30

Production planning system coping with changing customer requirements

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Abstract

This paper presents a reactive production planning system that reassigns material and production load to shops rapidly according to changes of order, and then adjusts the schedule or production so as to result in a feasible schedule. First, a shop by shop MRP calculation system that considers production load and capacity of shop facility is explained. Next, a decision support system which allows for changes in the MRP-derived schedule is explained. Finally, experimental results such as calculation times for this system are presented.

Keywords

Intelligent CIM, MRP, Reactive scheduling

1. INTRODUCTION

Market conditions such as product life cycle and short delivery time are changing and customers now demand unique or customized products more than ever. Manufacturing industry must respond to this situation by developing the next generation production planning systems which can handle a large variety of products in a Just In Time environment [1] [2] by integrating, end sales and production information.

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We are pushing forward with such CIM system developments by using a broad sales support information network with the purpose of improving lead time estimation accuracy and reducing total order to delivery lead time [3].
The first issue we addressed was to improve lead time estimation accuracy by not relying on fixed standard lead times in production planning, but using ones which is proportional to production loads and facilities status. The second issue was to adjust a production plan rapidly, in terms of product type, volume and completion date to cope with customer requirements changing. For this purpose, we developed the reactive production planning system. The characteristics of this system are as follows:

(1) Proposal of a daily production plan using dynamic lead times which reflect production load and facility capacity. The MRP calculation is carried out using these dynamic lead times and a daily schedule is put forward correctly.

(2) Decision support system. If problems (e.g. capacity and/or parts shortage) occur due to a change in the production plan in accordance with customer requirements, they must be rectified rapidly. In order to rectify these problems, we have developed decision support system to analyze capacity and parts shortage and to propose a countermeasure by canceling order and/or changing the due dates and order sizes for lesser priority (e.g. Non-reserved) planned orders.

In the following sections, we will describe these characteristics of the reactive production planning system .

2. PROCESSING METHOD

2.1. System axioms

The system's axioms are:

(1) A factory is made up of a number of shops and organized by shop groups.
(2) One shop group contains at least one shop.
(3) All shops capable of processing the same part are members of the same shop group.
(4) Shop groups can be placed in an order such that each group only gets parts from groups lower than itself in the hierarchical ranking.

Figure 1 shows the MRP tree for a part p9 in a factory consisting of seven shop groups (organized in hierarchical order).

2.2. Scheduling calculation

As an example, the calculations required to schedule an order for a number of p9 parts will be described.

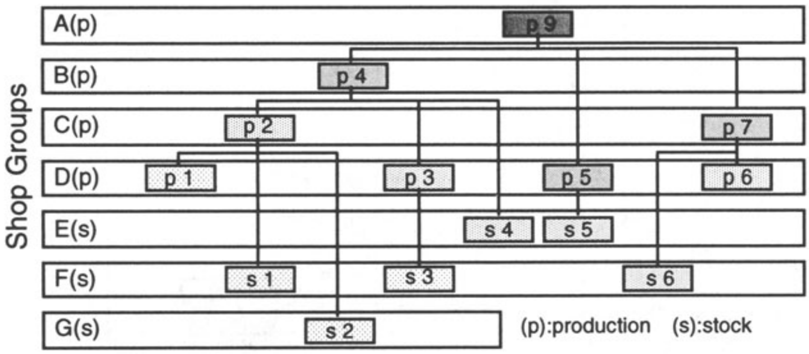


Figure 1 Structure of shop group in factory

Assume that an order for five p9 parts are to be produced by the end of Friday June 10. The calculation must be done on Monday morning, June 6, before the detailed work schedule for that day has been drawn up. The calculation begins with the top shop group in the factory, in this case shop group A. The calculation for each shop group is done by a two-step process:

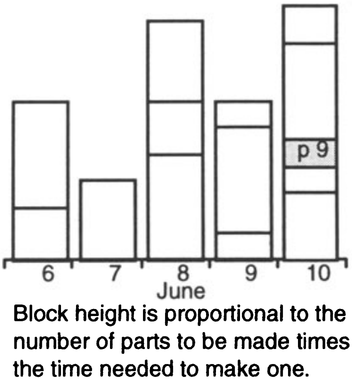
Step 1: Shop Load Completion and Net Calculation.

For shop group A , a "Completion Shop Load" (figure 2) diagram is produced, which shows which parts must be completed by each day. In Figure 2a the part p9 appears again in other parts in the column for June 10, (its "due date"). The Net Calculation routine scans the Completion Shop Load from left to right and from the bottom of the columns to the top to get total number of the parts and assigns available stock to jobs. The system now knows that five p9 parts must be made.

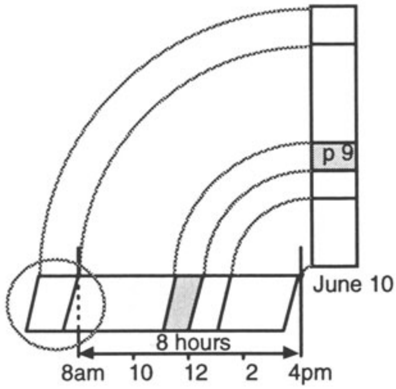
Step 2: Beginning Date Calculation.

The next step is to schedule the work in the completion shop load and using this calculates when the child parts, which are components of the higher parts like p9, need to be ready by backtracking using a dynamic lead times. This is called the "Begin Date" Calculation.

The calculation is carried out from right to left, and from the bottom of the columns to the top through the shop group.



(2a) Completion shop load



(2b) schedule

Figure 2 Completion shop load and schedule for Shop Group A

The system output for 10th of June is represented in Figure 2b, and as can be seen, job spills over into the previous day (inside of the circle in figure 2b). Figure 2b shows a continuous 8 hour shift and contains the same jobs that appeared in the completion shop load diagram, but now with quantified production times. The use of parallelograms is an attempt to represent what actually happens in the factory.

Figure 3 provides a detailed view of the production of each of the five p9 parts in shop group A. Parts p5, p4 and p7 are prepared at 11am at the loading point of the shop, where they wait (expressed by the horizontal line) until the previous job (from other order) has cleared the loading station. In the case of parts p9, let assume it takes 12 minutes in process. This is called the "cycle time". Processing commences at 11:12am. Over the next 30 minutes (termed "one (part) lead time") the parts progress from the start to the finish of the shop, and a part p9 emerges at 11:42am; the constituent parts cease to exist. Meanwhile back at the loading point, the second set of parts wait to be processed, eventually being released at 11:24am and finishing one cycle time behind the first job at 11:54am. The fifth job is finished at 12:30pm, however the first part of the next job began before then (actually releasing at 12:12pm). Consequently, for this job the finish time is 12:30pm and the "begin time" is 11am. The difference between these times is equal to one lead-time plus five cycle times (30 minutes plus 5 times 12 minutes equals 90 minutes).

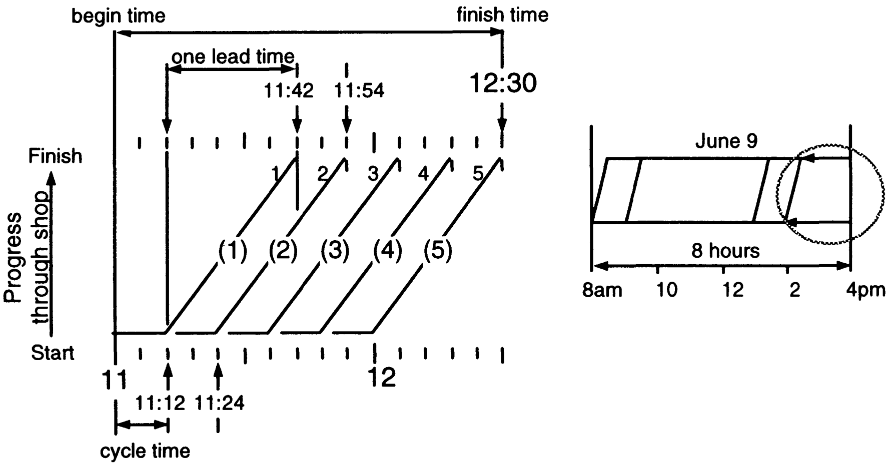


Figure 3 Production schedule for part p9 in Shop Group A.

Referring back to Figure 2b, at the left hand side, jobs spill into the previous day (June 9th). Therefore when work is scheduled for that day (in this shop group) it will be displaced to the left by the size of the spill (inside of the circle in figure 3).

A schedule is termed as being "unbalanced" if work spills to the left from the earliest day in a shop group, across the "Today deadline". Such jobs have, in effect, been scheduled yesterday.

The position of each job in the Completion Shop Load diagram determines where it appears in the schedule which is used to calculate the job's begin date.

3. DECISION SUPPORT SYSTEM

3.1 Decision support for shortage of production capacity

1) Pick up of candidate orders

As shown in figure 4, in the case of a shortage of production capacity, it can be said that there is an overload in the production order of the current day (first day).The overloaded capacity of the first day is caused not only by requirements for the day itself but also by continuous capacity overloading in the advanced dates. Therefore, in any duration in which there is continuous capacity overloading in each subsequent day, the capacity for an existing process will have been exceeded. In this duration, any orders of lesser priority (e.g. Non-reserved) are candidates for replanning as a countermeasure against such overloading.

2) Resolving a sequence of consecutive daily overloads

It can be seen in figure 4b, that total work overload for a particular period of days increases if the load of any day exceeds the load capacity, and conversely, it decreases if any day's load is less than the capacity. The final total overload for the whole time period is derived by shifting the overload of the last day to the previous day (indicated in figure 4b by the moving grey areas), recalculating the overload for that previous day, and repeating the process until the cumulative overload for the period has been completely shifted to the first day (indicated by dark shaded area). Finally, the overload is distributed over several parts of the whole period. The period is subdivided (as shown in figure 4c) whenever the forward shifted overload for any day is smaller than the calculated minimum. For example, period (X) is set when the overload drops below the amount m. For the next period (Y), a new minimum overload (equal to n) is then calculated.

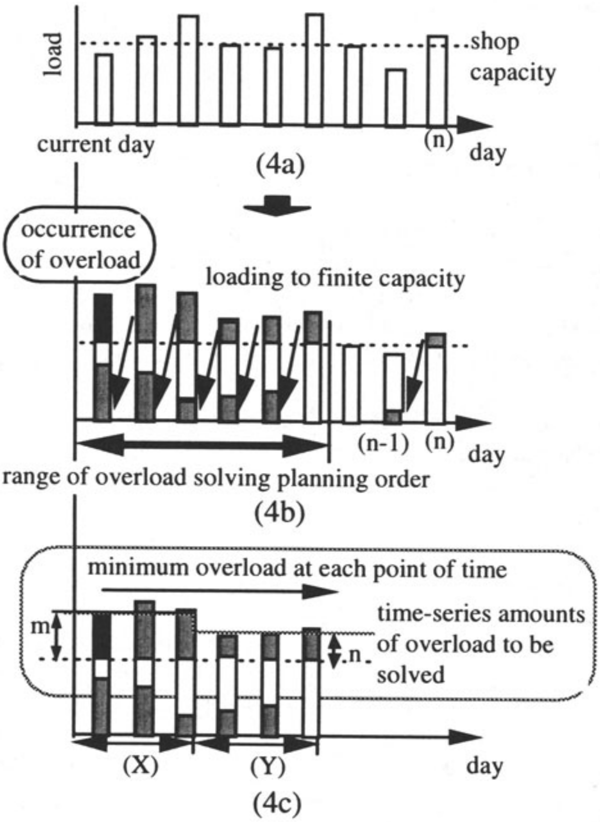


Figure 4 Decision support for shortage of production capacity

The system then can decide the total amount of overload by spreading out load m over duration (X), or by spreading out amount n over duration (Y) and amount (m-n) over duration (X).

3.2 Decision support for shortage of parts

1) Pick up of candidate orders

As shown in figure 5, when a shortage of parts occurs, stock or scheduled stock is less than the required amount for a particular day such as on the (current day +1) and the (current day +3). The total duration of a shortage is defined from the present day to the last day in which a shortage occurs in this case (current day +3).

During this duration, any orders of lesser priority (e.g. Non-reserved) are candidates for replanning as a countermeasure against such shortages.

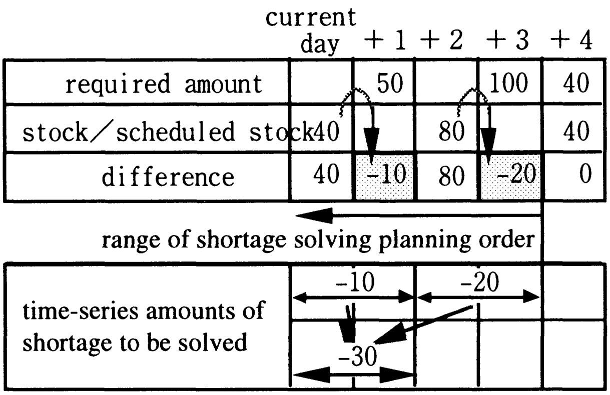


Figure 5 Decision support for shortage of parts

2) Resolving a duration of stock shortages

The duration of stock shortages is subdivided in to periods running up to the last consecutive day of a shortage. For instance, in figure 5, a period with shortage of 10 runs from the current day through (current day+1) and a period with shortage of 20 extends from (current day +2) through (current day +3). The parts requirement for these periods can be reduced by 10 and 20, respectively, or the total shortage of 30 for the duration can be reduced during the first period from current day to (current day +1).

3.3 Decision support system

If the total amounts of overload and of shortages, calculated above, are less than total postponable loads and parts requirements (e.g. for non-reserved orders) during the duration, we can make a feasible production plan by canceling orders and/or changing the due dates and order sizes for candidate planned orders. Then, considering what candidate planned orders are available and using an objective function for minimizing the number of canceled planned orders and the amount of overstocked parts, the system uses the vector method to automatically choose the candidate planned orders.

4. PRODUCTION PLANNING SYSTEM

4.1. Structure of the system

Figure 6 shows how this system can make possible adjustments and produce trial schedules. Rectifying adjustments must be made if a planner detects jobs spilling across the "Today deadline" (in the "Gantt Chart"). Possible adjustments are:

(1) change of shop capacity
(2) change of shop for process
(3) change of order's due date
(4) change of order's priority
(5) change of orders size
(6) adjustment of MPS (add/cancel)

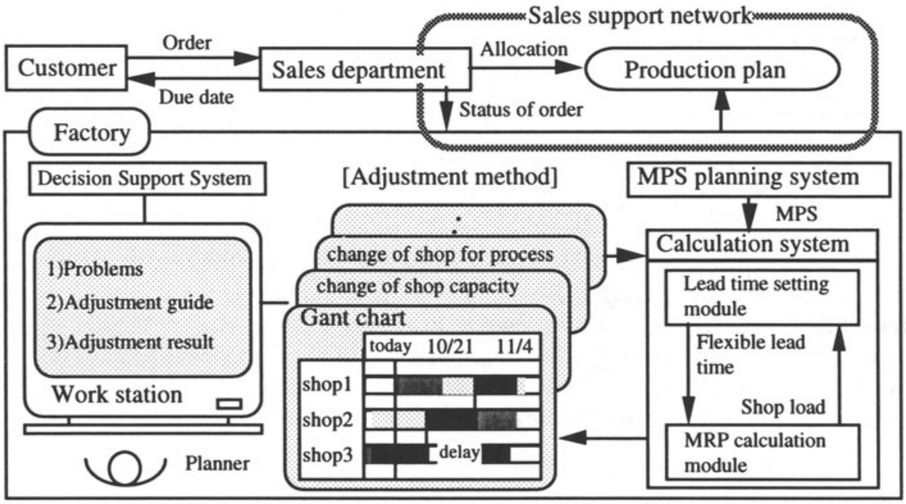


Figure 6 Structure of production planning system

To help these types of coordination, we have developed a graphical interface in which the user can easily find the problems in the production schedule by surveying the status of the shop for each day. All coordination can be directed by mouse input.

Furthermore, in order to obtain a better man-machine interface, we have tuned the MRP program faster so as to make the coordination and MRP calculation cycle short by maximizing information storage in workstation RAM and minimizing hard disk access frequency. As a result it has become possible to plan the production schedule with immediate feedback regarding the required changes in manufacturing resources.

5. MRP CALCULATION TIME EXPERIMENT

This system is an interactive production planning system, i.e. a decision support system for a feasible production planning. Calculation times for this system were experimentally measured by implementing the system on a work station with a 131MIPS CPU and a 64Mbyte RAM. Figure 7 shows the results of calculation times required to generate production plans.

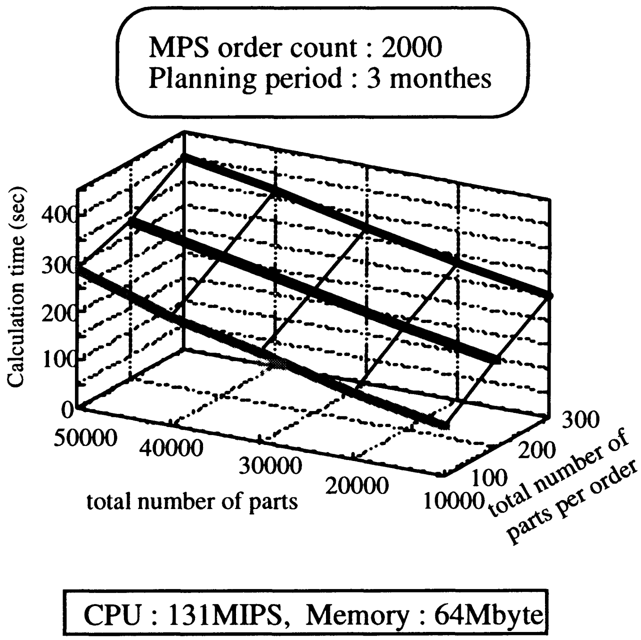


Figure 7 MRP calculation time used for production plan regeneration

The x-axis, the y-axis and z-axis represents the total number of parts, the total number of parts per order, and the calculation time respectively. We have also studied the time for a net-change calculation, which is a calculation to be necessary for only the difference of orders from a previous schedule, as it might potentially be more important since the net-change calculation is used in the iterative cycle of adjustment and result checking. The calculation time turned out to be, at most, one seventh of the time needed for production plan regeneration. We assumed it will be able to be of practical use in daily.

6. CONCLUSION

We have developed the reactive production planning system that reassigns material and production capacity rapidly considering priority of planning order. This system has the following characteristics.

(1) It performs shop by shop MRP calculations using appropriate lead times based on shop load and capacity data in stead of fixed lead times and generates a reasonable production plan.

(2) It provides a decision support system to analyze capacity and parts shortages, and support functions to resolve these shortages.

(3) The calculation time of this system is tolerable for daily practical use as verified experimentally.

7. REFERENCES

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8. BIOGRAPHY

Mitsuhiro Enomoto was born in 1964. He received a B.S. degree in 1986 and M.S. degree in 1988 in Industrial Engineering from Tokai University. He is a researcher at the Production Engineering Research Laboratory, Hitachi, Ltd. His present interests include production management system. He is a member of JIMA.