DEVELOPMENT OF A COMPUTER BASED MRP SYSTEM ON SIMULATED PRODUCTION DATA OF A MANUFACTURING UNIT

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ABSTRACT

Material requirement planning is an essential activity in a manufacturing organisation to ensure that right quantity of materials are available at the right time and the inventories are not excessive. MRP helps a great deal in carrying out production efficiently and maintaining valid priorities contained in master production schedule (MPS). This paper presents a study in which an MRP system has been developed on simulated data of a manufacturing unit engaged in the production of large variety of automobile components in small batches. The system takes inputs from MPS, bill of material (BOM) and considers factors like first time through, delays in processes, scrap rates, normal and crash lead times and develops an algorithm and a computer programme for MRP. The system has been applied and validated on the simulated data of the manufacturing unit for its efficiency and applicability.

KEYWORDS: MRP, MPS, BOM, Scrap Rate, Crash Lead-Times

INTRODUCTION

In today’s highly competitive manufacturing industry, it is very important to supply customer’s goods of high quality at competitive price in the time frames required by the customers. To realize this, the manufacturing units require right quality and quantity of materials and components for efficient and economic production. At the same time, the inventories need to be at the lowest levels to ensure that excessive money is not bound in inventories. An MRP system aims to accomplish this by precisely calculating the quantity of material required by considering inventory on hand. It also makes sure that materials are received in the inventory not much earlier than the time at which they are needed for production. An MRP system takes inputs from master production schedule (MPS), bill of materials (BOM) and available inventory in the system. It operates on a logic that net requirements are gross requirements minus the inventory on hand. MRP system gives its outputs to production control system to ensure priority and capacity control. MRP is a time phased priority-planning technique that calculates material requirements and schedules supply to meet demand across all products and parts in one or more plants [1]. Information Technology plays a major role in designing and implementing material requirements planning systems and processes as it provides information about manufacturing needs (linked with customer demand) as well as information about inventory levels. MRP techniques focus on optimizing inventory. MRP techniques are used to explode bills of material, to calculate net material requirements and plan future production. MRP is a computer-based production planning and inventory control system. For decades, the trusty MRP system continues to be used in one form or another by many manufacturers. Sure, at most medium-size and larger companies, MRP has been dominated by a client-server-based multi-application enterprise resource planning (ERP) system. However, it still plays an important role.

As organizations continue to seek ways to improve their overall performance and new computer technology supports industry to update and renovate information systems, computer applications to support manufacturing have developed rapidly in recent years. So far, for developing a flawless MRP system, researchers have studied many
terminologies and implemented different approaches. DeBodt et al. [2] found that the effect of change in cost effectiveness of lot sizing heuristics disturbs efficiency of MRP system. Gupta and Brennam [3] implemented back order lot sizing rules in multi-level product structure in order to gain performance in presence of lead-time uncertainty. Two lot-sizing rules, the silver meal (SM) and the least unit cost (LUC) were studied on the basis on variability of orders. Pujawan [4] found that SM rule tend to produce shorter order interval hence more orders are placed during a certain time of horizon as compared to LUC rule. Continuous material requirements planning approach of Sadeghian [5] made it possible to order the requirements at irregular time moments due discreteness of time in production planning. Grubbstroma and Tang [6] developed an explicit expression to solve dynamic lot sizing problem. Ho and Lau [7] investigated the influencing factors, lot sizing rule and product structure and confirmed that lead-time uncertainty deteriorates MRP system performance. Dolgui and Louly [8] carried out mathematical formulation under lead-time uncertainty to find optimal control policies. The safety stock strategy (SS) and repair procedure (RP) are the two approaches which were implemented by Dellaert and Jeunet [9] to cope with stock out situations arising when positive lead times are introduced. Simulation results showed that the Wagner–Whitin algorithm provides the best overall performance when combined with the repair procedure over the safety stock policy in most cases. Grubbstrom and Huynh [10] developed theoretical model for Multi-level, multi-stage capacity-constrained production–inventory systems. To handle arbitrary nonzero lead times, AlyLouly and Dolgui [11] established an optimal MRP system. For make-to-order manufacturing systems, Ioannou and Dimitriou [12] generated an algorithm that estimates lead-time. Numerous conceptual models are proposed in order to serve as a reference to develop a new production technology that integrates material planning decisions and production resource capacities. Kim and Kim [13] combined the classical LP formulation approach and simulation approach to find the capacity feasible production plan. Xiea et al [14] built a computer model to simulate master production scheduling activities in a capacitated multi-item production system under demand uncertainty and a rolling time horizon. Oladokun and Olaitan [15] developed an MRP software to be used by the local industries for inventory management in a job shop-manufacturing environment due to lack of affordable, efficient, and user-friendly inventory management tools in manufacturing firms. From the literature review, it is observed that many complex system and algorithms have been proposed which generally apply to large-scale manufacturing systems. However, all over the world, there are still many small and medium size industries, which may not find it economical to implement expensive and complex MRP systems. Therefore, there is a need for a simple algorithm which can be implemented by considering current challenges and factors affecting production planning and control and determines schedule of orders. Moreover, such a system can also be easily adapted by the users to suit their needs.

In this paper, a study is presented in which an MRP system has been developed for a small manufacturing unit. The system takes into account various necessary inputs and factors and calculates quantities and timings of material acquisition. The system has been tested and validated on simulated data of an organisation.

THE STUDY

The objective of the study has been to prepare a computer based MRP system which calculates the material requirements from the available data of master production schedule, bill of materials, lead times of procurement of various components, both normal lead times and crash lead times, inventory on hand of both the finished products and the components, expected delays in placing orders, ‘first time through’ products, costs associated with crash lead times and the expected scrap lots at the customer end. The prepared computer based system also provides information on the performance of MRP in terms of number of orders delayed, number of orders completed through crash lead times and associated costs. For development of system, python language is used at front end whereas SQLite expert is used at back end, for management of database. At first, a flow chart of the tasks is shown in Figure 1.
Development of a Computer Based MRP System on Simulated Production Data of a Manufacturing Unit

As depicted by the flow chart, the first phase of work takes inputs from an already prepared MPS and recalculates the exact requirements of materials and their timings of acquisition by considering factors like delays in placing orders, orders that may be scrapped and other delays at the suppliers end. Material requirements are calculated by considering gross requirement of materials, inventory on hand and ‘first time through’ percentages.

**Figure 1: Flow Chart Depicting all the Processes Required in Generation of MRP**

**Figure 2: Steps of Algorithm**
The MRP processing logic analysis is summarized in Figure 2 in the form of an algorithm. It represents the systematic process, which generates the final MRP fulfilling the necessary conditions. A computer programme is prepared using the algorithm which not only prepares the material requirements plan but also analyses it in terms of delays and extra costs due to crashing involved in the process. The computer programme initially calculates the gross quantities to be produced from the inputs of MPS by considering ‘first time through’ products and the likely delay in placing orders for some components. Simulation has been extensively used in this study for generation of data pertaining to delayed orders and scrap products. The developed programme checks the gross requirements of products, considers the inventory on hand and computes the net requirements. From the net requirements of the product quantities, the requirement of various components is calculated by using bill of material (BOM). The gross component requirements are then checked with inventory on hand of various components of the products. Net requirements along with the required delivery dates are then calculated. The programme assumes that the components of a product should be available in inventory one day before the start of production of that product. A trial MRP is then prepared by using normal lead-time of procurement of various components and then analysed against the MPS requirements. At this stage, the developed system takes into account all those cases where the arrival of components may be delayed and as a result the production of the product may get delayed. In all such cases, if any, crash lead times are applied depending upon the customer importance and MRP is developed again. The system also takes into account any rejection of material by the customers while recalculating material requirements. Finally, the system works out the performance of the MRP system and that of the company by calculating delayed components and additional costs.

**TESTING AND VALIDATION OF THE SYSTEM**

The evolved MRP system has been tested and validated on a filter manufacturing firm. All the processes, products and various factors and parameters were studied for a sufficiently long time and the information required for generation of MRP was acquired. This collected data was then summarised and analysed. Using data of the organisation and the factors studied for simulated production, an MPS and the inventory on hand was generated.

The company manufactures 26 different types of filters for various customers. Each product is made of five different parts namely end cap, inner retainer, outer retainer, gasket and filter element which are common for specific set of products. Each filter get assembled with these components and undergoes four production processes; paper pleating, stitching, gluing and testing for completion of final product. Collected data comprises of different customers of the company, their importance, general size of the order, timing of placing orders, receipt of the orders, their dates of arrival, delivery date, and time available for production, different delays, etc. It also covers the information about the operations carried in house, components procured from suppliers, cycle times (CT) of operations, inventory on hand, lead times, crashed or reduced lead-times, scrap percentages, percentage of first time yield and subsequent production, rechecking time for defective lot, different categories of setup time change overs, time taken for change over from one product type to another and so on. From the collected data of company, the probabilities of the scrap rate and first time yield of each product were calculated. It was seen that an average scrap rate was about 2 % of every product whereas the probability of first time yield varies from 5 to 10 %, with maximum number of products having an FTY of 8 %. These probabilities are used for recalculating the gross requirements of the products to be manufactured. Depending upon the market, products which are in higher demands are kept in selected quantity in warehouse whereas the products which are in low demand have negligible inventory. The filter element is manufactured in-house from impregnated paper whereas all the other components are procured from suppliers. The lead-time of procurement varies from component to component. It was experienced by the company that in 5 to 8 % of the cases there had been some delays in the past in placing orders for
components. From a large number of observations of the system, it was detected that in such case the order date was delayed by 1-2 days. Company has the strategy to accommodate orders of important customers even if they place their orders late. Sometimes it is not possible to receive the ordered material at time using normal lead-time. At this stage, lead-time is reduced in order to satisfy such customers. The crash lead-time is used as per the customer priority. Higher the rank less will be lead-time for procurement and more will be cost addition. The lead-time is reduced by studying different factors from the collected data. Time taken for placing order, sending order, preparation for production (tooling, material, setups), production, delivery are minimized to the possible extent so that they can be fitted in the scheduled date of MPS. Sometimes after delivery of the goods to respective customer, some orders are rejected. From the observed data, it was seen that about 2% of orders get rejected at customer end. When this scrap order comes back 100% inspection is carried out. Since the orders delivery is already late, the production is taken up on urgent basis and goods are supplied to customers.

RESULTS AND DISCUSSIONS

Table 1 shows a part of material requirement-planning sheet prepared by using the developed system on simulated data of the organisation. It depicts the scheduled dates taken from MPS sheet, calculated delayed scheduled dates and the new scheduled dates by considering the parts requirements, expected delivery dates and necessary crash lead-time for each order with its respective parts and other specifications.

<table>
<thead>
<tr>
<th>Order ID</th>
<th>Product ID</th>
<th>Rank</th>
<th>Cust ID</th>
<th>Part Description</th>
<th>Parts Required</th>
<th>Lead Time</th>
<th>Crash Lead Time (%)</th>
<th>CT</th>
<th>Scheduled Date</th>
<th>Scheduled Date Delay</th>
<th>New Scheduled Date Delay</th>
<th>Cost Addition</th>
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<td>12</td>
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<td>High</td>
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<td>11.5</td>
<td>10-03-2013</td>
<td>11-03-2013</td>
<td>09-03-2013</td>
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</tr>
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</table>

The system computes number of rescheduled orders and the orders getting delayed even after crashing lead time with exact number of days. As shortening of lead-time requires additional expenditure, the delayed orders are rescheduled on expense of additional cost as shown in Table 1. From the material requirement plan prepared by using the software of
prepared algorithm it is observed that the software takes into account all factors and data and correctly calculates the material requirements and delays if any. It also brings out the extent of extra cost and efforts which need to be made to ensure that MRP system provides materials on date to satisfy MPS requirements.

CONCLUSIONS

The proposed MRP system is user friendly and gives realistic results and ease of calculation as compared with the manual method of calculation. The system eliminates all the difficulties arising due to manual method of computation and provides accurate scheduling of orders. The main advantage of the proposed algorithm is that it comprises of all the situations and parameters that are very essential in process of scheduling. With the use of this system, industry can achieve reduction in inventories and satisfy delivery commitments to their customers. In addition, the supplier of raw materials can be given order notices early enough so that they arrange the needed supply and reduce the possibility of delivery delays. The output of this algorithm can be further used for producing final master production schedule, priority control, capacity control and for future production planning.

REFERENCES

5. R. Sadeghian, 2011, “Continuous materials requirements planning (CMRP) approach when order type is lot for lot and safety stock is zero and its applications,” Applied Soft Computing.

