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TWO-STAGE HYBRID FLOWSHOP SCHEDULING USING HEURISTIC METHODS:STUDY CASE PT XX MILITARY EQUIPMENT

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Keywords: Scheduling, Hybrid Flowshop, Makespan, Heuristic Method

ABSTRACT

Scheduling is a production process or work carried out to plan a production for determining the process time of the machine, to do each work by minimizing the process time and achieving maximum production results. The problem that occurred in this Xx company was scheduling the machining process to avoid delays in production, to solve this problem the scheduling method was done using the Johnson method and scheduling by the Gupta model with the Sule Algorithmic approach, and Shortest Processing Time (SPT) and then the comparison of each method was done to get the best results from each method. The scheduling result using the Johnson method has a makespan value of 159, the Sule Algorithm method has a makespan value of 151, and the Shortest Processing Time method has a makespan value of 66. From among the Johnson method, the Algorithm method, and the Shortest Processing Time method, the one chosen is the Shortest Processing Method Time because it has the smallest makespan value.

Keywords: Scheduling, Hybrid Flowshop, Makespan, Heuristic Method

I. INTRODUCTION

PT Xx is an industrial company engaged in the production of weapons. PT Xx will certainly always improve the quality of each production in order to compete in the increasingly fierce industrial competition.

The production process in this company uses a hybrid scheduling problem and proposes an efficient heuristic algorithm to solve a special case with only one machine. The effectiveness of the proposed heuristic algorithm to find the minimum schedule range that is evaluated empirically. In the production process, the company

executes the assembling process of 9 different products. However in this case, the researchers only took 1 part of the assembling product processin the company, which is the Power Pack. As is known, the problem that is currently happening to the company is the procurement of power packs that support production needs, which results in the company being subject to fines due to delays in order completion.
One of the things done to overcome this problem is by scheduling, it is known that making a schedule in each production process will result in good quality products/goods and relatively efficient production time. In the production process, this company uses the type of flowshop scheduling method where the work is processed in the specified order and each work goes to each machine at a certain time and only processed once by each type of machine. Each machine work is processed sequentially, moves from one machine to another (linear diagram).

II.LITERATURE STUDY

Scheduling plays an important role in the manufacturing industry because ineffective scheduling will result in a low level of usage according to the existing capacity. Scheduling can be separated in an order because in scheduling there is a kind of work that must be done first. Scheduling problems will arise when a series of tasks arrive together at a certain time (per month, per week, per day) while the resourcessuch as machines and tools are limited. If that happens, it is necessary to reschedule those resources efficiently.

Scheduling is a decision making process that aims to achieve optimality (Pinedo, 2002). Conway and Forgaty (1967) revealed that scheduling is the task of assigning each operation to a certain position or time scale of a particular machine and often includes determining the start time and the completion time. Decisions on scheduling which are interpreted as tasks are in the form of sequences & when to start a work, when everything must be chosen, we must first know the order of each operation.

In this company, the process carried out considering the hybrid scheduling problem has n problems that must be processed, each problem is processed first in the first stage and then proceed to the second stage. At stage s, has m, the number of identical machines to determine the minimum scheduling range for this problem. As a secondary goal to minimize the number of machines used at each stage. If m_s1 = 1 for both stages, this problem can be solved efficiently by using Johnson's algorithm. If m_s1> 1 for each s the problem becomes somewhat difficult to solve. The purpose of doing the scheduling is to maximize production and minimize errors that occur in order to create a decision making process that aims to achieve optimality.

The Johnson method is a method of scheduling a systematic amount of work, while the rules of the Johnson method itself are that the process must be maximized so that it produces the best value of makespan or the total time on the work. By doing work processes like this can help or minimize idle time on every work. (Ginting, 2009).

The Sule method is a work having a larger process for a higher-weighted work. The Sule algorithm compares the setup time and removal time divided by the processing time to carry out the production design in reducing the makespan for the flowshop case of the two machines (Sule 1982). This method has been used for Hybrid Flowshop research (Gupta, 1994).

The SPT method is a method that gives priority to the shortest production process for completion. Usually used to minimize work in process. The weakness of this method can be seen, namely procrastinating work with a longer production time. The work will be finished on more than the predetermined date. (Tanuwijaya and Bambang (2012: 89)

III.METHODOLOGY

At this stage the problem faced is hybrid flowshop. If the number of machines in one of two everything is zero, then the problem is in one. It is assumed that $m_1 \leqq m_2$ on stage 1 and stage 2 have 2 machines and the processing time for stage one is all zero. Then the problem is one of scheduling n on m_2 the number of identical parallel machines if no pre-action is allowed. This problem is equivalent to solving the m_2 - partition problem which is *NP-complete*. Similar conclusions can be reached if $m_1 > m_2$. Thus, a limited problem with the absence of processing time for all works at any one of the two stages is *NP-complete*. This result is true even if one of the two stages contains only one engine, provided the other machine has at least two machines.

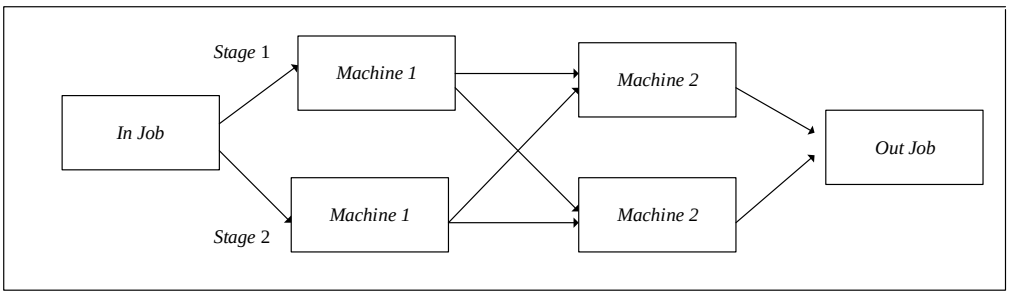

*Figure 1.*Ilustration System

IV. RESULTS AND DISCUSSION

Table 1. is the result of data collection obtained from company Xx. Which will then be processed using the Scheduling method using the Gupta Model.

Table 1. Data Collection Results

No	*Workstation 1*			*Workstation 2*		
	Work Center	*Setup Time*	*Processing Time*	*Work Center*	*Setup Time*	*Processing Time*
1	*PPC*	24	21	*Welding*	12	6
2	*PPC*	24	21	*Welding*	4	2
3	*PPC*	12	8	*Welding*	8	4
4	*PPC*	14	12	*Welding*	6	2
5	*PPC*	6	3	*Welding*	4	1
6	*PPC*	32	27	*Welding*	4	2
7	*PPC*	4	3	*Welding*	5	2
8	*PPC*	3	2	*Welding*	3	4
9	*PPC*	32	27	*Welding*	8	6

No	*Workstation 1*			*Workstation 2*		
	Work Center	*Setup Time*	*Processing Time*	*Work Center*	*Setup Time*	*Processing Time*
10	*PPC*	1	1	*Welding*	1	3

Johnson Method

Table 2. The Sum of WS1 and WS2 Setup Time and Processing Time

J	$S_{t1}P_{t1}$	$S_{t2}P_{t2}$
10	2	4
8	5	7
7	7	7
1	45	18
9	59	14
3	20	12
4	26	8
2	45	6
6	59	6
5	9	5

Table 3. Calculation Results of Johnson Method

	Machine1		Machine 2		Machine 1		Machine 2	
j	Start	Finish	Start	Finish	Start	Finish	Start	Finish
10	0	2			2	6		
8			0	5			5	12
7	2	9			9	16		
1			5	50			50	68
9	9	68			68	82		
3			50	70			70	82
4	68	94					94	102
2			70	115	115	121		
6	94	153					153	159
5			115	124	124	130		

Table 2 is the sum of the setup time and processing time on workstation 1 and vice versa on workstation 2. Where the results of the total setup time and processing time are used to find the next calculation in the Johnson algorithm method, the Sule algorithm method, and the Shortest Processing Time algorithm method.

Table 3 is the calculation result of Johnson's method. As is known, the Johnson method illustrates the problem of the makespan value which minimizes two machines.

The scheduling steps with the Johnson Method are as follows:

1. Count all works with two machines, for the minimum time, which is tn, 1. and tn, 2 (n: number of works).
2. At the minimum process time 1, the work is placed on the starting schedule of a process..
3. At the minimum process time 2, the work is placed on the schedule starting from the end of a work, because process 2 is done after process 1 is completed. The time is based on the completion.
4. Works that have been scheduled and the remaining works, the numbers must be eliminated.

SuleAlgorithm Method

Table 3. The Sum of WS1 and WS2 Setup Time and Processing Time

j	S_tP_t	S_tP_t
10	2	4
8	5	7
3	20	12
4	26	8
2	45	6
1	45	18
7	7	7
9	59	14
6	59	6
5	9	5

Table 4. Calculation Results usingSule Algorithm Method

	Machine 1		Machine 2		Machine 1		Machine 2	
J	Start	Finish	Start	Finish	Start	Finish	Start	Finish
10	0	2			2	6		
8			0	7			7	14
3	2	22			22	26		
4			7	33			33	39
2	22	67			67	73		
1			33	78			78	96
7	67	74			74	81		
9			78	137			137	151
6	74	133			133	139		

	Machine 1		Machine 2		Machine 1		Machine 2	
J	Start	Finish	Start	Finish	Start	Finish	Start	Finish
5			137	146			146	151

Table 4 is the calculation result of the Sulemethodn. Where in determining the Job on this method is done by sorting jobs by comparing the lowest value on workstation 1 and on workstation 2 and taking the best value.

The steps for scheduling with the Sule Method are as follows:

1. Sort the jobs by comparing the lowest value based on the sum of the setup time and processing time on workstation 1 and the setup time and processing time on workstation 2.
2. At the minimum process time 1, the work is placed on the on the starting schedule of a process.
3. At the minimum process time 2, the work is placed on a schedule starting from the end of the work, because process 2 is done after process 1 is completed. The time is based on the completion.
4. Works that have been scheduled and the remaining works, the numbers must be eliminated.

Shortest Processsing Time Method

Table 5. The Sum of WS2 Setup Time and Processing Time

j	$P_{t2}S_{t2}$
10	4
5	5
2	6
6	6
7	7
8	7
4	8
3	12
9	14
1	18

Table 6. Calculation Results ofthe Shortest Processing Time Method

J	Machine 1		Machine 2		Machine 1		Machine 2	
	Start	Finish	Start	Finish	Start	Finish	Start	Finish
10			0	4			4	8
5	0	5			5	10		
2			4	10			10	16
6	5	11			11	17		

J	Machine 1		Machine 2		Machine 1		Machine 2	
	Start	Finish	Start	Finish	Start	Finish	Start	Finish
7			10	17			17	24
8	11	18			18	25		
4			17	25			25	33
3	18	30			30	42		
9			25	39			39	53
1	30	48			48	66		

Table 6 is the calculation result of the Shortest Processing Time method. Where in determining the Job in this method is by sorting the jobs from the minimum value to the maximum value. In the job order, the SPT method takes one of the workstations. In this case the order of the SPT taken is on workstation 2.

The steps for scheduling with the Shortest Processing Time Method are as follows:

1. Sort the jobs with minimum to maximum values based on the sum of setup time and processing time on workstation 1 and setup time and processing time on workstation 2.
2. At the minimum process time 1, the work is placed on the starting schedule of a process.
3. At the minimum process time 2, the work is placed on a on the schedule starting from the end of a work, because process 2 is done after process 1 is completed. The time is based on the completion.
4. Works that have been scheduled and the remaining works, the numbers must be eliminated.

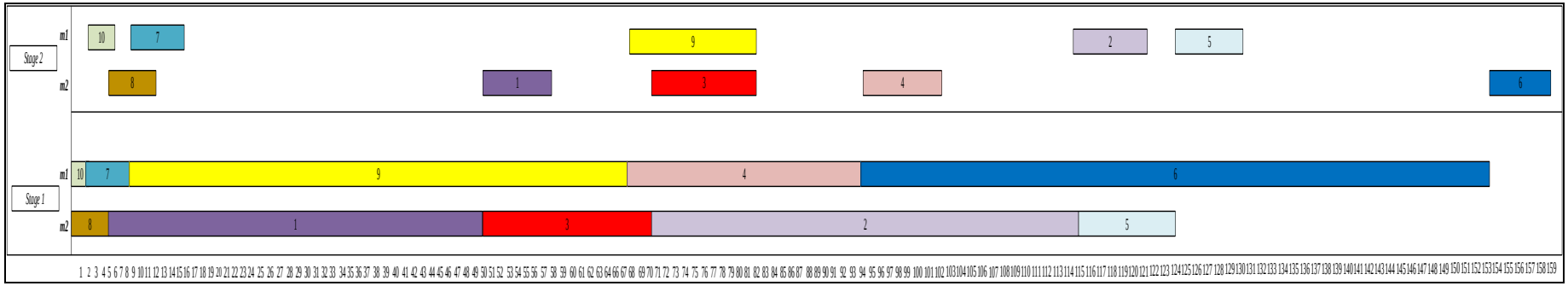

Figure 2. Gantt chart of Johnson Method

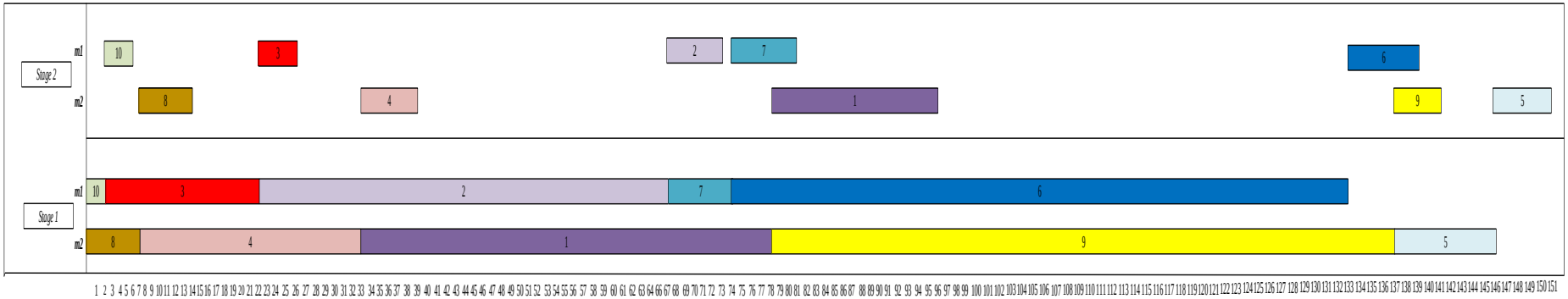

Figure 3. Gantt chart of Sule Method

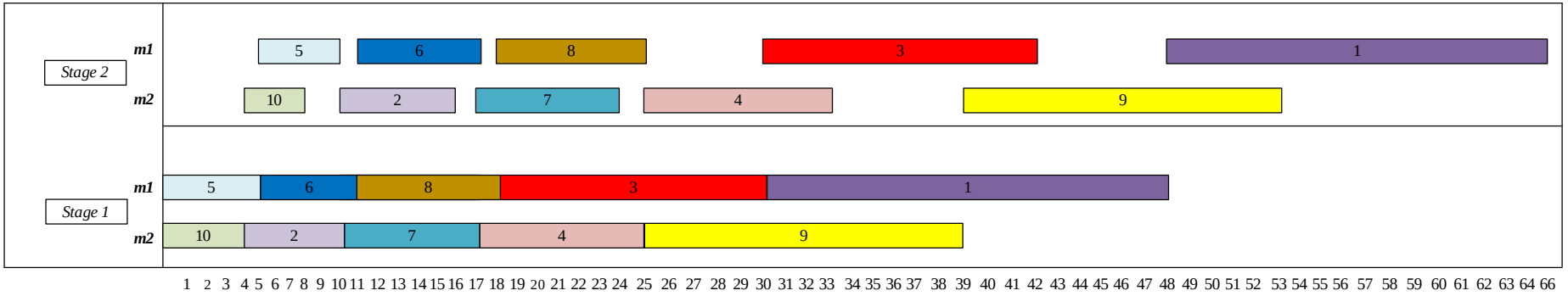

Figure 4. Gantt chart of Shortest Processing Time Method

Figure 2, Figure 3 and Figure 4 are ganttcharts of each calculation methods that have been done. As is known Gantt chart is the implementation time or work schedule of the start of the work and the time limit in orderto complete the work.

Figure 2 is a gantt chart of the Johnson method. It is known that the processing time that occurs in this work has a makespan value of 159 on stage 2 on the second machine.

Figure 3 is a gantt chart of the SuleAlgorithm method. It is known that the processing time that occurs in this work has a makespan value of 151 on stage 2 on the second machine.

Figure 4 is a gantt chart of the Shortest Processing Time method. It is known that the processing time that occurs in this work has a makespan value of 66 on stage 2 on the second machine.

V. CONCLUSION

From the results of calculations that have been done from the three methods which are the Johnson Method, the SuleAlgorithmMethod, and the Shortest Processing Time Method, the best makespan will then be obtained. It is known that Johnson Method is a method used to find the optimal work time schedule on the calculations that have been done. The makespan result of the Johnson Method is 159. For the second method, which is theSule Algorithm Method, the job determination is done by comparing the values at stage 1 and stage 2, then determining the lowest value on stage 1 and the best value on stage 2. The result of the calculation of the makespan is 151. When compared to the result of the Johnson Method, it is known that the Johnson Method has a greater value than the Sule Algorithm Method or $151 \geq 159$. The third method is Shortest Processing Time Method where in the calculation of this method, each Job sequence is done by sorting the minimum value to the maximum value. In this method, the Job comparison sorting is done only on 1 Stage, that is on Stage 2. Comparison of one of the Stages is only done to compare the results of the makespan from the three methods. So it is done by taking 1 Stage only. The resultof the makespan calculation from the Shortest Processing Time Method is 66. Then the Comparison of the Shortest Processing Time Method is smaller than the Johnson Method or $66 \leq 159$ and the Comparison of the Shortest Processing Time Method is smaller than the Sule Algorithm Method or $66 \leq 151$. So the conclusions obtained from the three methods, namely the chosen makespan is the Shortest Processing Time Method because as is known, this method has better performance than the makespans of the other two methods.

In the Shortest Processing Time method, the time used to make comparisons to other methods is that of workstation 2, because as is known in workstation 2, the setup time and processing time is more minimum than that of workstation 1. Otherwise, if we were to choose workstation 1, then the result of the makespan would be 207, whereasusing the time in workstation 2 is 66, therefore the authors chose workstation 2 in order to produce makespans that

are not much different in intervals between the johnson method and the sule method. Then the next step taken was to choose workstation 2. Because, the authors' goal to conduct this research was to find the minimum makespan between the Johnson method and the Sule method.

REFERENCES

[1] B.S. Mittal and P. C. Bagga (1973), "Two machine sequencing problem with parallel machines." Riset Operasi 10, p. 50-61.

[2] Conway, R. W., (1967), "Theory of Scheduling."Addison Wesley, Massachusets.

[3] Forgarty, S., D. W., J. H. Blackstone, dan T. R. Hoffmann(1991), *Production and InventoryManagement* 2*nd* ed., South-Western Publishing Co, Cincinnati-ohio.

[4] Ginting, R. (2009). Penjadwalan Machine. Yogyakarta: Graha Ilmu.

[5] Gupta, J. N., & Tunc, E. A. (1994). *Scheduling a Two- Stage Hybrid Flowshop with Separable Setup and Removal Time. European Journal Of Operational Research 77, 415-428.*

[6] Hamzah Agung Azhari (2017). Penjadwalan Hybrid Flowshop Menggunakan Model Gupta Dengan Pendekatan Alogaritma Sule dan Heuristic Dispatching Rules Untuk Animasi Makespan di PT. Indoneptune Net Manufacturing. Widyatama.

[7] Pinedo M. dan Chao, X., (1999), "Operations Scheduling with Applications in Manufacturing and Services." McGraw-Hill, Singapore

[8] R. N. Murty (1974), "On two machine sequencing problems with parallel machines." Riset Operasi 11, p. 42-44.

[9] S.M. Johnson (1954), "Optimal two-and three production schedules with setup times included." Naval Research Logistics Quarterly, John Wiley & Sons, Volume 1, p. 6168.

[10] Tanuwijaya, Haryanto and Bambang Setyawan, Henry. 2012. Buku Ajar: Manajemen Produksi dan Operasi. Surabaya: STIKOM Surabaya.