Optimization Of Shop Floor Operations: Application Of MRP And Lean Manufacturing Principles

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Abstract: This research work is concerned with the optimization of shop floor operations by the application of Material Requirements Planning (MRP) and lean manufacturing principles. The present research covers the involvement of MRP and lean manufacturing techniques in manufacturing environment. The work is intended to decrease cycle time, reduce waste in material movement and inventory, improve the flow of material through improved system layouts and subsequently increase productivity in shop floor environment. 

Keywords: Material Planning, Lean Manufacturing, Scheduling, Production, cycle time.

I. INTRODUCTION

Increasing shop floor efficiency through the integration of Material Requirements Planning (MRP) and Lean manufacturing principles has become one of the major concerns of manufacturing companies. In today’s complex manufacturing sector, we are confronted to do more with less, and also challenged with new philosophies and concepts that often push or pull us in different directions. A case in point is the ongoing integration of MRP and lean manufacturing principles. MRP systems are frequently condemned as one of the main reasons so many manufacturing companies are locked into push systems, while lean concepts imply that pull systems are the ideal. Nevertheless, one shouldn't throw one out for the other, as the two can coexist harmoniously and beneficially with a better definition of roles (Steinbrunner, 2004).

According to the American production and control society, MRP constitutes a set of techniques that use master production schedule, bill of material and inventory data to calculate material requirements. In simple words, MRP is a technique used in determining when to order dependent demand items and how to reschedule orders to adjust for the changing needs. A key question to MRP process is the number of times a company procures inventory within a year. One can readily realize that a high inventory ratio is likely to be conducive to lowering production cost since less capital is tied up to unused inventory.

MRP systems relies on four pieces of information in determining what material should be ordered and when. Namely:

- The master production schedule: This describes when each product is scheduled to be manufactured;
- Bill of materials: Gives information about the product structure, i.e., parts and raw material units necessary to manufacture one unit of the product of interest;
- Production cycle times and material needs at each stage of the production cycle time and Supplier lead times.

The master production schedule and bill of materials indicate what materials should be ordered; the master schedule, production cycle times and supplier lead times jointly determine when orders should be placed.

The Master Production Schedule includes quantities of products to be produced at a given time period.

The Lean Manufacturing is a production method that calls for building products with as few steps and as little work-in-process inventory as possible. It relies on work centres or manufacturing cells that are capable of building multiple products, giving the company the flexibility to produce the exact mix and quantity of products required.

Its fundamental objective is to provide perfect value to the customer through a perfect value creation process that has eliminated all unnecessary waste.

To accomplish this, lean thinking changes the focus of management from optimizing separate technologies and assets to optimizing the flow of the product or family of products through the entire value stream. Eliminating waste along the entire value stream, instead of at isolated points, creates processes that need less human effort, space, capital and time. This allows companies to make products and services at far lower costs and with fewer defects, compared with traditional business systems. Companies are able to respond to changing customer desires with great variety, high quality, low cost and very fast throughput times. Also, with the application of visual methods to control material flow and work-in-process, information management on the shop floor becomes much simpler and more accurate.

II. PROCEDURE FOR THE IMPLEMENTATION OF MRP

The following procedures are followed while implementing Material Requirements Planning.

Demand for Products: the demand for end products stems from two main reasons. The first is known customers who have placed specific orders, such as those generated by sales...
Each organization poses a unique environment and that means that specific actions need to be taken with due regard to environment specifics. We approach MRP as an organizational innovation and identify the necessary measure which management should adopt in implementing it. Motivational influences underlying MRP implementation include:

1. Recognition of business opportunity for the timely acquisition of MRP.
2. Recognition of technical opportunity for the timely acquisition of the technologies supporting MRP implementation.
3. Recognition of need for solving manufacturing and/or inventory problems using MRP. Given the above motivational factors one may readily identify what and how issues underlying MRP design and implementation, What refers to a generic process model composed of steps and indicative levels of effort to implement each step. How refers to management involvement with respect to the process.

C. Mrp Computer Program

The MRP program works as follows:

A. A list of end items needed by time periods is specified by the master production schedule.
B. A description of the materials and parts needed to make each item is specified in the bill of materials file.
C. The number of units of each item and material currently on hand and on order are contained in the inventory file.
D. The MRP program “works” on the inventory file. In addition, it continuously refers to the bill of materials file to compute quantities of each item needed.
E. The number of units of each item required is then corrected for on hand amounts, and the net requirement is “offset” to allow for the lead time needed to obtain the material.

D. Output Reports

Primary Reports: Primary reports are the main or normal reports used for the inventory and production control. These report consist of
1. Planned orders to be released at a future time.
2. Order release notices to execute the planned orders.
3. Changes in due dates of open orders due to rescheduling.
4. Cancellations or suspensions of open orders due to cancellation or suspension of orders on the master production schedule.
5. Inventory status data.

Secondary Reports: Additional reports, which are optional under the MRP system, fall into three main categories:
1. Planning reports to be used, for example, in forecasting inventory and specifying requirements over some future time horizon.

A. Conditions for implementation

Several requirements have to be met, in order to given an MRP implementation project a chance of success, among the conditions:

A. Availability of a computer based manufacturing system is a must. Although it is possible to obtain material requirements plan manually, it would be impossible to keep it up to date because of the highly dynamic nature of manufacturing environments.
B. A feasible master production schedule must be drawn up, or else the accumulated planned orders of components might mix with the resource restrictions and become infeasible.
C. The bills of material should be accurate. It is essential to update them promptly to reflect any engineering changes brought to the product. If a component part is omitted from the bill of material it will never be ordered by the system.
D. Inventory records should be a precise representation of reality, or else the netting process and the generation of planned orders become meaningless.
E. Lead times for all inventory items should be known and given to the MRP system.
F. Shop floor discipline is necessary to ensure that orders are processed in conformity with the established priorities. Otherwise, the lead times passed to MRP will not materialize.

B. Techniques for the implementation of MRP

MRP represents an innovation in the manufacturing environment. Thus, its effective implementation requires explicit management action. Steps need to be clearly identified and necessary measures be taken to ensure organizational responsiveness to the technique being implemented.

Bill of Materials File: This is simply known as BOM file. It contains the complete product description, listing materials, parts, and components but also the sequence in which the product is created. The BOM file is often called the product structure file or product tree because it shows how a product is put together. It contains the information to identify each item and the quantity used per unit of the item of which it is a part.

Inventory Records File: Inventory records file under a computerized system can be quite lengthy. Each item in inventory is carried as a separate file and the range of details carried about an item is almost limitless. The MRP program accesses the status segment of the file according to specific time periods. These files are accessed as needed while running the program.

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Secondary Reports: Additional reports, which are optional under the MRP system, fall into three main categories:
1. Planning reports to be used, for example, in forecasting inventory and specifying requirements over some future time horizon.
2. Performance reports for purposes of pointing out inactive items and determining the agreement between actual and programmed item lead times and between actual and programmed quantity usage and costs.  

3. Exceptions reports that point out serious discrepancies, such as errors, out of range situations, late or overdue orders, excessive scrap, or non-existent parts. The Figure below shows an overall View of a Material Requirements Program and the Reports Generated by the Program.

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**E. MRP objectives**

The main theme of MRP is “getting the right materials to the right place at the right time”. Specific organizational objectives often associated with MRP design and implementation may be identified among three main dimensions, namely: inventory, priorities and capacity.
Inventory
- Order the right part
- Order the right quantity
- Order at the right time

Priorities
- Order with the right due date
- Keep the due date valid

Capacity
- Plan for a complete load
- Plan for an accurate load
- Plan for an adequate time to view future load

III. LEAN MANUFACTURING

Lean manufacturing is a western adaptation of the Toyota Production System, developed by the Japanese carmaker and most famously studied (and the term “Lean” coined) in “The Machine That Changed the World” (Womack, 1996). The Internet offers some useful resources on this topic, including BCG systems inc.(http://www.mmsonline.com), which state that Lean Manufacturing is a production method that calls for building products with as few steps and as little work-in-process inventory as possible. It relies on work centres or manufacturing cells that are capable of building multiple products, giving the company the flexibility to produce the exact mix and quantity of products required.

Taiichi Ohno, the engineer commonly credited with development of the Toyota Production System, and therefore Lean, identified seven types of waste: defective products, unnecessary finished products, unnecessary work in process, unnecessary processing, unnecessary movement (of people), unnecessary transportation (of products) and unnecessary delays. Lean focuses on eliminating these wastes from a manufacturing system. In particular, this work is interested in the second and third types – unnecessary finished goods and work in process. The Lean answer to these wastes is to link production at each step in the process with the subsequent process (or the consumer for finished goods). At Toyota, they use kanban (a Japanese word for “shop sign”) cards attached to each sub-assembly that are sent back to the producer each time one is used. The cards then become a signal to produce one more. As a result, the number of cards in the system controls the amount of work in process.

Liker (1997) describes a sequence of phases that a manufacturing facility must visit to become Lean: process stabilization, continuous flow, synchronous production, pull authorization, and level production. Such anecdotes are useful advice for managers and provide a general framework for becoming Lean, although they do not provide specific strategies for changing production control schemes.

Lean Manufacturing or Lean production, which is often known simple as “Lean”, is a production practice that considers the expenditure of resources for any goal other than the creation of value for the end customer to be wasteful, and thus a target for elimination.

According to Steinbrunner (2004), lean is centred on creating more value with less work. Lean manufacture is a generic process management philosophy derived mostly from the Toyota Production System (TPS) and identified as “Lean” only in the 1990s. It is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world’s largest automaker, has focused attention on how it has achieved this.

Lean manufacturing is a variation on the theme of efficiency based on optimizing flow; it is a present-day instance of the recurring theme in human history toward increasing efficiency, decreasing waste, and using empirical methods to decide what matters, rather than uncritically accepting pre-existing ideas. Lean manufacturing is often seen as a more refined version of earlier efficiency efforts, building upon the work of earlier leaders. A fundamental principle of lean manufacturing is demand-based flow manufacturing. In this type of production setting, inventory is only pulled through each production center when it is needed meet a customer’s order. The benefits of this goal include: decreased cycle time, less inventory, increased productivity, increased capital equipment utilization.

The core of lean is founded on the concept of continuous product and process improvement and the elimination of non-value added activities. The value adding activities are simply only those things the customer is willing to pay for, everything else is waste, and should be eliminated, simplified, reduced, or integrated (Rizzardo, 2003).

Improving the flow of material through new ideal system layouts at the customer’s required rate would reduce waste in material movement and inventory.

A. Steps to achieve lean systems

The following steps should be implemented to create the ideal lean manufacturing system:

1. Design a simple manufacturing system
2. Recognize that there is always room for improvement
3. Continuously improve the lean manufacturing system design

B. Basics for the design of a simple lean manufacturing system

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- increased productivity
- increased capital equipment utilization

(a) There is always room for improvement

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everything else is waste, and should be eliminated, simplified, reduced, or integrated” (Rizzardo, 2003).

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(b) Continuously improve

A continuous improvement mindset is essential to reach a company’s goals. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance (Suzaki, 1987).

C. Lean Goals

- The four goals of Lean manufacturing systems are to:
- Improve quality: To stay competitive in today’s marketplace, a company must understand its customers' wants and needs and design processes to meet their expectations and requirements.
- Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service. There are seven types of waste:
  1. Overproduction (occurs when production should have stopped)
  2. Waiting (periods of inactivity)
  3. Transport (unnecessary movement of materials)
  4. Extra Processing (rework and reprocessing)
  5. Inventory (excess inventory not directly required for current orders)
  6. Motion (extra steps taken by employees because of inefficient layout)
  7. Defects (do not conform to specifications or expectations)
- Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.
- Reduce total costs: To minimize cost, a company must produce only to customer demand. Overproduction increases a company’s inventory costs because of storage needs.

IV. Discussion

MRP can be used to set priorities for the production of finished goods, in an environment where mixed mode is practised and in the job shop environment in order to develop a plan for common raw materials consumed. Uniform containers can be used to standardize lot sizes in production lines, for unique items consumed to signal the need to replenish materials and to simplify transport between the vendor and customer. Materials can then be pulled into the production lines as needed to support the required production rate of finished goods. Sharing material plans can lead to partnerships with vendors that not only reduce lot sizes and lead-times, but also result in reduced costs and less work-in-process at both vendor and customer locations. For the job shop environment, the planning and inventory tools of MRP can also be applied to set priorities for raw materials and manufactured products, in addition to developing plans for when and how much will be required. Companies will continue to find ways to apply lean manufacturing concepts, if they should remain competitive, to simplify material planning, reduce waste and improve their operations. But it may not be feasible to apply pull methods to all of the company’s product lines. When MRP planning and inventory tools are needed to support the job shop environment, and pull methods make sense to support the repetitive production lines, manufacturers will find that a blend of MRP push methods and lean manufacturing pull methods can provide the right material planning mix for their mixed mode environment. In order to have a successful implementation of MRP, the recommended steps are to be followed:

A computer based manufacturing system should be made available. It would be impossible to keep material requirements plan up to date because of the highly dynamic nature of manufacturing environments. Although it is possible to obtain material requirements plan manually, but it is time consuming and a daunting task.

A feasible master production schedule must be drawn up, or else the accumulated planned orders of components might fall into the resource restrictions and become infeasible.

The bills of material should be updated and accurate. It is essential to update BOM promptly to reflect any engineering changes brought to the product. If a component part is omitted from the bill of material it will never be ordered by the system.

Inventory records should be a precise representation of reality, or else the netting process and the generation of planned orders become meaningless.

Lead times for all inventory items should be known and given to the MRP system.

The last but not the least is maintaining Shop floor discipline. It is necessary to ensure that orders are processed in conformity with the established priorities. Otherwise, the lead times passed to MRP will not materialize.

V. Conclusion

MRP and lean are not only capable of co-existing, but they can also support one another, provided that the following concepts are understood and conditions exist:

Commitment to planning: First and foremost, there must be a commitment to planning. The “P” in MRP is for planning, yet its role is often overshadowed by the zeal to reduce waste. The importance of planning simply cannot be overlooked. Beyond better inventory control, planning enables you to have the right quality and quantity at the right location and time. Good material planning can help reduce the waste of downtime and reduce overtime. It also helps with overall product quality.

Communication with suppliers: While lean concepts reduce waste throughout every cycle of production, MRP can reduce waste in the supply chain through better relationships with suppliers. Planning enables better data and information that can be shared with vendors.
Dedication to data: While MRP systems can play an important role in synchronizing products, if changes occur, MRP can be slow to respond. This is usually a result of transactions not being entered in a timely manner. Effective product data management is critical to adapting traditional manufacturing systems to agile and lean manufacturing methods. However, it all begins with the data. By gaining an understanding about which bills of material and routing schemes are appropriate for given situations, you learn how they can be used to streamline operations, improve quality, reduce waste, minimize inventory and increase the use of manufacturing assets.

MRP is effective when people understand that the system cannot think for them. Too often, team members know that the information loaded into the system is useless, and they therefore have no faith in the resulting data that is intended to guide their ordering, systems, processes and operations - a classic case of garbage in, garbage out. However, if team members have confidence in the data, they will have confidence in the system.

Finally, when the principles are well integrated the following benefits will be obtained.

Improve quality: To stay competitive in today’s marketplace, a company must understand its customers' wants and needs and design processes to meet their expectations and requirements.

Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service.

Reduce time: Reducing the time it takes to finish an activity from start to finish is one of the most effective ways to eliminate waste and lower costs.

Reduce total costs: To minimize cost, a company must produce only to the customer’s specification and demand. Overproduction increases a company’s inventory costs because of storage needs and inventory carrying cost.

VI. REFERENCES


