

Assessing the Priority Rules of Scheduling Application in Job Shop Manufacturing Company

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Abstract

Manufacturing sector tactically generates the nation economic growth. However, the rapid growth seems have overlooked on inventory and production, thus leading to distribution time prolongation. A study on assessing the priority rules of scheduling application has been conducted, aimed to determine the most efficient and reliable scheduling practice. This study targets on job shop manufacturing companies and data on the worktop processing time were analysed according to different priority rules. The outcome indicates the current policy used; First Come First Serve (FCFS) is not compatible for the performance thus a new scheduling policy is proposed for the overall production improvement.

Keywords

Scheduling, production, distribution time prolongation, priority rules, and job shop.

1. Introduction

According to definition defined by [6], scheduling is a process which involves allocated resources to perform a collection of tasks over a period of time. It is also involves in decision making process that widely used in most manufacturing and production systems, transportation and distribution settings and also in information-processing environments. Whereas in the context of manufacturing systems, scheduling refers to the determination of the sequence in which jobs are to be processed over the production stages, then followed by determining the start-time and finish-time of the job processing.

A good and effective scheduling provides a foundation for the effective plant utilization and attaining on the strategic objectives of the firm, as how it is reflected in the production plan. Wondered how did the job shop manufacturers made their decisions in manufacturing the products? What are the rules or principles used in determining the processing orders? How do they manage a large scale of production as how customers demand within a certain period of time? A question that bothers every operational manager, what is it there to boost the production movement hence giving dependable and faster delivery? It is questionable whether the scheduling policy practiced by the manufacturing company is enough for the production performances.

In manufacturing sectors, customers' demands are the most crucial elements that enables manufacturer to predict on their operations outcome. As customers, they are the modern society that changes as the world evolves and they play the hugest role in catalyzing a business's growth, whereas increasing global competition is forcing manufacturing and service companies to focus on producing high quality goods at a low cost, besides being able to quickly respond to fluctuating market demands. The ability to respond quickly to customer demands can be a key competitive factor, since delivering goods to customers on the promised due dates is reflected in customer satisfaction levels besides able to gain their trust and continuous support. In business, maintaining the smooth flow in supply chain gives the effectiveness in providing and giving out the inventory to the customers.

The remainder of the paper is organized as follows. Section 2 will be describing the problems that arise in scheduling, whereas the mathematical formulation and calculation is shown in section 3 and 4, respectively. Lastly section 6 will describe on the conclusion for the overall findings.

2. Problems in Scheduling

Looking back at a scenario took place 20 years ago when there were lots of car assemblers compete and produce cars for European and Japanese. The competition was too tight as there were too many models stacked. This caused the demand for particular model to be low, thus causing the manufacturers failed to achieve economies of scale. This is due to lack of strategy which is called scheduling; great practice in providing smooth and effective production. Scheduling is proclaimed as one the method that controls the production based on forecasting. It is a strategy to avoid excessive production that will end up cause more internal problems such as lack of inventories for the next month, higher cost to hire, subcontracts or making overtime.

So due to the rapid development and strong competition amongst the manufacturing companies, needing a systematic planning in job shop manufacturing is crucial in order to enable smooth release of inventory and great assembling. Hence, it is needed to expose on the suitable method in managing small scale production, and what is it can be done to minimize the completion time of jobs, mean flow time, lateness of jobs, and processing cost. As how the company is currently practicing First Come First Serve (FCFS) as their scheduling application, this study aims to find out what is the effective priority rules in scheduling application used by the manufacturing companies that focus on job shop manufacturing.

3. Preliminaries

In this section, the features of mathematical formula used is reviewed and manipulated. Then, the outcome from the manipulation of the different priority rules are compared in order to get the suitable alternative apart from what the company have practiced..

3.1 Illustrative Diagrams

This section will be featuring on the process flow that explains at which point did the priority rule is needed to applied in the company scheduling operation.

3.1.1 Process Flow

As shown in Figure 3.1, the production starts by receiving the purchase order from the customers. In this company, the orders are usually made by fax, websites and also manually. The order will then be processed by referring to the order and inquiry form issued by the business development and marketing department. It will then processed by the production department to ensure the existing stock is sufficient enough to occupy the orders. The existing stock is determined to cater the first order made, and the sub sequent batch of order. Thus, whenever the inventory has recorded for zero stock, the production planner will consider for the lead time needed to process the order before they are able to release the order back to the business development and marketing department, this includes the discussion and advice on the time of delivery to the customers.

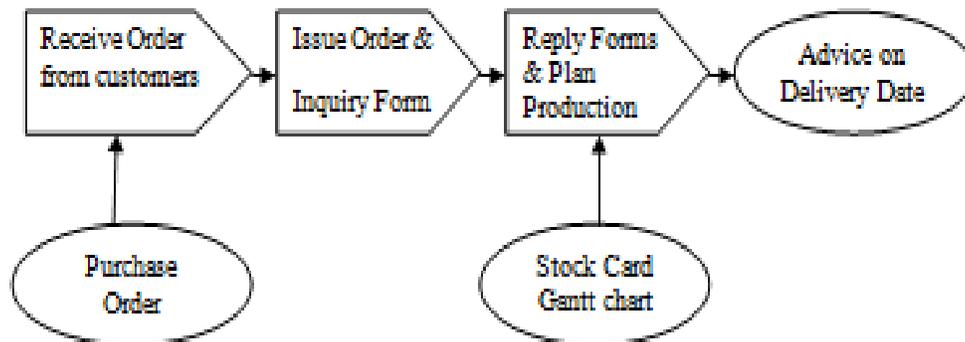


Figure 3.1: Flow of scheduling production

3.1.2 Alternatives in Priority Rules

The company currently uses FCFS as the scheduling application. As [3] mentioned, there are other priority rules in scheduling that applicable for implementation;

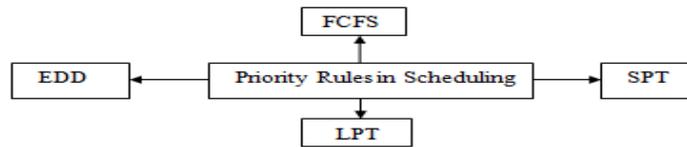


Figure 3.2: Applicable priority rules in scheduling

3.2 Mathematical Formulation

In getting the right decision to propose for the alternative, the proposed mathematical formula is used as the measure of effectiveness for all priority rules. [3]

Table 3.1: Measure of effectiveness

<p>i. Average Completion Time</p> $= \frac{\text{the sum of total flow time, } x}{\text{Number of jobs}}$	<p>ii. Average Hours Early</p> $= \frac{\text{total job work (processing)time, } y}{\text{sum of total flow time}}$
<p>iii. Average no. of Job</p> $= \frac{\text{sum of total flow time}}{\text{Total job work (processing) time}}$	<p>iv. Average no. of Lateness</p> $= \frac{\text{total late days, } z}{\text{Number of jobs}}$

As mentioned in the problem statement, this study aims in minimizing the job average completion time, average number of job, average number of lateness and to maximize the average hours early. Thus, these measures will become the main benchmark that shows the effectiveness of each priority rules.

4. Data Interpretation

4.1 First-Come, First Served (FCFS) as the Current Scheduling Policy

First-Come, First-Served is the current scheduling policy which has been practiced by the company throughout the establishment.

Table 4.1: Calculations for job with First-Come, First-Served Sequence Measures

Product	Begin + Processing Time	= Job Time, <i>t</i>	= Job Flow Time	Scheduled Delivery	Actual Delivery	Hours Early (Scheduled Delivery - Actual Delivery = <i>positive value</i>)	Hours Past Due (Scheduled Delivery - Actual Delivery = <i>negative value</i>)
1	0	+	48 = 48	52	48	4	
2	48	+	45 = 93	57	93		36
3	93	+	35 = 128	43	128		85
4	128	+	33 = 161	45	161		116
5	161	+	26 = 187	30	187		157
6	187	+	20 = 207	22	207, <i>y</i>		185
Total			824, <i>x</i>		828	4	579, <i>z</i>

Table 4.1 shows the calculation from FCFS. Compared to other rules, FCFS is the rule which conducts or operates the job according to the sequence of order [3]. The measure of effectiveness for FCFS will be shown in Table 4.2 along with the measure for other priority rules; SPT, LPT and EDD. For other priority rules, the calculations are made almost similar to FCFS except that the arrangement of the job is done according to the priority indicated by respective names. As showed in the table above, the priority rules are used in different basis. For First Come First Serve (FCFS), it prioritizes the first sequence of the incoming job. Compared to Shortest Processing Time (SPT), it prioritizes the job that has the shortest processing time while Earliest Due Date (EDD) prioritizes the job that has the earliest due date to be processed first. And for the last rule is Longest Processing Time (LPT) which gives the priority to job with longest processing time to be completed first.[3]

4.1.2 Steps to Calculate the FCFS Sequence Measures

Step 1: Arrange the sequence of job according to the sequence of job coming in and enter all the respective data into the table.

Step 2: Place 0 at the begin time for the first job.

Step 3: Subtract Scheduled Delivery to Actual Delivery. For the positive answer indicates hours of early whereas negative answer indicates hours of lateness.

Step 4: Get the total amount for total job flow time x , cumulated job flow time y , and also the total for hours of early and lateness z .

Step 5: Calculate the Measures of Effectiveness according to the mathematical formulation showed in Table 3.1.

Step 6: Repeat Step 1 according to the name specification till Step 5.

4.2 Summary on the Measures of Effectiveness for Different Priority Rules

The interpretation on the calculation for the measures of effectiveness for all priority rules are tabulated as shown in Table 4.2.

Table 4.2: The Summary on the data interpretation according to Priority Rules in Scheduling

Priority Rules \ Measures	First-Come, First Served (FCFS) (Current)	Shortest Processing Time (SPT)	Longest Processing Time (LPT)	Earliest Due Date (EDD)
Average Completion Time	133.50	104.17	104.00	105.00
Average Hours Early	0.25	0.33	0.25	0.33
Average Number of Job	3.87	3.02	3.98	3.04
Average Number of Lateness	94.00	63.00	96.5	63.83

4.3 Research contribution

4.3.1 Different Priority Rule Yields Different Outcome

Most of the companies in Malaysia do not have the exposure on other scheduling application. The most popular and frequently used job shop scheduling application is First Come First Serve (FCFS). The stereotype thinking is to prioritize the first that came in without studying from the other aspect, such as total cost, time duration to complete and average number of job involved. Due to lack of awareness on the production scheduling, the company applied the rule to process the job accordingly to the orders' arrival. As how the company had applied First Come First Serve (FCFS) rule throughout the years of operation, it is seen as fair to the jobs or customers. They only concentrate on minimizing customers waiting time and job completion time. Nevertheless, they overlooked the other factors such as Work in Process (WIP) inventory and to maximize the facilities utilization thus resulting in poor performance with respect to all performance measures. This is the biggest disadvantage for FCFS because it does not concede any jobs or customers characteristics. This shows how the current policy is just unreliable and unaccountable in terms of justifying the productivity.

A company that manage to minimize customer' waiting time is a company that thinks of their customers, partially. Minimized waiting time is not the only thing that customers care much, but also when the company gets their demand within short period of time, with a very reasonable cost involved. Thus, this study contributes in giving the ideas to the entrepreneur, and manufacturing line to improve on their production performances. Being able to serve efficiently is not good enough as it must come with reasonable package. As this study digs on the other priority rules apart from FCFS, it shows the efficiency of other job shop priority rules as well. The outcome is shown in Table 4.2.

Table 4.2: Summary of comparison on priority rules in scheduling for jobs dispatching

Priority Rules	First-Come, First Served (FCFS) (Current)	Shortest Processing Time (SPT)	Longest Processing Time (LPT)	Earliest Due Date (EDD)
Average Completion Time	133.50	104.17	104.00	105.00
Average Hours Early	0.25	0.33	0.25	0.33
Average Number of Job	3.87	3.02	3.98	3.04
Average Number of Lateness	94.00	63.00	96.5	63.83

From Table 4.2 shows the comparisons on the priority rules in scheduling for jobs dispatching. Each rules yield different measures. Thus in determining the best rules, detailed comparison was done to cross out the least efficient rule. The first aspect is regarding the average completion time. Amongst the four data obtained, FCFS is ought to be crossed out since it has given a very huge difference compared to SPT, LPT and EDD. So from this it is known that FCFS is unreliable thus, being crossed out. It is shown that SPT and EDD rules gave the more effective measurement for job sequencing and working process, in contrast to the company current scheduling policy; FCFS.

Looking into the similar efficiency in the measures for SPT and EDD, these both rules give the yield that fall within the range. Their efficiency in yielding the lowest average processing time, contradict to the current scheduling policy; FCFS. The calculated processing time for FCFS is rather high because of the practice that prioritizes the order that came first, regardless of the quantity ordered. Thus when the business development and marketing department had issued the order and inquiry form accordingly to the production department; the orders will be processed accordingly to the sequence for their order to complete. This is why the average processing time is relatively high than SPT and EDD thus creating nuisance to the customers where they needed to wait longer. So, why bother practicing FCFS when SPT and EDD can actually save up the prolonged time to enhance the production number.

The next aspect is regarding the average hour early. So the comparison is ought to be done to compare the reading amongst SPT, LPT and EDD. From the table, it is known that SPT and EDD yielded for the same average, 0.33 whereas the lowest average is from LPT. Since SPT and EDD have the greatest and equal reading, thus LPT is ought to be crossed out also. LPT is somehow not practicable in certain scenario, in a way that it will consume the longest time and causing the other job either with earliest due date or shortest processing time to delay its processing time, and fail to fulfil customers' demand within the agreed time period. Thus, LPT is just not a good choice of rule to be practiced in this company,

The third aspect is the average number of job. And as how the FCFS and LPT have been crossed out from the analysis, thus this should be comparing between SPT and EDD only. And the result in the table has pointed out that SPT yields the lowest average number of job and is slightly lower than EDD.

In justifying SPT yield the most efficient reading amongst all, the last aspect is taken into consideration. From the table, it shows that once again SPT yield the lowest average number of lateness. Thus, it is proven that SPT is

the best rule to be applied in improving the current scheduling policy SPT since it is able to schedule for a lower average of job processing time thus processing the job with rapid progress [2], records the highest percentage on average hours early, lowest average number of job and also having the lowest average on job lateness. This indicates the SPT is able to serve better for their customers due to lower job processing time and promises production efficiency. It also helps in reducing the cost in lowering the work in process and inventory. Nevertheless, the proper and suitable practice for the four different rules can be applied by looking at the job nature and the operation involved.

As a whole, SPT is the best job shop priority rule suitable to be implemented, taking over the classic FCFS rule. Implementing SPT will be able to improve the production planning by minimizing the number of job and hours of job lateness thus resulting in speedy delivery. Great business starts from a very great working culture. These are the criteria that customers' look into in proposing business.

Table 4.3: Cost Comparison between Initial and Proposed Priority Rules

Black	Price/Unit	Loss/hour late
15mm	RM1400	RM550
19mm	RM1800	RM700
25mm	RM1800	RM850
Colour		
15mm	RM2200	RM950
19mm	RM2500	RM1050
25mm	RM2800	RM1200

Table 4.4: Total cost generated through FCFS

FCFS	Total	Loss	Gross
19mm B	102600		102600
25mm B	200000	31450	168550
19mm C	281600	79800	201800
15mm C	277200	117800	159400
15mm B	261800	78100	183700
25mm C	579600	222000	357600
Total Cost			1173650

Table 4.5: Table of total cost generated through SPT

SPT	Total	Loss	Gross
25mm C	61600		
15mm C	101200	15200	86000
25mm B	142200	28900	113300
15mm B	159600	39050	120550
19mm C	397500	107100	290400
19mm B	372600	108500	264100
Total Cost			874350

As how the tables indicate in Table 4.4 and Table 4.5, they show the cost generated through the practice of FCFS and SPT. Obviously, Table shows the expenses involved for FCFS is higher as it has a high value of loss, compared to the loss due to job lateness in SPT.

5. Conclusion

In this study, it is considered that knowledge and awareness are the causal to the lacking of awareness in scheduling. Since the company has been applying FCFS as the main job shop scheduling application, thus it is to be proposed that they switch the priority rules from FCFS to SPT. Compared to FCFS, SPT is as how mentioned by [5] the cycle times in the dispatch rule reduces when SPT is used as the priority rule replacing FCFS. Applying SPT as the new priority rules helps in increasing the capacity of the production where it allows the jobs with shortest processing time to be processed first and reduces the amount of work which awaits capacity at the end of the work schedule [1]. Besides that, SPT is the rule that prioritise customer desires; and this will increase the customer satisfaction towards the reliable business and services provided by the company.

Due to lack of awareness on the production scheduling, the company applied the rule to process the job accordingly to the orders' arrival. As how the company had applied FCFS rule throughout the years of operation, it is seen as fair to the jobs or customers. They only concentrate on minimizing customers waiting time and job completion time. Nevertheless, they overlooked the other factors such as Work in Process (WIP) inventory and to maximize the facilities utilization thus resulting in poor performance with respect to all performance measures. This is the biggest disadvantage for FCFS because it does not concede any jobs or customers characteristics. This shows how the current policy is just unreliable and unaccountable in terms of justifying the productivity.

As a whole, it is learnt that different priority rules give different implications on various performance measures. Thus, the selection should cover all aspects to be taken for considerations. As how the studies have covered, it shows all jobs were examined independently and the assumptions were made that sufficient capacity such as the availability of raw materials, machines, and orders will ensures the smooth ongoing of the production process.

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