A STUDY ON PRODUCTION SEAT PLANNING FOR MAKE-TO-ORDER PRODUCTION WITH MAKE-TO-STOCK PARTS

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ABSTRACT

This paper focuses on make-to-order production. Since the goal of the sales department is to receive orders as much as possible, they tend to meet their customers' requirements without considering the productivity of the production department. This results to the unbalanced workload of the production department. Consequently, overtime work happen frequently and sometimes taking more orders may even decrease profitability of the manufacturer. To solve this problem, a production seat system has been designed. Product type (seat type) and quantity of each time period (month or week) are planned in advance so that workload unbalance can be considered. However, no research is conducted on how to prepare the parts for the production seat system. Since the customer desired delivery lead time is often shorter than production lead time, therefor parts need to be prepared the in advance, and now large parts inventory becomes a key issue in the target manufacturers. In this paper, a new seat is designed for the target manufacturers, and parts preparing based on the seat is also proposed. The proposal is compared with the traditional production method and is confirmed to be effective on reducing parts inventory.

Keywords: Make-to-order production, production seat system

INTRODUCTION

This paper focuses on make-to-order production. The target product examples include machine tools, elevators and power equipment. There are three characteristics of this kind of products: the demand of such products is intermittent, the due date is short compared with the production lead time, and both the specification and due date of a product are determined after numerous negotiations conducted between the salesman and the customer.

Since the goal of the sales department is to receive orders as much as possible, they tend to meet their customers' requirements without considering the productivity of the production department. This results to the unbalanced workload of the production department. Consequently, overtime work happen frequently and sometimes taking more orders may even decrease profitability of the manufacturer.

To solve this problem, a concept of production seat planning system is developed [1][2][3][4][5].

Inspired by the train or airplane seat booking systems, production capacities are treated as seats and set in advance so that customer orders can be assigned to the prepared empty seats. Productivity can be considered while planning the seats. Moreover, if the seat is occupied already, then alternative delivery date can be soon negotiated based on the seat planning system between the customer and the salesman, so that lateness of delivery can be decreased.

Since the customer desired delivery lead time is often shorter than production lead time, the target manufacturers need to prepare the parts in advance. However, the target products have a large number of types. Each product type requires a set of parts (components/modules) and the required parts varies among product types. Moreover, the demand of each product is intermittent. Therefore, parts preparing is a key issue in this kind of manufacturers. For acquiring more orders, excessive number of parts are prepared, which causes large inventory costs.

By reviewing the literatures related to production seat system, it is clarified that all the proposed seat planning systems focus on how to reserve production capacity for orders without discussion of parts preparing. In this paper, parts preparing for production seat planning system will be mainly focused. Moreover, seat setting for the target products is also proposed.

PRODUCTION SEAT SYSTEM

The focused manufacturer in this paper has two production stages. In the first stage (parts processing shop), parts are processed in a make-to-stock production environment. In contrast, products are assembled in the make-to-order environment in the second stage.

Literature Reviewing of the Production Seat System

There is only a few literatures related to the production seat system. Academically, the seat planning system is firstly designed by Tamura [1], the proposed system is also called customer oriented production planning system (COPPS). In that paper, monthly production schedule (seat planning) is created based on the product demand forecasting information with the consideration of the difference in workload among months. It is confirmed that since the due date can be negotiated, the ratio of tardiness order of COPPS is less than that of the traditional system which creates production planning after orders are received. The concept and some practices of the production seat system are further introduced in [2]. The effects on reducing order delay and increasing productivity are confirmed, and some future tasks are clarified, such as how to develop an optimal production seat table, how to assign orders to the production seats and so forth. Tsubone and Kobayashi [3] designed a seat planning systems for the following two kinds of products: the make-to-order (MTO) product and the make-to-stock (MTS) product. Two parameters are discussed to determine the seat ratio for these two kinds of products. However, no literature considers how to prepare parts in advance. This is because in the target manufactures of the previous studies, the product type is limited so that the

parts preparing is not a big issue.

Definition of Seat

Production capacity is treated as seats, and in the previous studies the seats in a time period (a month or a week) are set by product type. For example, in [1][2], a seat presents the processing time of a product, and the seat amount for each product type is equal to the demand of that product type. Tsubone and Kobayashi [3] also set the seat by product type, the difference is that the seat is set as the total processing time of a product type. For the target products in this paper, there is numerous considerable product types, and the demand of each type is intermittent, so it is not practical to set seat by the product type unit. Thus, we propose to set seat by the unit of a product group. Products are grouped with the consideration of product specification (parts) similarity. Therefore, a seat presents one unit of any product type that belongs to the product group. Since the processing time varies among product types, in this paper, the average processing time of the products in a group is used for seat setting.

Production Planning

Demand of each product group *g* in month *t* is calculated by equation (1).

$$DG_{gt} = \sum_{i=1}^{N} D_{it} \times \gamma_{ig} \qquad (1)$$

i: product type $i \in \{1, 2, ..., N\}$

g: group type $g \in \{1, 2, ..., G\}$

D_{it} : forecasted demand of product type *i* of month *t*

σ_{it} : forecasted demand variation of product type *i* of month *t*

γ_{ig} : group coefficient. If product *i* belongs to group *g* then $\gamma_{ig} = 1$, otherwise, $\gamma_{ig} = 0$

DG_{gt} : demand of product group *g* of month *t*

And based on the additivity of variance, demand variation of group *g* of month *t* can be calculated by equation (2).

$$\sigma'_{gt} = \sqrt{\sum_{i=1}^{N} \sigma_{it}^{2} \times \gamma_{ig}} \qquad (2)$$

Then safety stock is considered and the demand of a product group considering with the demand variation is calculated by equation (3).

$$DG'_{gt} = \sum_{i=1}^{N} D_{it} \times \gamma_{ig} + \alpha \sigma'_{gt} \qquad (3)$$

α : confidence coefficient

Production planning of each month is determined with the consideration of the difference in workload among months. Then, weekly production plan (seat schedule) is determined by equally divide the monthly amount into weeks.

Parts Preparing

Parts preparing is based on the seat schedule (weekly). And both lead time of assemble *L1* and parts preparing *L2* are considered. For example, suppose that lead time required for assembling and parts processing is 2 and 4 weeks respectively, then in order to satisfy the demand of week t+7, the necessary parts needs to be ordered at the beginning of week *t+1* and delivered to the assembly shop at the beginning of week *t+5* (Figure 1).

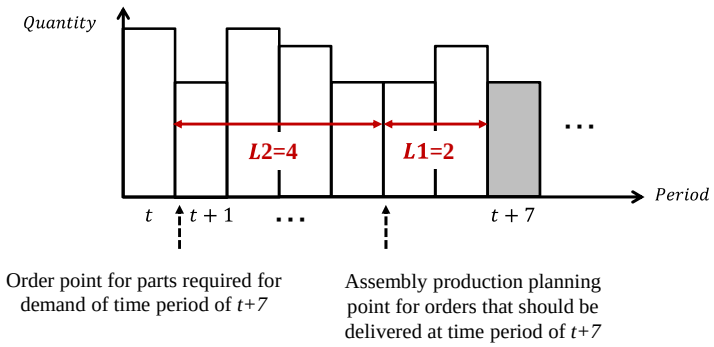

Figure 1. Time points for parts order and assembly production planning

Necessary parts of product group *g* at the beginning of week *t* (which is to meet the demand need of week *t+L1*) is calculated by equation (4).

$$QP_{jg}^{t} = \sum_{j=1}^{M}\sum_{i=1}^{N} PG_{g,t+L1} \times \gamma_{ig} \times \beta_{ij} \quad (4)$$

j: parts type $j \in \{1, 2, ..., M\}$

β_{ij} : required quantity of parts type *j* for product type *i* $\beta_{ij} \geq 0$

PG_{gt} : production amount of group *g* of week *t*

Order Receiving

The production seat planning is shared within the department of production and sales. As soon as an inquire come, the seat occupancy of the desired delivery date is checked. If the seats are full, then the salesman can easily and quickly propose an alternative delivery date to his customer. Moreover, there exists a limited range to change the due date (+days from the desired due date).

EXPERIMENTS

The proposed seat setting and parts preparing method is compared with the traditional production system to testify its effect on reducing parts inventory.

The Traditional Production System

[Parts Preparing]

Required parts are calculated with the product demand forecasting data. The necessary parts that should be finished processing at the end of week *t* is to meet the demand need of week *t+L1*, the amount is calculated by equation (5). Here, demand uncertainty is considered, so safety stocks are added for each product type.

$$QP_{jt} = \sum_{i=1}^{N} \beta_{ij} \times (D_{i,t+L1} + \alpha \times \sigma_{i,t+L1}) \qquad (5)$$

[Production Planning]

Since the lead time for assembly shop is *L1*, at the end of week *t*, orders that should be released to customers at week *t+L1* are considered. Assembly schedule for all the received orders are determined with the consideration of minimizing the lateness of due date.

[Order Receiving]

Inquiries are checked by the first come first serve rule. If the desired due date is date D of week *t*, then the parts availability of week *t-L1* is checked. An order will be fixed (contracted) if its necessary parts are available. Otherwise, parts availability of weeks after week *t-L1* is checked and an alternative due date will be proposed by the production department. If the proposed due date cannot be accepted, then order will be lose.

Moreover, parts reservation will not be executed in this stage. After orders are received, assembly scheduling is conducted weekly, and sometimes lack of parts will be found out at that time yielding late delivery of orders or overtime production.

Results

A set of experiments are conducted under the conditions as follows.

- Simulation weeks : 52
- Product Type: 10
- Parts types required for a product type: 10～100
- $\alpha = 1.64$
- Demand of a product at month *t*: average:100, variation :50

(1) Parts inventory

Firstly, product demand is supposed to be equal to the real demand, parts inventory of the proposed production seat system is compared with that of the traditional production one. Figure 2 shows one result example. It is obvious that the proposed production seat system is effective on reducing parts inventory. This is because less safety stock are needed for the proposed seat setting system.

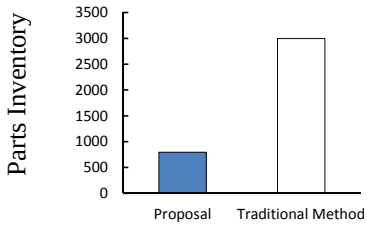

Figure 2. Parts Inventory

(2) Opportunity Loss

Also, another situation is testified, in where real demand is created randomly. Figure 3 shows one result example. In this experiment, the customers are supposed to have no time to wait the manufacturer to propose an alternative due date. So if there is no available parts for the desired due date, then the order will lose. For the proposed production seat system, the order will also lose if the alternative available due date exceeds the changeable range. Figure 3 shows that the proposal can decrease the order lose rate.

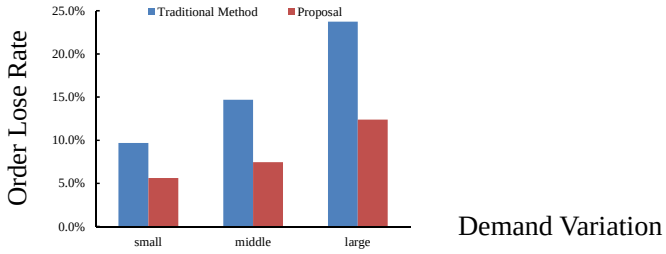

Figure 3. Parts Inventory

CONCLUSIONS AND FUTURE WORK

This paper focuses on parts preparing for the production seat system. A new production seat system is proposed for the target products that has various types and intermittent demand. Seat is proposed to be set by product group unit, and parts preparing is proposed to be conducted basing on the seat schedule. The effect of the proposed production seat system on reducing parts inventory is confirmed by comparing the traditional production system. Future works includes such as how to determine the production plan (seat schedule) by considering both parts inventory and order receive rate, how to assign the orders to seats and so forth.

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