Determination of Order Delivery Time in Event Organizer Industry Using a Non-Delay Scheduling Approach

Nur Indrianti[1] and Vina Islamia Vervly Suandevin[2]
[1, 2]Department of Industrial Engineering,
Universitas Pembangunan Nasional "Veteran" Yogyakarta,
Jalan Babarsari 2, Tambakbayan, Yogyakarta 55281, Indonesia

[1]n.indrianti@upnyk.ac.id, [2]vinaislamiav@yahoo.com

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ABSTRACT

This study discusses the determination of order delivery time in the event organizer (EO) industry. With regard to the characteristics of the EO production process that is identical to the job shop production process in the manufacturing industry, a non-delay scheduling approach is applied. The non-delay schedule is compiled using the non-delay algorithm with the criteria for makespan minimization. Job assignment is done using the shortest processing time (SPT), longest processing time (LPT), and first comes first served (FCFS) priority rules. We consider the situation where all orders arrive simultaneously (offline) and at different time (online). As a case study, the modified non-delay algorithm is examined to solve the problem of an EO in Indonesia. The results of the study show that the non-delay algorithm using SPT rule provides the best schedule performance which results in the shortest makespan and the lowest resource idle time. In addition to determining the delivery time, the resulting non-delay schedule can be used to control the execution of each order. The method of determining order delivery time in this study can be applied to other service industries. Further study can be developed for situations where order arrival and processing time are probabilistic. Furthermore, it is also necessary to consider the balanced distribution of the workload among operators.

Keywords: *Order delivery time; Event organizer; Make-to-order; Non-delay schedule*

Services have become increasingly vital for economic growth in many countries, not only in developed countries but also in developing countries and even poor countries (Ghani, 2011). Modern productivity services have increased significantly along with the development of information and communication technology (ICT). The average contribution of services to Gross Domestic Product (GDP) and value added in high-income countries increased from 69% in 1997 to 74% in 2015. In middle-income countries the contribution of the service sector to GDP in the year 2015 increased to 57% from 48% in 1997. Growth in the service sector has led to employment growth. In 2017 in all member countries of the Organization for Economic Cooperation and Development (OECD), more than 70% of the workforce is employed in the service sector (Buckley & Majumdar, 2018).

The average growth in the service sector in Indonesia over the past eight years has reached 7.05% per year. Although Indonesia is a lower-middle income country, the contribution of the service sector in Indonesia to its GDP continues to increase, from 45% in 2000 (Hidayatullah, 2018) to 59% in 2018 (Basri, 2019). In 2017 a total of 47% of the workforce worked in the service sector (Hidayatullah, 2018). One service industry that is growing in Indonesia is the event organizer (EO). It is a professional service provider for organizing events such as meetings, parties, performing arts, entertainment, weddings, conventions, exhibitions, and so on.

Back stagers Indonesia founder said that the EO industry has a growth of around 15% to 20% with an industry value of more than Rp500 trillion. At present, there are already around 4,000 business people with formal employment of around 40,000 people (Richard, 2019). The growth of EO in Indonesia is driven by the growth of creative industries in the world which is also followed by positive trends in the growth of creative industries in Indonesia (Karja, 2019). Deputy Head of the Indonesian Creative Economy Agency said that the creative economy, including the entertainment industry, is targeted to become one of the industrial powers in Indonesia (Movanita, 2019).

The basic function of EO is event management. In general, EO has a duty to assist clients starting from the planning, preparation, execution, and evaluation of the running of the event. EO responsibilities take place from before the event starts until the event is finished. The client only monitors whether the activity is running smoothly (Mbiz, 2019). Accordingly, the services offered by EO include planning, production, management, and post-event. EO expertise in carrying out those four service activities will certainly affect consumer satisfaction.

Studies in event management have been focused on the economic or social impacts of the individual events while some researchers attempted to study what motivates visitors to come to an event. The most obvious topic in the future for event management would be safety/security, event experiences expectations, social media, information technology, and green events (Backman, 2018). A study using a convenience sample survey of all members of the International Special Events Society (ISES) has been done to conduct impact assessment of event organizers in terms of capital, ecological, media, political, and stakeholder benefits (Goldblatt, 2000).

Event experiences expectation can be influenced by service quality which is measured by several dimensions. One of the service quality dimensions is reliability which can be defined as the ability of the service provider to perform the promised service such as on time delivery performance. The delivery time can be interpreted as the time from the time a customer orders a service until the service is received. Shortened delivery time and falling prices can increase consumer demand. There are even consumers who are willing to pay more for faster lead times. Therefore, EO must be able to determine delivery time accurately so that the order can be received by consumer on time.

A study on lead time in the service sector proposed an analytical procedure to determine capacity based on optimal lead times. The study observed the impact of profits on variations in demand when consumers are very sensitive to lead time and companies are penalized if they are late (Nguyen & Wright, 2015). The study dealt with a single product, in fact orders received by EO can be more than one and may vary with different processes.

In terms of order sequencing, EO that receives multiple orders may deal with two conditions called offline and online conditions. Offline condition is a condition where all orders are received by EO simultaneously whereas online condition is a condition where orders are received by EO at different time. In online condition some orders arrive when the previous orders are being processed. Of course, the two conditions have different characteristics and will have different consequences in scheduling the orders. The scheduling process will produce the completion time of each order that can be used as a basis for determining the delivery time of those orders.

With regard to the problem above, this study is intended to determine the delivery time in the event organizer industry taking offline and online conditions into account. Our work differs from the previous studies in that we focus on determining order delivery time using order scheduling approach. Here the sequence of the order execution is determined in such a way as to obtain a minimum total completion time or makespan. Furthermore, order delivery time can be determined based on the resulting completion time by taking transportation or shipping time and procurement time into consideration.

LITERATURE REVIEW

In the EO industry, order processing is carried out by employees or operators with certain expertise according to the operating needs. Operators in EO industry are similar to machines in the manufacturing industry. That EO characteristic is identical to the job shop production process in the manufacturing industry. In job shop manufacturing system, a different set of jobs are processed on a series of machines with different flow patterns or process routes with different processing times. Each job can be processed on one machine more than once (Baker, 1974).

In general, the production system of EO is make-to-order (MTO), where production is only done if there is an order. Order processing in an MTO production system is usually started by the producer who offers the estimated price and order delivery time to the customer. Orders will be placed if the customer agrees with the price and delivery time offered. If the order is received by the customer beyond the agreed delivery time, the producer will be charged a penalty fee.

To optimize the performance of job shop manufacturing system, job shop scheduling (JSS) can be carried out. JSS can be done using a non-delay algorithm. The basic principle of the non-delay algorithm is that no idle machine is allowed. "A feasible schedule is called non-delay if no machine is kept idle while an operation is waiting for processing" (M. L. Pinedo, 2008, p. 22).

JSS has been the focus of a large amount of studies over the past decade for both static and dynamic situations. Dynamic events such as random job arrivals, machine breakdowns, and changes in processing time are inevitable events in the production environment. A numerical evaluation of Dynamic Job Shop Scheduling (DJSS) has been conducted by demonstrating the superiority of the hybrid genetic algorithm (GA) approach. The approach integrated GA and conventional taboo search (TS) algorithms to minimize makespan (Kundakci & Kulak, 2016). The study emphasized on the efficient solution using predictive-reactive scheduling approach for dynamic job shop manufacturing system, which is different from the characteristic of MTO production system. In addition, the production system discussed in the study is rescheduled periodically. While, in MTO environment job scheduling will only be possible if there are new orders.

Another study has been done to assess dynamic job shop performance. The study used nine criteria and concluded that the shortest processing time rule provides the best performance, namely flow time and a minimum number of late jobs (Sharma & Jain, 2014). Although the JSS models in this study is more complicated than classical JSS model, the characteristic of the proposed model is not suitable for EO production process as the study is not concerned with online scheduling where jobs arrive at different time.

In the MTO environment, there has been a study to determine quoted lead time using a queuing and semi-Markov decision process. The study considered MTO manufacturers in two types of consumers, namely (1) lead-time-sensitive customers who are willing to pay higher prices for shorter lead times and (2) lead-time-insensitive customers who want to wait (Weng, 1996). Another study discussed the problem of determining the optimal lead-times plan and production capacity for each stage of the two-stage MTO manufacturing system using M/M/1 queuing systems (Altendorfer & Minner, 2011). Furthermore, the rules of flexibility in price, lead-time, and delivery in an MTO environment has been examined taking limited production capacity with a stochastic demand function into account (Chaharsooghi et al., 2011).

The previous studies of MTO manufacturing lead time focused more on the analysis of the correlation between lead-time and price which is used as a basis to determine the lead time in order to obtain optimal production capacity. The studies did not consider the operational aspects in the production shop floor when in fact lead time is highly influenced by operational factors such as job sequencing and scheduling.

In terms of scheduling in the service industries, an overview that considers five areas of scheduling in service industries has been conducted. The scheduling areas include (1) project scheduling, (2) workforce scheduling, (3) timetabling, reservations, and appointments, (4) transportation scheduling, and (5) scheduling in entertainment (M. Pinedo et al., 2015). The article discusses in detail the problems and methods that can be used to solve scheduling problems in service industries. The methods discussed in the article mostly cover the issues of resource allocation in order to minimize makespan. Nonetheless, the article does not review scheduling problem in the case of an event organizer that has production process similar to MTO job shop manufacturing system.

METHODOLOGY

The characteristic of order processing in the EO industry is identical with MTO job shop manufacturing system. Hence, we propose to use JSS approach to solve the problem.

Delivery time in this study was determined based on order completion time. A non-delay scheduling approach is applied to determine the order completion time. The scheduling criteria is minimizing makespan, which is the time needed to complete all tasks, starting from the first task to the n^{th} task. Job assignment or order execution was done using three priority rules, namely shortest processing time (SPT), longest processing time (LPT), and first come first served (FCFS).

In the SPT rule, jobs with the shortest processing time are processed first, followed by jobs that have the second shortest processing time and so on. The SPT rule does not pay attention to due dates or order arrivals. Conversely, in the LPT rules the job with the longest processing time will be done first. In the FCFS rules, job execution is done in the order of their arrival. From those three priority rules, one rule is chosen that gives the shortest makespan. The flow time of each order generated from the non-delay schedule will be used to determine the delivery time of the related order.

In this study, order arrival and processing time are assumed to be deterministic. In addition, this study does not consider the probability of failure with the production process and the workload of each operator. The original non-delay algorithm can be used in offline situation, where all orders arrive together at $t = 0$ and no order arrives during the order processing. We modified the non-delay algorithm to accommodate online condition. In this case a new order is done without interrupting the production process of the order in progress. So, there is no change to the delivery time of the old orders that was promised to the consumer.

We use triplet form notation (*i, j, m*), which means the order *i* operation of *j* at workstation *m*. Operators at the same workstation are assumed to have the same skills. So, the capacity or available time of the workstation is linear to the number of the operators assigned at that workstation. The notations used in this study are as follows:

PS_t	a partial schedule containing *t* scheduled operations.
S_t	the set of schedulable operations at stage *t*, corresponding to a given PS_t.
γ_m	the earliest time at which workstation *m* ready to work.
σ_j	the earliest time at which operation $j \in S_t$ could be started based on the completion time of the predecessor of operation *j*.
t_{ij}	processing time of order *i* operation *j*.
t_c	the earliest time which operation $j \in S_t$ could be started based on γ_m and σ_j.
$\emptyset_j$	the earliest time at which operation $j \in S_t$ could be completed.
$\emptyset_{jp_{t-1}}$	the completion time of the predecessor of operation *j* at stage *t*-1.
td_i	delivery time of order *i*
tm_i	material procurement of order *i*

tf_i flow time of order *i*
tt_i transportation time of the delivery of order *i* to the customer
t_o operation time
T_p total processing time

To solve the problem, we use non-delay algorithm adopted from Baker(1974). The following is the non-delay algorithm that uses SPT rule:

1) At the beginning of $t = 0$, the value of $PS_t = 0$ (as a null partial schedule), $\gamma_m = 0$, and σ_j=0. As a first step, S_t includes all operations that do not have a predecessor.
2) Determine $\sigma^* = \min_{j \in S_t}\{\sigma_j\}$ and workstation m^*, that is the workstation that is realizing σ^*. Both of these values will be used in subsequent calculations. If there is more than one operation that produces σ^* and uses the same workstation m^*, select the operation that has the smallest t_{ij} runtime, which will produce the fastest turnaround time. Determine t_c and calculate $\emptyset_j$.
3) For all $j \in S_t$ operations that use the workstation m^* and fulfil $\sigma_j = \sigma^*$, then make a new PS_t by adding the j operation to the existing PS_t.
4) For each new partial schedule (PS_{t+1}) produced in step 3, make changes to the data set as follows:
   a. Remove operation j from S_t.
   b. Create S_{t+1} by entering the next operation of the same order from the omitted operation into S_t.
   c. The price of t changes to $t + 1$.
5) Return to step 2 for each PS_{t+1} generated in step 4 and continue these steps until all non-delay schedules are obtained.

For scheduling using LPT, the difference only lies in step 2. In this step, if there is more than one operation that can be realized at the same workstation, then the operation that has the largest processing time of t_{ij} will take precedence. However, in the FCFS rules, the use of all workstations is prioritized for jobs or orders that are received in advance.

For online scheduling we modified the non-delay algorithm based on the following two principles: (1) scheduling is done from the point of time the addition of the order and (2) operations that have been completed before the arrival of the order are not considered anymore. In step 2 of the algorithm above, if there are two jobs that are ready to be processed at the same workstation, then the old job of which the delivery time has been promised to the customer, will be processed first.

Based on SPT, LPT, and FCFS rules, a non-delay schedule will be selected which will produce the smallest makespan. From this schedule, it can be seen the flow time of each order. Flow time is the time span between when an order can be started and when an order is completed. The delivery time can be calculated as follows:

$$td_i = tm_i + tf_i + tt_i \tag{1}$$

THE CASE STUDY

As a case study, a problem will be examined in an EO named Mili Production (MP). The company is located in Purwo Martani, Sleman Regency, the Special Region of Yogyakarta, Indonesia. This EO has experience in handling various forms of events such as meetings, gatherings, outbound, advertising, and web developers compared with those who are using general concepts to specific concepts. MP has 9 employees who have tasks as project officer (PO), graphic designer (GD), IT & production (IT&P), administrator (ADM), marketing & public relations (M&PR), supervisor (Spv), and supervisor Jr (Spv) Jr.). The average MP does 5 to 15 orders per month. At the same time MP often receives orders of different types.

In the offline situation, the situation will be discussed when MP receives four orders from different clients, namely making mobile branding, outlets branding, company profile, and graphic design. At the stage of receiving an order, MP must determine the price and delivery time to be offered to consumers. If the consumer accepts the offer, the order can begin to be produced. Conversely, if the consumer rejects the offer, the order is canceled by the consumer.

In online scheduling, order 5 and 6, which are billboard and brand activation, arrive when order 1 through 4 are being worked on, precisely at $t = 100$. Order 5 and 6 should not interfere with the work on order1 to 4 that are running. Thus, if there is more than one order ready to be done on the same workstation, orders1 to 4 will be prioritized, according to the schedule that has been promised to consumers. Production data of the orders is presented in Tables 1 through 3. In this scheduling problem the workstation is identical with machinery because the operators at the same workstation have the same skills.

Table 1: Production Workstation

Workstation	Operator	Order description	Number of operators
1	*M&PR*	Marketing services	1
2	Adm	Managing letters and administration	2
3	*PO*	Taking care of permits and taxes	1
4	*GD*	Designing process equipment	2
5	*Spv*	Inspecting the orders	1
6	*Spv*Jr.	Inspecting the orders	1
7	IT&*P*	Carrying out work related to the website and the production process	1

Table 2: Production routing

Order	Name	Operation				
		1	2	3	4	5
1	Mobile branding	1	2	3	5	7
2	Outlet branding	2	4	6	7	
3	Company profile	1	3	4	5	7
4	Graphic design	4	6	7		
5	Billboard	3	4	6	7	
6	Brand activation	1	4	5	7	

Table3: Processing Time

Order	Operation (hours)					Total
	1	2	3	4	5	
1	24	64	24	8	32	152
2	72	120	40	64		296
3	32	24	64	16	24	160
4	88	32	24			144
5	72	32	16	24		144
6	24	64	16	64		168

RESULTS AND DISCUSSION

Based on Tables 2 and 3 it can be calculated that the total working time of each workstation is 56 hours for workstation 1, 136 hours for workstation 2, 48 hours for workstation 3, and 272 hours for workstation 4. Table 4 shows the first and second iterations of non-delay scheduling using SPT for offline condition. First step we put job 111, 212, 311, 414 into a column. As shown in Table 2, the first operation (*j*) of the first order (*i*) is done using workstation (*m*) 1. So, 111 is part of the first iteration.

At the first iteration all $\alpha_i = 0$ because all workstations are not yet utilized. The $\gamma_m = 0$ means that all workstations are ready to use at $t = 0$. We can then assign order 1, 2, and 4 at each of the appropriate workstation. We can see that order 1 and 3 use the same workstation. In this case, order 1 will be assigned first because it has shortest operation time.

At the second iteration we replace job 111, 212, and 414 from S_t column by the subsequent operations. The γ_m at the second iteration is the completion time of the jobs that has been assigned at the first iteration. We then assign job 311 at $t = 24$ because at that time workstation 1 has finished job 111. We repeat the steps until all jobs have been assigned.

Table 4: The 1st and 2nd Iterations of Offline Non-Delay Schedule using SPT Rule

Stage	γ_m							S_t	σ_j	σ^*	t_{ij}	m^*	t_c	$\emptyset_j$	PS_t
	1	2	3	4	5	6	7								
1	0	0	0	0	0	0	0	111	0	0	24	1	0	24	111
								212	0		72	2	0	72	212
								311	0		32				
								414	0		88	4	0	88	414
2	24	72	0	88	0	0	0	122	24	0	64				
								224	72		120				
								311	0		32	1	24	56	311
								426	88		32				

The non-delay schedule performance in offline condition is shown in Table 5 and 6. Table 5 shows that the SPT rule produces the shortest makespan compared to the LPT and FCFS rules. From Table 6, we can see that SPT rule provides the highest average workstation utilization or the shortest idle time compared to the LPT and FCFS rules. Thus, we can conclude that the offline non-delay schedule generated by the SPT rule results in better performance than LPT and FCFS. The Gantt chart of non-delay schedule based on SPT rule can be seen in Figure 1.

Table 5: Makespan of Offline Non-delay Schedule

Order	T_p (hours)	Flow time (hours)		
		SPT	LPT	FCFS
1	152	200	224	152
2	296	312	376	384
3	160	360	192	408
4	144	144	144	432
	Average	254	234	344
	Makespan	360	376	432

Table 6: Workstation Utilization and Idle Time of Offline Non-delay Schedule

Work-station	t_o (hours)	Utilization			Idle time		
		SPT	LPT	FCFS	SPT	LPT	FCFS
1	56	15.56%	14.89%	12.96%	84.44%	85.11%	87.04%
2	136	37.78%	36.17%	31.48%	62.22%	63.83%	68.52%
3	48	13.33%	12.77%	11.11%	86.67%	87.23%	88.89%
4	272	75.56%	72.34%	62.96%	24.44%	27.66%	37.04%
5	24	6.67%	6.38%	5.56%	93.33%	93.62%	94.44%
6	72	20.00%	19.15%	16.67%	80.00%	80.85%	83.33%
7	144	40.00%	38.30%	33.33%	60.00%	61.70%	66.67%
	Average	29.84%	28.57%	24.87%	70.16%	71.43%	75.13%

In online scheduling, order 5 and 6 arrive at $t = 100$, when order 1 to 4 are being processed. In this situation if there are more than one orders ready to be assigned at the same workstation, order 1 to 4 that are being processed will be prioritized.

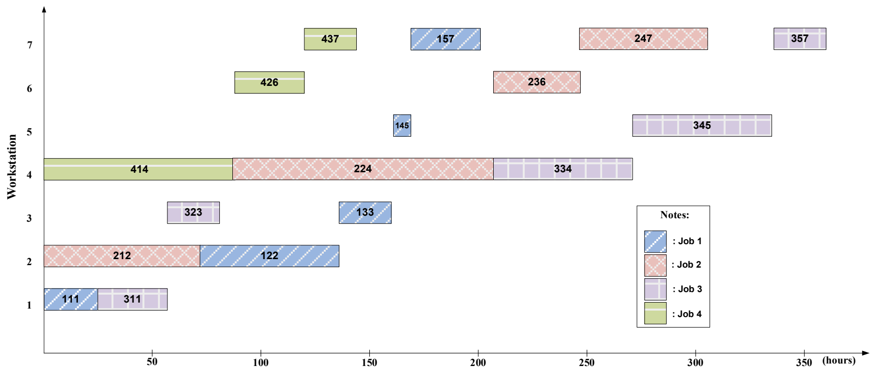

Figure 1: Offline Non-delay Schedule using SPT Priority Rule

The performance of non-delay schedule for online condition is shown in Table 7 and 8. It can be seen that compared to LPT and FCFS rules, SPT rule produces the best non-delay schedule because it obtains the minimum makespan, the highest average workstation utilization, and the lowest average workstation idle time. The online non-delay schedule using SPT rule is shown in Figure 2.

Table 7: MakeSpan of Online Non-delay Schedule

Order	T_p (hours)	Flow time (hours)		
		SPT	LPT	FCFS
1	152	200	200	200
2	296	312	312	312
3	160	360	360	360
4	144	144	144	144
5	144	448	464	356
6	168	424	440	520
	Average	314.67	320	415.33
	Make Span	448	464	520

With regard to the calculation results presented in Table 7 and 8, it can be concluded that in online condition the non-delay schedule using SPT rule provides better performance than LPT and FCFS. Table 7 shows that the non-delay schedule using SPT rule results in 448 hours to complete order 1 to 6. It is shown in Table 6 and 8 that non-delay schedule using SPT rule yields the highest average workstation utilization both for offline and online conditions. In other words, SPT rule results in minimum workstation idle time.

Table 8: Workstation Utilization and Idle Time of Online Non-delay Schedule

Work-station	t_0 (hours)	Utilization			Idle time		
		SPT	LPT	FCFS	SPT	LPT	FCFS
1	80	17.9%	17.24%	15.38%	82.14%	82.76%	84.62%
2	136	30.4%	29.31%	26.15%	69.64%	70.69%	73.85%
3	120	26.8%	25.86%	23.08%	73.21%	74.14%	76.92%
4	368	82.1%	79.31%	70.77%	17.86%	20.69%	29.23%
5	40	8.9%	8.62%	7.69%	91.07%	91.38%	92.31%
6	88	19.6%	18.97%	16.92%	80.36%	81.03%	83.08%
7	232	51.8%	50.00%	44.62%	48.21%	50.00%	55.38%
	Average	33.93%	32.76%	29.23%	66.07%	67.24%	70.77%

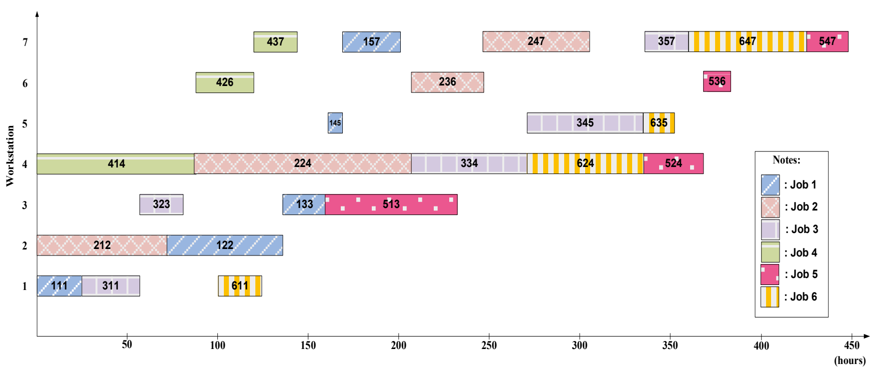

Figure 2: Online Non-delay Schedule using SPT Priority Rule

The above results are in line with the results of a study conducted by Sharma and Jain (2014) which concluded that SPT provides the best scheduling performance. From Figure 1 and 2 we can see the execution schedule of each operation of each order. The execution of order 3 will be started at $t = 24$ after workstation 1 completes the first operation of order 1. The execution of order 5 will be started at $t = 160$ after workstation 3 complete processing the third operation of order 1. Although order 5 arrives at $t = 100$, it can not be executed directly because when it arrives workstation 3 is processing job 133. Thus, job 513 must wait until the process of job 133 is finished. Conversely, order 6 can be done directly after it arrives. This is because when order 6 arrives at $t = 100$ workstation 1 is not being operated.

The flow-time values generated by the non-delay schedule in Table 5 (offline) and 7 (online) can be used to determine the delivery time. If the time of material procurement and the shipping or transportation time of the orders are known, the delivery time can be calculated using Equation (1). For example, if it takes 48 hours for material procurement and 10 hours for shipping order 2, then the delivery time of order 2 will be 370 working hours.

We must be careful when determine the completion time of order 5. Table 7 shows that order 5 will be completed at $t = 448$. Because the order is received at $t = 100$, the actual time required to complete the order is 338 hours after the order is received.

The non-delay schedule presented in Figure 1 and 2 can be used as a guidance in executing the orders received by the company. The conformity in complying with this schedule becomes the key to the company's success in delivering the orders on time. From the figures we can also see the idle time of each workstation or operator. Based on this information production manager can manage the utilization of each operator. The company may assign the operators for other tasks during their idle time.

CONCLUSION

This study is aimed at proposing an approach to determine delivery time in similar to job shop manufacturing production system, a non-delay algorithm is applied to solve the problem. We considered SPT, LPT, and FCFS priority rules with the criteria of minimizing makespan. A case study has been examined taking offline and online conditions into account.

The results of the study showed that the SPT rule obtained the best performance both in offline and online conditions. Non-delay schedules using SPT rule produces the shortest makespan and lowest average workstation idle time. Order delivery time of each order can be determined by adding up the flow time of each order resulting from the non-delay schedule with the order procurement and shipping time.

In addition to determining delivery time, the non-delay schedule approach can be used to create the execution schedule for each order in EO industry. In terms of operational aspect, the schedule can be used as a guidance for the production manager to control the execution of each order so that the order can be received by the customer in a timely manner.

The method of determining order delivery time in this study can be applied to other service industries. Other approaches that are commonly used to determine lead time in the manufacturing industry might be applicable to solve the problem. However, orders in the service industry are mostly done by humans whose performance may be unstable throughout the working hours due to fatigue and so on. This can be the focus of any future study. Moreover, this study assumed deterministic order arrival and processing time. The workload of each workstation has not yet been considered. Therefore, further study can be developed for situations where order arrival and processing time are probabilistic. In addition to minimizing the makespan, it is also necessary to consider the balanced distribution of workload among workstations.

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