MRP is a framework for providing useful information for decision makers. The key to realizing the benefits from any MRP system is the ability of the inventory planner to use the information well. The specific benefits of MRP include the following [6]:

- Increased customer service and satisfaction
- Improved utilization of facilities and personnel
- Better inventory planning and scheduling
- Faster response to market changes and shifts
- Reduced inventory levels without reduced customer service

The MRP is also a very powerful tool since it takes into consideration changes in certain assumptions especially under uncertain conditions, especially when the inputs to the MRP system change because of the following realities in the production area [6]:

- Delays in scheduled receipts
- Changes in planned order sizes because of capacity constraints
- Changes in gross requirements which dictate changes in lot sizes at sub-component levels
- Unavailability of raw materials for one sub-component which negates the need for a fellow subcomponent as both must be ready for the parent production
- Utilization of same parts at different levels.

VII. MAJOR PROBLEMS OF MRP

The first major problem of MRP is the need to set planned lead time. Planned lead time represents the amount of time allowed for orders to flow through the production facility. It plays an important role in the phasing principle of MRP, that is, the planned order receipt date is offset by the planned lead time. Lead time is very much determined by how long it takes to obtain the required capacity, in other words, the congestion level of the shop. Therefore, setting optimal planned lead times for MRP is not a simple task.

The major issue in MRP deals with the question: how to decide the order quantity? This is generally called the lot-sizing decision. The second major issue of MRP is that it does not produce a workable schedule for the shop-floor. The planned order release and the planned order receipt merely specify the start date and finish date of an order. Hence, MRP cannot determine the exact time period and workstation for processing each operation.

The last major problem of MRP is capacity planning. When MRP is employed to perform capacity requirements planning, it assumes that the resource capacity (machine time) is utilized at the period that a job is released or at the middle period between planned order release and planned order receipt dates [2].

VIII. OVERVIEW OF JIT

JIT has been developed by Taiichi Ohno (1982), Executive Vice-President of the Toyota Motor Company and it spread to other companies of Japan in late 1970s. By the early 1980s, JIT became a very popular manufacturing innovation in Western and Asian countries. It is an approach to continuous manufacturing improvement based on the idea of eliminating all waste in the manufacturing process and gaining edge over the others through improving the manufacturing process [8].

In other words, JIT manufacturing is closely associated with the principles of pull production control. Releases are authorized by material withdrawal from the output inventory of the production system, or an endogenous signal determines whether a release is allowed or not. Thus, JIT is controlled by downstream information and is inherently make-to-stock [9].

The principle of Just in Time (JIT) is to eliminate sources of manufacturing waste by getting right quantity of raw material and processing the right quantity of products in the right place at the right time. Just-in-Time (JIT) theory has been operating widely in the Japanese automobile industry and the electronics industry, though more and more applications can be found in many industries over the world. In today's competitive global business environment, the goal of all manufacturing systems is long-term Survival.

The ideology of JIT is 'producing the necessary item the necessary quantity at the necessary time is an eternal diver of production and operations management.'. A manufacturing company's survival in an increasingly competitive market closely depends upon its ability to produce highest quality product at lowest possible cost and in a timely manner with shortest possible lead time.

Just in Time (JIT) means making only what is needed, when it is needed, and in the amount needed. For example, to efficiently produce a large number of automobile parts, which can consist of around 40,000 parts, it is necessary to create a detailed production plan that includes parts procurement. Supplying what is needed, when it is needed according to this production plan can eliminate waste, inconsistencies, and unreasonable requirements, resulting in improved productivity [10].

IX. GOALS OF JIT

There are three main objectives [11]:

- Increasing the organizations ability to compete with others and remain competitive over the long run. The competitiveness of the firms is increased by the use of JIT manufacturing process as they can develop a more optimal process for their firms.
- Increasing efficiency within the production process. Efficiency is obtained through the increase of productivity and decrease of cost.
- Reducing wasted materials, time and effort. It can help to reduce the costs.

Other short-term and long-term objectives are [11]:

- Identify and response to consumer's needs- Customers' needs and wants to seem to be the major focus for business now, this objective will help the firm on what is demanded from customers, and what is required of production.
- Optimal quality/cost relationship-The organization should focus on zero-defect production process. Although it seems to be unrealistic, in the long run, it will eliminate a huge amount of resources and effort in inspecting, reworking and the production of defected goods.
- Reduce unwanted wastes- Wastes that do not add value to the products itself should be eliminated.
- Develop a reliable relationship between the suppliers- A good and long-term relationship between organization and its suppliers helps to manage a more efficient process in inventory management, material management and delivery system. It will also assure that the supply is stable and available when needed.
- Plant design for maximizing efficiency- The design of plant is essential in terms of manufacturing efficiency and utility of resources.
- Adopt the work ethic of Japanese workers for continuous improvement- Commit a long-term continuous improvement throughout the organization. It will help the organization to remain competitive in the long run.

X. ELEMENTS OF JIT MANUFACTURING

JIT manufacturing consist of several components or elements which must be integrated together to function in harmony to achieve the JIT goals. These elements essentially include the human resources and the production, purchasing, manufacturing, planning and organizing function of an organization. In short, these elements can be grouped together into the above-mentioned Toyota production system of people, plants and system [12].

- People involvement- Stockholders and owners of the company, Labour organization, Management support, Government support.
- Plants- Numerous changes occur about the plant which encompass plant layout, multi- function workers, demand pull, Kanban, self-inspection, MPR (material requirements planning) and MRP II (manufacturing resource planning) and continuous improvement. Ex-Plant layout, Demand pull production, Kanban, Self-inspection, Continuous improvement.
- Systems- Systems within an organization refer to the technology and process used to link, plan and co-ordinate the activities and materials used in production. Two such system is MPR and MRP II.

XI. BENEFITS OF JIT

Some the benefits of JIT are shown below [13]:

- Elimination of waste in production and materials.
- Improving communication internally (within organization) and externally (between the organization and its customers and vendors).
- Reducing purchasing costs which is a major cost to most organizations.
- Reducing lead-time, decreasing throughput time, improving production quality, increasing productivity and enhancing customer responsiveness.
- Foster organizational discipline and managerial involvement.
- Integration of the different functional areas in the organization. It especially bridges the gap between production and accounting.

XII. LIMITATIONS OF JIT

Although the benefits of using JIT are numerous and cited more frequently than any potential limitations, several shortcomings have been identified as follows [12]:

- Cultural differences have been cited as a possible limitation of JIT. There exist many cultural differences which may be intrinsically tied to JIT success. These will be problems that may be difficult to overcome or work around without changes in attitudes and worker philosophy. The magnitude of their impact may be difficult to measure because of their nature.
- The traditional approach to manufacturing involves the use of large inventories with safety stocks. Safety stocks can act as a buffer for companies to fall back on to offset inaccurate demand forecasts. This has the potential to cause problems for the organization which relies heavily on safety stocks to absorb any increases in demand.
- The benefits associated with increased employee involvement and participation resulting from the use of quality circles may be evident in Japanese organizations. However, Western ideas of participation involve largely ‘empowering’ the workforce with respect to decision making. This suggests that the level of involvement established within Japanese organizations using JIT is not compatible with the degree of employee participation required to satisfy Western workers. The benefits associated with JIT may be culturally bound and somewhat limited to the Japanese environment.
- Loss of individual autonomy has been suggested as another possible short-coming of JIT. Loss of autonomy has largely been attributed to limited cycle times or the ‘time between recurring activities’. Buffers such as slack or idle time are significantly reduced resulting in greater amounts of stress and pressure placed upon the worker to perform. The time which would otherwise be present would allow the worker more freedom to perform ‘vertical tasks’ which constitute administrative tasks or team meeting. In addition, reduced cycle times force workers to adjust immediately to changes in demand without taking their needs into consideration.
- Loss of team autonomy is a possible result of reducing or eliminating buffer inventories. This serves to reduce the flexibility of workers to discuss possible solutions to problems. This is a function of quality circles, which are an important part of JIT. Reduced buffer inventories and workers flexibility contradict the other aspects of JIT concerning quality circles.
- Loss of autonomy over methods involves the idea that, under JIT, employees must adhere to strict methods of production in order to maintain the system. This idea diminishes the ‘entrepreneurial spirit’ which many workers may have previously enjoyed prior to JIT implementation.
- JIT success may be ‘industry specific’, i.e. craft-oriented businesses are considered to be better candidates for a JIT programme than organizations producing commodity-type products.
- Resistance to change may be experienced since JIT involves an organizational level of change which will affect almost every member of the organization. Employees may resist the change based on two different levels: emotional and rational resistance. Rational resistance occurs when an individual is deficient of the necessary information and facts pertaining to the degree to which the change will affect them. Emotional

resistance refers to the psychological processes of fear, anxiety and suspicion which arise which arise from inducing change and cause resistance.

XIII. MRP VS JIT

Table 2 shows the comparison between MRP and JIT [14].

Table 2: MRP vs JIT

MRP	JIT
Very costly software, difficult to implement, consumes more time to install and cost.	Manual based card system, cheaper software, easy to implement, takes less time to install and cost.
Takes less time to react for variation in demand.	Takes more time to react to variation in demand.
Higher raw materials inventories, levels of work-in-progress and holding cost.	Lower raw materials inventories, levels of work-in-progress and holding cost.
More chances for defects and rework is required.	Less chance for defects and almost no rework required.
More discounts and better price opportunities.	Less discounts and price opportunities are limited.
No relation between managers and workers.	Better understandings between managers and workers.
Small or no changes to setup and larger lot sizes.	Frequent changes to setup and smaller lot sizes.
No specialized and trained workforce required.	Specialized and trained workforce required.
Short range contracts, few deliveries	Long range contracts, more deliveries

XIV. HYBRID OF MRP-JIT PROTOTYPE

A hybrid MRP-JIT model or prototype is shown in figure 2. In this environment, raw material can be transformed into common semi-finished products at a point where next downstream operations are triggered by customer orders. The production of the earlier upstream stations is controlled by push-type production, while the production of the later downstream stations is controlled by pull-type production. The objective function for the presented hybrid model is to minimize the sum of inventory holding cost and delivery lead -time cost, which is the cost of the time period since customers have placed an order until it is fulfilled. The model is applied to solve the inventory and late delivery problems in an assemble-to-order manufacturer.

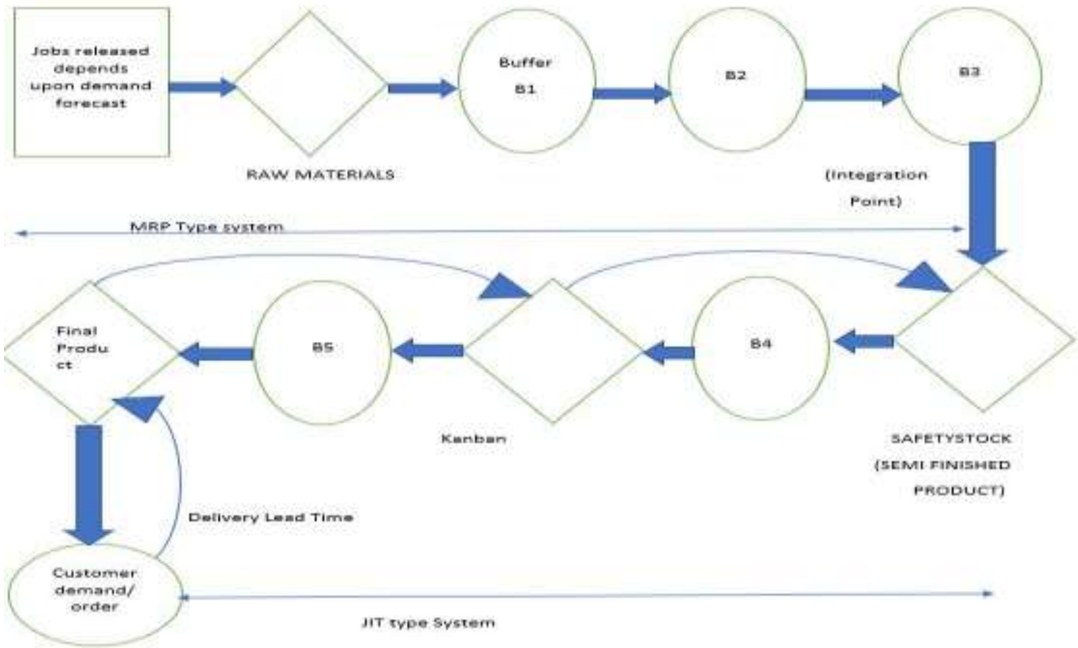

Figure 2: Hybrid MRP-JIT model

One approach to the issue of designing hybrid push-pull systems can be framed as trying to maintain the incentives present in Kanban systems, while adding some information about future demand and parameter variations, insofar as the increased information processing costs are justified. An example of the use of demand information in a pull system is the use of demand forecasts to adjust parameters such as Order Quantities and Order Points. In that case, a forecast increase in demand levels would cause reorder points as well as lot sizes to be changed, thus leading to an earlier and larger order release. Here the advance processing of information about demand, even though not deterministic as in MRP, is affecting the order release process. A second broad approach to hybrid systems is to add "pull" components to push systems. An example of this is the use of safety stocks or contingency stocks at select points in the production systems, which are released when unplanned demands or unexpected events occur.

In numerous production circumstances, pull frameworks can't be utilized due to long lead times combined with lead time fluctuation and demand vulnerabilities. To make the point in another path, if there were no uncertainties in demand or in lead times, at that point a pull system could be utilized regardless of whether lead times were long. Particularly when demand is variable however known, push frameworks are profitable in planning supply and production exercises with the demand. Then again, there are circumstances where despite the fact that a push framework is fitting for general material control, it makes local adjustment to contingencies very costly, if some moderately little here and now change in accordance with production plans is required, it might be too expensive to make any changes since updating the framework's data base would be a long and costly activity. In such cases the capacity to respond locally in the short term, without causing the system overhead, is significant.

For a framework to have any push part, the assumption underlying the utilization of MRP frameworks must be available. In particular, final production necessities must be solidified sufficiently far into the future to cover the production lead times of those production stages that will be worked in a push manner. In a hybrid framework, it will be familiar that the phases that have long uncertain lead times would be driven by a push framework; i.e., order releases to these stages would be created by MRP or detailed scheduling frameworks. Stages which have short unsurprising lead times could be driven by a pull framework. Once more, the inconstancy and consistency of demand has a great influence in deciding if a pull or push framework is pertinent at a given stage.

An ordinary utilization of this idea would be in a company that acquires raw material and components forms a geographically diverse supplier base, assemble few parts, and produce at least one final product. Such a company may utilize a push approach to buy components from far off providers especially in categories, (for example, castings) where lead times are long. They may utilize a pull approach for components from close-by providers to feed parts directly to assembly. They may likewise utilize a pull approach to pull parts from parts banks or a sections distribution centre. Here, some portion of the purchasing system may be driven by a MRP framework with coarse "containers" of seven days to a month. At the opposite end of the spectrum, parts may be pulled for final assembly numerous times in a day. It will have a tendency to be the situation that parts supply to final assembly can be controlled in this way. This creates flexibility in adjusting final assembly schedule in the short term without causing a high transactions cost and without running the whole MRP framework each time little changes are made. Obviously, the MRP framework should in the long run be informed of some modifications, yet the compromise should be possible occasionally and in the aggregate. For instance, at an AT&T plant, where MRP is utilized to control a parts "bank", from which material is pulled to subassembly and assembly stages.

Based on the definitions given earlier in this paper, it is apparent that push and pull methods are not disjoint categories of production control systems. Rather, many systems have both a push and pull character. For example, the timing of order releases may be driven by actual inventory withdrawal (pull) but the release rule and the order quantity could be set based on future demand. The Order Point, Order Quantity system is an example of this case. In another example, the releases in an MRP system might normally be driven by a master production schedule, but reserve safety stocks could be maintained that are released based on unplanned events. The "E-LOT" scheme, is an example of such a system. The exact nature of the system to be used is a design issue based on the costs and benefits of the two kinds of mechanisms [15].

XV. THE BENEFITS FROM HYBRID SYSTEMS

There are several specifically identifiable advantages to this hybrid scheme [16]:

1.Local Inventory Management-A major role of a conventional MRP system is inventory management. The quantities (and perhaps location) of on-hand inventories at all production stages are controlled by the system. In the hybrid system, inventories in a cell. whether of raw material or finished parts. are the responsibility of that cell. As a result, there is no need to impose discipline about inventory management from "above" or to monitor inventory levels and locations. It is in the cell supervisor's interest to see that inventory levels and locations are known and controlled. It should be noted that there are situations where inventory tracking is required because lot identities must be maintained.

2.Reduction of Shop Floor Data Collection-Since material and inventory management on the floor is decentralized. data on inventory levels and locations does not have to be collected and centrally maintained. Furthermore. individual orders do not have to be tracked. since the responsibility of supplying a succeeding cell promptly. lies with the cell manager. Recall that this system is thus most appropriate for a repetitive batch flow environment. rather than for engineered products. customized products or customer order oriented production. It should be noted that while current shop status information does not have to be collected. shop performance over a given period does have to be measured. Among the measurements that should be made are cell lead times, average work-in-process levels, scrap and rework levels, backorder and shortage incidence. and setup and processing times. Many of these measurements can be conveniently done using the card system itself.

3.Reduction of MRP Computations-Since inventory management is a local function. and since the incremental quantities produced are at the discretion of the cell. Certain computations become unnecessary. In particular. netting of requirements is not required; in effect it is done locally by determining which of the authorized cards are already covered by available material. Furthermore, pegging is not required, and the associated data management overhead can be eliminated. Even if pegging is to be implemented, MRP generated cards can be pegged directly to end item orders or the end item production schedule. Stage by stage pegging is not possible. and should not be necessary. MRP computations in this system are thus reduced to simply converting end item production schedules to gross requirements for each item. offsetting the gross requirements by total lead time for that item. and then computing the corresponding card count or equivalently a card generation schedule. Note that this can be done without a level by level BOM explosion. and a single level BOM is adequate.

4.Reactive Ability-Since the cell level is controlled with a pull approach, the manufacturing system is able to react to unplanned events by local adaptation. Por example. in a pure push system, the loss of part inventory due to damage would require the generation of a new order from the MRP system. The loss would only be discovered at a cycle count point or when the inventory was found to be unavailable for use. In the pull framework. inventory responsibility lies with each cell. and there are incentives to continually monitor inventories. A loss of inventory would tend to be noted immediately, and replacement initiated. Note that this causes unplanned use of incoming material and the card generation scheme must be modified to account for the additional production.

5.Local Incentives for Performance Improvement-An important feature of the Kanban environment, is that there are incentives at the local level for lead time and WIP reduction, and quick response to contingencies. These incentives are lost in an MRP or push environment, because lead times are planned by the system. and allowance is made for lead time variability in the release policy. As a result. there is no benefit and no reward for reducing production lead times, or equivalently, work-in-process. In this hybrid system, the cell level incentive structure can be maintained by assigning responsibility for inventory levels to the cell, and by clarifying that the cards released by the MRP system are authorization to produce and not production releases in the usual sense. The *cell* manager has the option of holding a card as late as possible, to reduce the importation of raw material into the cell.

6.Performance Measurement-The cell organization that is maintained in the system requires the measurement of manufacturing performance at the cell level. Lead time monitoring is especially important. Production lead time in the cell is measured as the average time taken from the time that a card is posted in the cell to the time that finished material corresponding to that card is available for use by succeeding cells.

XVI. CONCLUSION

In this paper, we investigate a new hybrid MRP-JIT system model to find an optimal inventory control strategy. In this environment, raw material can be transformed into common semi-finished products at the point where next downstream operations are dictated by customer orders. Therefore, the production of the earlier upstream stations is controlled by push-type production, while the production of the later downstream stations is controlled by pull-type production. We described a hybrid push/pull system embodying element of both kinds of control system. An MRP system without netting is used for material planning and for generating purchase orders. The manufacturing process is organized as cells which are operated by a JIT system, using cards or some other signalling or triggering device. Unlike the typical JIT system, the number of cards in the system is varied dynamically. Cards are generated by the MRP system, based on the gross requirements for each cell, over a cell production lead time interval. Thus, the cell can react to changing demand and load conditions by making use of advance information about planned orders. This is the "push" part of the process. At the same time, production activity is triggered by the cards and the incentives in the system are local as in a pull system.

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