WINDSHIELD PRODUCTION SCHEDULING FOR ON-TIME DELIVERY BY EARLIEST SHORTAGE DELIVERY TIME

[1]TANAGORN CHAIMUAANGGAEW, [2]JUTA PICHITLAMKEN, [3] SUWIWAT SUEBSANKUL

[1,2,3]Master of Engineering Program in Engineering Management, Kasetsart University
E-mail: [1]c.tng@hotmail.com, [2]juta.p@ku.th, [3]suwiwat.s@ku.th

We consider the windshield production scheduling in order to reduce the delay of delivery time. Our approach is to modify the current scheduling rule with the earliest due date (EDD) dispatching rule by applying the minimum stock first (MSF) under the actual production process requirements, such as the number of times to change the product models, the quality rates and the efficiency of the production processes. We also determine the batch production amount, the safety stock levels and the re-production points. We simulate the process by trace-driven simulation on the actual delivery schedule and the overall effectiveness of the actual process. The results show that the new production scheduling can reduce the delivery shortage from 13.2% to 0.0%, which meets the company's target. However, there are two other measures that do not meet the company's policy: the downtime from model changed is 5.2% above the target and the inventory level is 7.8% more than the target.

Keywords - Production Scheduling, Dispatching Rules, Production Scheduling Heuristic, Windshield Production, Earliest Due Date (EDD)

I. INTRODUCTION

We consider the windshield production scheduling of two continuous production processes which is mixed between push and pull systems as shown in Figure 2. The windshield pre-processing and the windshield post-processing are the batch processes which are controlled by the push systems. The planner uses Gantt charts to monitor the customer's due dates and the orders of the windshields.
The pre-processing uses the EDD rule to schedule the production plan. The windshield-glass from the post processing is sent to the stock area. It waits for "pulled system" of the customer's due date in the Toyota production system (TPS).

The windshield production process starts from cutting and grinding the glass. The second step is to send the cutting glass to the printing process to print black ceramic on the surface glass. Then, it is moved to the bending process that is called "windshield pre-processing." After the bending process, the glass is moved to film lay-up and pre-pressing process to attach film and to transform glass to the pre-laminated ones, respectively. The glass is then moved to the autoclave process to complete the lamination process and then the laminated glass is sent to quality inspection that is called "windshield post processing."

The product shortage is found when the planning system fails to fill the stock before the pull production system. There are two factors that affect the product shortage. First, the production lead time of push production system is not related to the customers' due dates because the re-production points are not defined in the push production system. Another factor is the stock before the pull production system cannot accommodate the uncertainty of demand and in the actual processes. This is the cause of the product shortage in 13.2% of the customer orders in June 2018.
Figure 1 presents the product shortage ratio of six processes. The product shortage of Process A is the highest, at 20.2% of the total orders. Thus, we select Process A to be the case study of the new production scheduling heuristic. This process uses the planning production system to fill the stock before the pull production system.

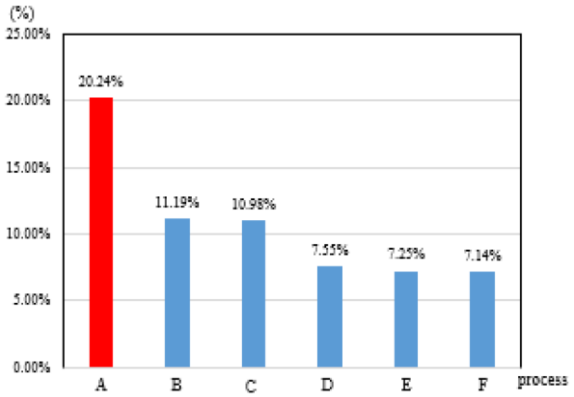


Fig. 1. The product shortage of each process.

II. LITERATURE REVIEW

Our heuristic applies the EDD rule which considers the delivery dates of the products first to be scheduled first. The problem of this policy is when there are many types of products, and many product types have the same due dates. [1] develops the mixed product scheduling rules by considering the delivery dates and the production times of each product. [2] applies the EDD rule to find the suitable delivery policy for the manufacturer. It considers the following factors: the delivery time, the production time, cost of setting up machinery, and the costs of waste from the production line.

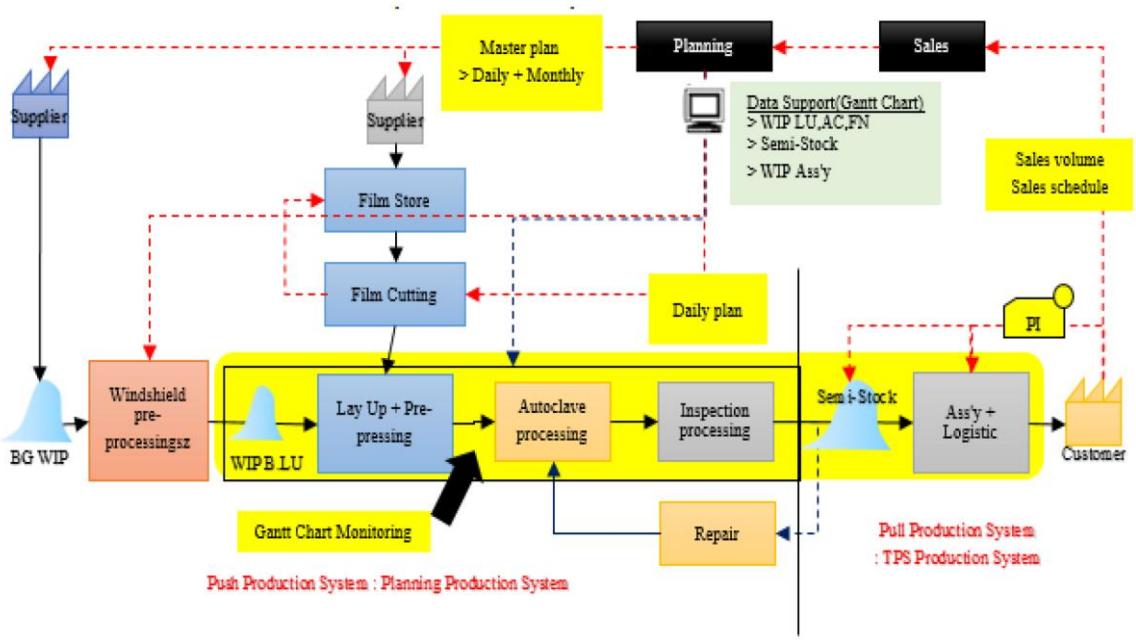


Fig. 2. The production system in this case study.

Moreover, [3] shows better results when applying the EDD rule to consider the resource constraints. It was found that the production delivery system needs a safety stock and the appropriate re-production point.
The re-production point is important for determining the lead time of the production process and to allocate for the appropriate inventory level, which is used to accommodate the demand uncertainty and to maintain the target's service level [4].

III. METHODOLOGY

In this case study, the product shortage is caused by 2 main factors: the production lead time to fill the stock before the pull production system and the stock level before the pull system. Currently, this stock level does not take into account the uncertainty of demand and in the actual processes. If there is a mistake in the stock determination, the production scheduling will be more difficult. To plan the suitable production scheduling to eliminate the product shortage, we use the EDD rule to plan the production scheduling before the pull production system. Our approach consists of the following parts.

A. Safety stock determination

The manufacturer wants the zero delivery shortage. Thus, the service level is set to 99.99%, resulting in the service standard or the standard normal quantile (Z) of 3.40. Eq. (1) is used to calculate the standard deviation of each product from the actual sales schedule [6].

$$\sigma_d = \sqrt{\frac{\sum_{i=1}^{n}(d_i - \bar{d})^2}{n-1}} \quad , \qquad (1)$$

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i \; ; i = 1,2,3,\ldots, \qquad (2)$$

where σ_d is the standard deviation of the demand, $\bar{d}$ is average demand, n is the number of the orders and d_i is the demand of each order i.
The lead time of the production process from the first to the final production process is determined by the minimum production time method based on the minimum number of products in the process.
Eq. (3) is the production process requirements of the cycle time of each process [4] as follows:

$$LT = q \; x \; CT \; , \qquad (3)$$

where LT is the minimum lead time from the first to the final process, q is the number of work in process from the first to the final processes, and CT is the cycle time of process.
Eq. (4) computes the safety stock of each product which is calculate by using (1)--(3) [6]

$$ss = Z\sigma_d\sqrt{LT} \quad , \qquad (4)$$

where ss is the safety stock, and Z is the service standard.

B. Re-Production Point Determination

The production order depends on the lead time of the production process. We adjust the lead times to accommodate the efficiency of the production process and the rate of good products. Because our production system is a batch process, the production time and the number of batches must be determined in order to satisfy the actual production process constraints.

The batch determination of each product type is limited by the requirements of the number of times the product model can be changed. When the model is changed, the downtime from model changed occurs. The company allows no more than 5% of the downtime from model changed.

The number of times to change the model can be calculated as the follows:

$$number\ of\ JC = \left(\frac{Total\ JC\ times}{Average(JC_s + JC_m)}\right), \quad (5)$$

where $number\ of\ JC$ is the number of times to change the model, $Total\ JC\ times$ is the total times of model change, JC_s is the model type change, and JC_m is the model group change.

Eq.(6) is the batch estimation of the number of times to change the model.

$$lot\ size = \frac{total\ demand}{number\ of\ JC}, \quad (6)$$

where $lot\ size$ is the batch estimation.

To adjust the lead time, we consider the production rate, defined as 1/Quality rate and the efficiency of the production as 1/Process Utilization.

Eq.(7) is the re-production point of each product by using Eq. (2)--(4) as follows:

$$ROP = \left(\bar{d}\ x\ LT\right) + ss, \quad (7)$$

where ROP is the re-production point.

The new production scheduling system must define the initial stock level at the beginning of the month from the process capacity:

$$A = \frac{D}{C}, \quad (8)$$

where A is the "compensated capacity" of the push system, D is average maximum demand per day, and C is the process capacity of the push production system. The "compensated capacity" adjusts the process lead time when customers' demands on that day are not satisfied. If average daily customer demand is less than process capacity, we will define lead time of process to be 1. If average customer demand is more than process capacity, we will define the process lead time by Eq. (8).

C. The dispatching rule and the minimum stock first (MSF)

The new production scheduling rules are defined by re-production point, customers' due dates and initial stock levels (Figure 3):

The first rule

The production scheduling rule depends on the delivery dates at the internal inventory storage area (ROP Early Due Date). The production order point is the delivery date to the customers. If a given product is in more than one order at the same time, consider the second rules

The second rule

The customer shortage scheduling rules take into account the delivery times to customers. If there are more than one products being delivered at the same time, consider the following third rule.

The third rule

The inventory production scheduling rule compares the inventory ratio of each product. The inventory ratio is inventory level of each product divide by total demand of each product. We consider the minimum inventory ratio to schedule first.

D. Production scheduling

The production scheduling is simulated by the actual production process (trace-driven Simulation). The 3 main input parameters are the actual sale schedule, the actual quality rates and the actual process efficiency in June 2018. Then, we compare the simulated results with the actual values under the current production scheduling.

IV. RESULTS

The stock level requirement is 10,710 units. Table 1 shows that the new production scheduling method is 7.8% higher than the company's target, and the current scheduling is also 5.8% higher. On the other hand, the number of times to change the model is 5.5% under the new scheduling rule, compared with 5.2% under the current rule although both are still higher than the company's target of 5%. The area of the biggest impact of the new rule is the reduction of product shortages from 20.2% to almost zero.

Table 1 Comparison of the of the production scheduling

Performance Indicators	Company's target	Current production scheduling	New production scheduling
Product shortage	0%	20.2%	0.0%
Stock level		5.8%	7.8%
Downtime from model changed	≤ 5.0%	5.5%	5.2%

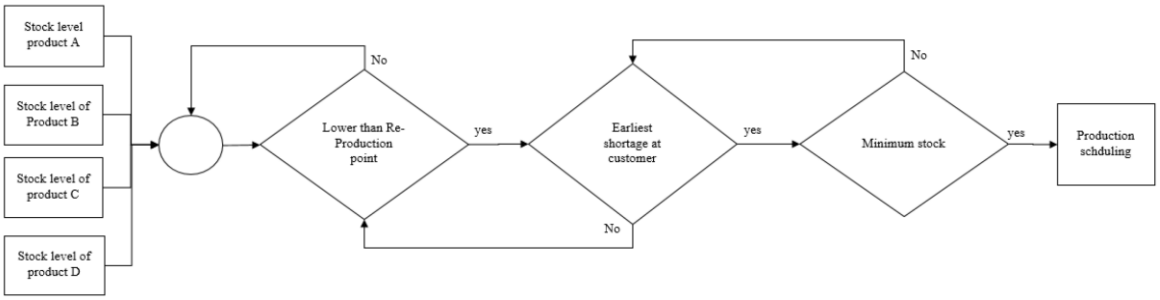


Fig. 3. The dispatching flow chart

CONCLUSION

We propose the production scheduling heuristic which applies the EDD rule. We focus on the delivery date first and minimize the ratio between inventory levels and total demand by setting the order points to accommodate the overall effectiveness of the production process under the constraints of the number of times of model changes.

We achieve the main goal of reducing the delay of delivery time from 20.2% to 0%, but we still do not achieve the company's target of the number of times the model change and the downtime from model changed. Under the new scheduling rule, the downtime from model changed of new production scheduling is reduced from 5.5% to 5.2%.

REFERENCES

[1] Kaban, A. K., Z. Othman and D. S. Rohmah. 2012. Comparison of dispatching rules in job-shop scheduling problem using simulation: A case study. Int simul model 11 (3): 129 – 140.

[2] Atiwat Meesomwang 2010. Development of a production scheduling in automotive lamp equipment use hybrid heuristic scheduling method. Master of Engineering, Kasetsart University.

[3] Andrew A.H. Brown 2014. Dispatching Work: Finding the best dispatching method for real job shop. Master of Applied Science in Management Sciences, University of Waterloo.

[4] Atthapit Pisetpichaya 2016. Inventory system improvement for a special dental clinic. Master of Engineering Program in Industrial Engineering, Chulalongkorn University.

[5] Sridhar Adina 1993. Trace driven simulation of cache memories. Master of Science in Electrical Engineering, University of Rhode Iskand.

[6] Nednapa Siangprasert 2015. The analysis of purchase quatity/ABC analysis/EOQ order quantity of domestic raw material: A case study of rubber compound industry. Master of Science in Logistics and Supply Chain Management, Burapha University.

★★★