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Proposed Production Scheduling Using Non-Delay Algorithm to Reduce Makespan (Case Study: PT. XYZ)

Moh. Fakhruddin Farhan
Defense Industry, The Republic of Indonesia Defense University

Abstract: *PT. Xyz is a manufacturing company that produces piano musical instruments. There are two types of pianos produced, namely Grand Piano and Upright Piano. Where each type has a variety of models. Due to the diversity of piano models and types, companies had to divide the work. There are sections of woodworking, assembly, and painting. Each part has a different production process. In the Cabinet Side section, the system flow in production belongs to the workshop category because many models and cabinets are manufactured using different machines. This causes the Cabinet side to experience problems, namely the difficulty of achieving daily targets. Ineffective resource allocation and scheduling are at the root of the problem. The current scheduling system is the FCFS system or items that arrive earlier will be processed earlier. In other conditions, the Cabinet Side Section schedules the most targeted cabinets that are planned to be produced to be prioritized in their work. Based on this, this study aims to reduce makespan by designing a production scheduling proposal using a non-delay algorithm method for several machines. The object under study is the B1 and B3 cabinet models because they have the most productive targets among other models. The data that has been processed produces a makespan from the company's actual schedule of 321.66 minutes with the order of completion J3-J8-J7-J5-J6-J2-J1-J4. Scheduling with a non-delay algorithm method produces a makespan of 277.31 minutes with the order of completion of work J8-J3-J5-J7-J6-J2-J4-J1. The proposed scheduling non-delay algorithm method is able to reduce makespan by 13.78% or 44.35 minutes. This proves that this method is good for companies to implement. This is supported by the resulting efficiency index value greater than 1 (E > 1) which is 1.16, meaning that the performance of the non-delay algorithm method is better than the actual completion of the company's processes.*
Keywords: production scheduling, job shop, non-delay algorithm, makespan

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I. INTRODUCTION

PT. Xyz is a company that produces musical instruments, namely the piano. There are 2 types of pianos produced in this manufacturing company, namely Grand Piano (GP) and Upright Piano (UP). Each type has a different piano model. In the production process, the company has 3 production departments with different job descriptions, namely woodworking, painting, and assembly. The carpentry section processes raw materials into cabinets according to the specifications of the type and model of the piano. The painting department works on cabinets shipped from carpenters to carry out the painting, sanding, and polishing processes. Then the assembly section installs the cabinet so that it becomes a piano and then proceeds with the final process, namely packing the piano.

Side Cabinet is part of the woodworking division. Cabinet Side processes the cabinet of the piano from the cutting sizer and machine up to be sent to the Quality Control section. The production process on the Cabinet Side uses a rotary press, edge ex &nomi, wide sander, mentory, orbital, aquaproof, band saw, and table saw. In producing various types of cabinets, the Cabinet Side working group uses a job shop flow system, meaning that each cabinet has a different process flow and machine usage. Based on field observations, the problem that occurred on the cabinet side was the delay in the completion of production. This means that the results produced in this group are not in accordance with the production target. In February there was a production shortage of 568 units from the target of 4,615 units. Meanwhile, in March there was a production shortage of 385 units from the target of 4,372 units. The lack of targets that occur causes operators to have to work extra or overtime to achieve these targets. The data obtained shows that the average operator who works is 8 people active every day for 2.5 hours.

The root of the problem in the Cabinet Side working group was ineffective production scheduling. The absence of a work priority schedule has resulted in the production process and work completion time being erratic. The actual condition of the company has a work plan, namely prioritizing items or cabinets that have the most production targets first. But what often happens is the first come first serve system where the cabinet that comes first will be processed first. This is due to the availability of goods or cabinets to be processed. Regardless of whether the goods are available or not, the company's scheduling, which is to complete the work with the priority of the cabinet that has the most production plans to be processed first, also produces a fairly large makespan, making it difficult to achieve it. the target is in accordance with the available time each working day, which is 8 hours. So from these problems, a research was carried out by designing a proposal scheduling to reduce makespan.

II. LITERATURE REVIEW

2.1. Scheduling

Scheduling is a collection of work resulting from the allocation of company resources to time. Scheduling needs to be done so that production can be completed according to the specified time. Effective production scheduling is obtained by allocating resources such as machines, working operators, time, materials, and job sequencing [1]. According to [2], ineffective production scheduling will result in a low level of use of existing capabilities such as facilities, labor, and equipment will wait (idle) for a certain time, due to the absence of a good schedule system. This can reduce the effectiveness and competitiveness of the company, as well as decrease the level of service and other things indirectly. [3] said that the determination of the allocation of company resources, including humans, machines, and time is aimed at creating effective and efficient use of resources. So that it is able to produce the right output in quantity, time, and quality. There are two targets to be achieved in scheduling, namely the number of outputs produced, and the predetermined completion time limit [4].

According to [5], some general scheduling objectives are (1) Increase machine productivity by reducing idle time. (2) Reducing the inventory of semi-finished goods, namely by reducing the average number of jobs waiting in the process queue because the existing machines are working on other processes. (3) Reducing work delays that have exceeded the specified time limit, by reducing the maximum delayandreducing the number of late.

2.2. Factors to Consider Production Scheduling

In making a schedule there are factors that must be considered. These factors are (1) Facility and Infrastructure Capacity. Each company has different facilities and infrastructure capacities. Limited capacity must be taken into account for proper allocation of work in the company. (2) Request. Demand for production comes from consumers which are beyond the control of the company. It is a must to be able to fulfill this demand. Therefore, demand forecasting is carried out as a reference in production. This demand factor must also be considered in planning the production schedule. (3) Raw Materials or Auxiliary Materials. Raw materials and auxiliary materials are the company's basic needs to carry out the production process. If there is a limited supply of raw materials, it will have an impact on the limited fulfillment of consumer demand. So production scheduling is also limited, therefore raw materials and auxiliary materials are factors that need to be considered. (4) Human Resources Capacity. The large number of human resources who are workers often limits the production process, especially for experts. It is difficult to increase the number of experts, while the company's work capacity is quite limited. So the capacity of human resources is another factor that must be considered. (5) Technical terms. Technical requirements also need to be considered. These are technical procedures and job requirements. These provisions are made so that the production or work process can run properly and correctly according to the company's work standards. (6) Working days. The company has working days minus holidays. So that in a year is not fully used to work for 360 days. In making a schedule must pay attention to this. If necessary, it is a good idea to create a special production calendar that lists the days of work activities. (7) There are Express Orders and Special Orders.Sometimes companies accept express orders and special orders that must be special or take precedence over regular orders. What often happens is that companies receive express orders with higher rates, while special orders are priority orders to deal with emergencies, such as hospital needs, and so on. (8) There are Cost Constraints. Cost constraints that need to be considered include those concerning the availability of funds or budgets used to finance company activities, increase in production costs and so on [6]

2.3. Non-Delay Algorithm

The Non-Delay Algorithm method is one method of completing job shop scheduling. This is an active schedule in which no machines are left idle. This applies when at the same time can start certain operations. If there is an operation that uses the same machine at the same time, then the priority is carried out based on the fastest working time or what is called the SPT priority (Short Processing Time). If there is more than one operation with the smallest processing time, the operation is selected based on MWKR (Most Work Remaining). If after MWKR priority there is still more than one operation scheduled, then they will be selected at random. Basically, the Non-Delay Algorithm for multiple machines is the same as the Non-Delay Algorithm for a single machine. In no-delay scheduling for multiple machines, machine selection is based on machine availability. If a single machine, then it can be directly selected. If there is more than one machine, the machine with the fastest ready time is selected. The following are the steps for working on the Non-Delay Algorithm:

Step 1: Determine t = 0 which is an iteration. Include all jobs that will be scheduled in St. Where the scheduled job notation is formed using triplet notation (ijk), where i is a job, j is an operation, and k is a machine. Iteration 0 is the initial stage so all operations will be scheduled without all predecessors.

Step 2: Determine C* which is the minimum Cj (earliest workable time). Before determining Cj for each job, first look at the number of machines, because for iteration 0 the machine is used as a single machine so that there is no machine selection so that Cj can be determined directly. How to determine Cj for each job as in step 3.

Step 3: Since the machine is not operating at all, the start time of the operation follows the operating time of the previous operation on the same job. Because the previous job does not exist, the starting time for all jobs in iteration 0 is 0. Determine tij which is the processing time, and rij which is the completion time of each job's operation, where rij = Cj + tij.

Step 4: See if the minimum machine ready time is more than one. Since the minimum ready time for all machines is 0 or the minimum Cj for each machine is more than one, go to step 5. Cj is the start time of job j's operation.

Step 5: Select the operation based on the fastest Short Process Time (SPT) priority. For machines that have the fastest runtime of more than 1 go to step 6.

Step 6: Select an operation based on the Most Work Remaining (MWKR) priority or the highest number of unfinished jobs. If after that there is still more than one operation to schedule then proceed to step 7.

Step 7:Choose an operation at random.

Step 8: Schedule the selected operation according to step 6.

Step 9: Enter the selected operating time into the appropriate machine.

Step 10: Replace the selected operation with the next operation for the same job.

Step 11: Return to step 2 to redefine the Cj of each job to be scheduled. If not, then the process is complete.

III. RESEARCH METHODOLOGY

The research method used is the quantitative method. The steps in this research are:

1. Determination of Rating Factor
   To know the normal time of work, it is necessary to determine the adjustment factor (rating factor) first. The rating factor can be calculated by the formula:
   $$IP = 1 + \text{Performance Rating.}$$
2. Normal Time Calculation
   Normal time is obtained from the result of multiplying the cycle time with the rating factor value. The normal time calculation can be calculated by the formula:
   $$\text{Normal time} = \text{Cycle time x Rating Factor}$$
3. Calculation of Standard Time
   The allowance in this working group is 2%. So the standard time can be calculated by multiplying the normal time that has been obtained by the allowance value. The normal time calculation can be calculated by the formula:
   $$\text{Standard Time} = \text{Normal time x } \frac{100\ \%}{100\% - Allowance\ \ (\%)}$$
4. Calculation of Job Completion Time
   Job completion calculation time is the time required for each operation that is passed by each job in the Cabinet Side section.The calculation of job completion time can be calculated by the formula:
   $$\text{Job Completion Time} = \text{Standard Time x production targets}$$

IV. RESULT AND DISCUSSION

4.1. Working Time

The following is the working time data at PT. Xyz is described in table 1

Table 1. Working Time Data

Shift	Day	Start	Finish
1	Monday-Thursday	07.00	16.00
2	Monday-Thursday	16.30	23.00
1	Friday	07.00	16.30
2	Friday	17.00	23.30

4.2. Production Plan

The following is the production plan data presented in table 2 below.

Table 2 Company Production Plan Data / 8 Hours

No	Model	Production Plan / 8 Jam
1	B1	33,40
2	B2	18,94
3	B3	32,46
4	U1J	10,93
5	P121 PE	0,93
6	K121 PE	0,01
7	P116 PE	0,44
8	P116 PWH	0,15
9	K121 PWH	0,01
10	P121 PWH	0,17
11	Camridge	0,01
12	P118 GC	3,75
13	P121 GC	3,48
		105

4.3. Product Data

The following is the product data studied in this study. It is described in table 3 below.

Table 3. Product Data

No	Model	Job Code
1	*Side Arm B1*	J1
2	*Side Board B1*	J2
3	*Pedal Rail B1*	J3
4	*Side Arm B3*	J4
5	*Side Board B3*	J5
6	*Leg B3*	J6
7	*Side Base B3*	J7
8	*Pedal Rail B3*	J8

4.4. Cycle Time

The following table 4 describes the product cycle time based on the process sequence obtained from the calculation of the standard time for the cabinet side section.

Table 4. Data Cycle Time

	Cycle Time (Minutes)									
Job	**Op1**	**Op2**	**Op3**	**Op4**	**Op5**	**Op6**	**Op7**	**Op8**	**Op9**	**Op10**
Job 1	2,18	0,39	0,24	1,03	0,3	0,23	2,17	0,37	0,33	0,21
Job 2	1,27	0,42	0,06	0,62	0,56	0,49	0,46	0,85	-	-
Job 3	0,3	-	-	-	-	-	-	-	-	-
Job 4	1,09	0,39	0,24	1,33	0,3	0,23	2,17	0,37	0,33	0,21
Job 5	0,95	0,06	0,71	1,79	0,85	-	-	-	-	-
Job 6	1,93	0,23	0,13	1,26	0,41	0,33	0,3	-	-	-
Job 7	0,71	0,33	0,21	0,23	0,32	-	-	-	-	-
Job 8	0,3	-	-	-	-	-	-	-	-	-

4.5. Data Allowance

Figure 1 below describes the data allowance obtained from work sampling on the cabinet side.

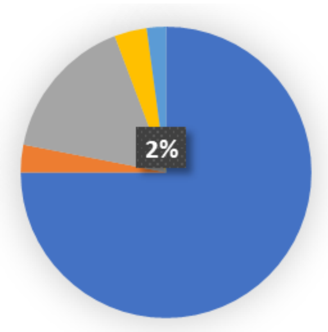

Figure 1. Allowance in *Work Sampling*

4.6. Determination of Rating Factor

Table 5 below is a recap table of rating factors based on the Westinghouse rating factor method.

Table 5. Rating Factor

	Westinghouse Rating									
Job	**Op1**	**Op2**	**Op3**	**Op4**	**Op5**	**Op6**	**Op7**	**Op8**	**Op9**	**Op10**
Job 1	1,12	1,22	1,05	1,05	1,22	1,05	1,10	1,22	1,13	1,10
Job 2	1,10	1,22	1,05	1,10	1,08	1,10	1,22	1,13	-	-
Job 3	1,13	-	-	-	-	-	-	-	-	-
Job 4	1,13	1,22	1,05	1,13	1,22	1,05	1,13	1,22	1,13	1,10
Job 5	1,22	1,05	1,09	1,08	1,13	-	-	-	-	-
Job 6	1,13	1,22	1,05	1,13	1,22	1,13	1,05	-	-	-
Job 7	1,22	1,13	1,10	1,10	1,05	-	-	-	-	-
Job 8	1,13	-	-	-	-	-	-	-	-	-

4.7. Normal Time

Table 6 below is the normal time data for all jobs.

Table 6. Normal Time

Normal Time (Minutes)										
Job	**Op1**	**Op2**	**Op3**	**Op4**	**Op5**	**Op6**	**Op7**	**Op8**	**Op9**	**Op10**
Job 1	2,45	0,48	0,25	1,08	0,37	0,24	2,38	0,45	0,37	0,23
Job 2	1,40	0,52	0,06	0,69	0,60	0,54	0,56	0,96	-	-
Job 3	0,34	-	-	-	-	-	-	-	-	-
Job 4	1,23	0,48	0,25	1,51	0,37	0,24	2,45	0,45	0,37	0,23
Job 5	1,15	0,06	0,78	1,94	0,96	-	-	-	-	-
Job 6	2,18	0,28	0,14	1,43	0,51	0,37	0,31	-	-	-
Job 7	0,87	0,37	0,23	0,26	0,34	-	-	-	-	-
Job 8	0,34	-	-	-	-	-	-	-	-	-

4.8. Standard Time

Table 7 below is the standard time data for all jobs.

Table 7. Standard Time

Standard Time (Minutes)										
Job	**Op1**	**Op2**	**Op3**	**Op4**	**Op5**	**Op6**	**Op7**	**Op8**	**Op9**	**Op10**
Job 1	2,40	0,47	0,25	1,06	0,36	0,24	2,34	0,45	0,36	0,23
Job 2	1,37	0,51	0,06	0,67	0,59	0,53	0,55	0,94	-	-
Job 3	0,33	-	-	-	-	-	-	-	-	-
Job 4	1,21	0,47	0,25	1,48	0,36	0,24	2,40	0,45	0,36	0,23
Job 5	1,13	0,06	0,76	1,90	0,94	-	-	-	-	-
Job 6	2,14	0,27	0,14	1,40	0,50	0,36	0,30	-	-	-
Job 7	0,85	0,36	0,23	0,25	0,33	-	-	-	-	-
Job 8	0,33	-	-	-	-	-	-	-	-	-

4.9. Job Completion Time

Table 8 below is the job completion time obtained by multiplying the standard time with the production plan.

Table 8. Job Completion Time

Job Completion Time (Minutes)										
Job	**Op1**	**Op2**	**Op3**	**Op4**	**Op5**	**Op6**	**Op7**	**Op8**	**Op9**	**Op10**
Job 1	80,09	15,75	8,19	35,31	12,11	7,90	78,06	14,89	12,14	7,65
Job 2	45,89	16,88	2,06	22,45	19,74	17,80	18,26	31,38	-	-
Job 3	11,10	-	-	-	-	-	-	-	-	-
Job 4	39,27	15,30	7,96	47,96	11,77	7,68	77,93	14,47	11,80	7,43
Job 5	36,67	2,00	24,75	61,65	30,50	-	-	-	-	-
Job 6	69,44	8,92	4,41	45,35	16,09	11,83	9,86	-	-	-
Job 7	27,62	11,80	7,43	8,14	10,69	-	-	-	-	-
Job 8	10,78	-	-	-	-	-	-	-	-	-

4.10. Actual Completion Process at the Company

The results of the calculation of the company's actual process completion are described in table 9 below. These results are obtained by prioritizing the cabinet with the most production plans.

Table 9. Actual Completion Process at the Company

Job	No	Process Time	Start Time	Finish Time	Mesin
J1	1	80,09	0	80,09	M1 (3)
	2	15,75	80,09	95,84	M2
	3	8,19	95,84	104,03	M4
	4	35,31	119,35	154,67	M1 (4)
	5	12,11	154,67	166,78	M2
	6	7,90	166,78	174,68	M4
	7	78,06	174,68	252,74	M1 (4)
	8	14,89	252,74	267,63	M2
	9	12,14	268,08	280,22	M8
	10	7,65	280,22	287,87	M6
J2	1	45,89	0,00	45,89	M3
	2	16,88	95,84	112,71	M4
	3	2,06	112,71	114,78	M1 (1)
	4	22,45	114,78	137,23	M3
	5	19,74	166,78	186,52	M8
	6	17,80	186,52	204,32	M1 (8)
	7	18,26	218,44	236,70	M2
	8	31,38	236,70	268,08	M4
J3	1	11,10	0	11,10	M1 (8)
J4	1	39,27	80,09	119,35	M2
	2	15,30	119,35	134,66	M8
	3	7,96	134,66	142,62	M9
	4	47,96	142,62	190,58	M2
	5	11,77	190,58	202,35	M8
	6	7,68	202,35	210,03	M6
	7	77,93	210,03	287,96	M7
	8	14,47	287,96	302,43	M9
	9	11,80	302,43	314,23	M8

	10	7,43	314,23	321,66	M1 (3)
J5	1	36,67	0,00	36,67	M2
	2	2,00	36,67	38,68	M4
	3	24,75	38,68	63,43	M1 (3)
	4	61,65	63,43	125,08	M2
	5	30,50	125,08	155,57	M4
J6	1	69,44	0,00	69,44	M1 (5)
	2	8,92	134,66	143,58	M2
	3	4,41	143,58	147,99	M8
	4	45,35	147,99	193,33	M6
	5	16,09	202,35	218,44	M1 (6)
	6	11,83	218,44	230,26	M2
	7	9,86	230,26	240,12	M4
J7	1	27,62	0,00	27,62	M1 (6)
	2	11,80	27,62	39,42	M2
	3	7,43	39,42	46,86	M1 (6)
	4	8,14	46,86	54,99	M2
	5	10,69	54,99	65,68	M8
J8	1	10,78	11,10	21,88	M8

4.11.Non-Delay Algorithm Scheduling

Table 10 below is the result of scheduling calculations using the non-delay algorithm method.

Table 10. Non-Delay Algorithm Scheduling

Stage	*St*	*Cj*	*Tij*	*Rj*	*C**	*m**	*Pst**
0	**111 (3)**	0	80,09	80,09	0	1(3)	**111**
	211 (6)	0	45,89	45,89	0	1(6)	**211**
	318	0	11,10	11,10			
	411 (3)	0	39,27	39,27	0	1(8)	**411**
	513	0	36,67	36,67	0	3	**513**
	611 (8)	0	69,44	69,44	0	1	**611(8)**
	712	0	27,62	27,62	0	2	**712**
	818	0	10,78	10,78	0	8	**818**
1	122	80,09	15,75	95,84			

	222	45,89	16,88	62,77			
	318	10,78	11,10	21,88	10,78	8	**318**
	422	39,27	15,30	54,57	39,27	2	**422**
	524	36,67	2,00	38,68	36,67	4	**524**
	622	69,44	8,92	78,36			
	728	27,62	11,80	39,42			
2	122	80,09	15,75	95,84			
	222	45,89	16,88	62,77	45,89	2	**222**
	434	54,57	7,96	62,53	54,57	4	**434**
	531(1)	38,68	24,75	63,43	38,68	1(1)	**531(1)**
	622	69,44	8,92	78,36			
	728	27,62	11,80	39,42	27,62	8	**728**
3	122	80,09	15,75	95,84			
	234	62,77	2,06	64,83	62,77	4	**234**
	441(4)	62,53	47,96	110,49	62,53	1(4)	**441(4)**
	543	63,43	61,65	125,08	63,43	3	**543**
	622	69,44	8,92	78,36	69,44	2	**622**
	736	39,42	7,43	46,86	39,42	6	**736**
4	**122**	80,09	16,88	96,97	80,09	2	**122**
	241(6)	64,83	22,45	87,28	64,83	1(6)	**241(6)**
	452	110,49	11,77	122,26			
	558	125,08	30,50	155,57	125,08	8	**558**
	634	78,36	4,41	82,77	78,36	4	**634**
	747	46,86	8,14	54,99	46,86	7	**747**
5	**134**	96,97	8,19	105,16	96,97	4	**134**
	252	96,97	19,74	116,71	96,97	2	**252**
	452	110,49	11,77	122,26			
	641(8)	82,77	45,35	128,11	82,77	1(8)	**641(8)**
	759	54,99	10,69	65,68	54,99	9	**759**
6	**141(3)**	105,16	35,31	140,47	105,16	1(3)	**141(3)**
	261(6)	116,71	17,80	134,51	116,71	1(6)	**261(6)**
	452	116,71	11,77	128,48	116,71	2	**452**
	652	128,11	16,09	144,20			
7	152	140,47	12,11	152,58			

	272	134,51	18,26	152,76			
	464	128,48	7,68	136,16	128,48	4	**464**
	652	128,48	16,09	144,57	128,48	2	**652**
8	**152**	144,57	12,11	156,68	144,57	2	**152**
	272	144,57	18,26	162,82			
	471(4)	136,16	77,93	214,09	136,16	1(4)	**471(4)**
	668	144,57	11,83	156,39	144,57	8	**668**
9	**164**	156,68	7,90	164,58	156,68	4	**164**
	272	156,68	18,26	174,93	156,68	2	**272**
	482	214,09	14,47	228,56			
	679	156,39	9,86	166,25	156,39	9	**679**
10	**171(5)**	164,58	78,06	242,64	164,58	1(5)	**171(5)**
	288	174,93	31,38	206,32	174,93	8	**288**
	482	214,09	14,47	228,56	214,09	2	**482**
11	**182**	242,64	14,89	257,52	242,64	2	**182**
	498	228,56	11,80	240,36	228,56	8	**498**
12	**198**	257,52	12,14	269,67	257,52	8	**198**
	4106	240,36	7,43	247,79	240,36	10	**4106**
13	**1106**	269,67	7,65	277,31	269,67	10	**1106**

4.12.Calculation of Efficiency Index

The efficiency index parameter is used to compare the company's scheduling method with the non-delay algorithm method.

$$\text{EI} = \frac{321,66}{277,31}$$

$$= 1.16$$

The efficiency index obtained from the comparison of the initial method with the proposed method is 1.16.

4.13.Analysis of Actual Company Production Completion

Cabinet Side PT. Xyz produces various kinds of cabinets. In the production process, each cabinet has a different process flow and machine usage. Based on the various products processed and their flow, the nature of the production flow includes job shop flow. With a varied process flow, the company completes the process or schedule with no work priority. The condition that occurs on the production floor is that the goods that arrive first will be processed earlier. Scheduling this completion is fairly conventional because there are no rules that lead to a schedule with a fixed priority of work. In other conditions, if the accumulation of production shortages on the previous day and daily targets produce large values, the cabinet with the largest production shortage will take precedence in the work process. But it comes back to the availability of goods. If it is not available, the production process will be carried out on the existing goods and come first. This production process is known as the FCFS (first come, first serve) process. Under certain conditions, if there is a demand for emergency goods, the work of the goods will be processed and put aside in the ongoing production process. Then resume the work that is aside when the item is finished.

Goods that are worked on in the Cabinet Side work section come from the cutting sizer and UP machines. The arrival of goods from the two suppliers is uncertain so in this study the supply of goods is considered smooth and normal. With a normal supply of goods, production work can be processed coherently from job 1 to job 8. The schedule that runs on the company to complete cabinet models B1 and B3 take 321.66 minutes. The time was recorded with an optimized process with 19 machines owned by the Cabinet Side. The work order starts from processing job 1 to job 8 by considering the readiness of the machine. 19 machines owned are maximized for a total of 8 jobs. So the order in which the work is done is the job sequence and its processes. Other machines that are not being used to process a job are filled with other job processes that can take advantage of these machines. In the process, there is some delay time between machines in waiting for the machine to be ready for the next process. Optimization of the machine with a job sequence of 1 to 8 resulted in a job completion time with a different completion order and ended on job 4 with a time of 321, 66 minutes. These details can be seen in the following table 11.

Table 11. Table 12. Details of MakespanActual Company Production Completion

Sequence	Cabinet	Job	Makespan (Minutes)
1	Pedal Rail B1	3	11,10
2	Pedal Rail B3	8	21,88
3	Side Base B3	7	65,68
4	Side Board B3	5	155,57
5	Leg B3	6	240,12
6	Side Board B1	2	268,08
7	Side Arm B1	1	287,87
8	Side Arm B3	4	321,66

From these details, the actual job completion order for cabinets B1 and B3 is obtained, namely J3-J8-J7-J5-J6-J2-J1-J4.

4.14.Non-Delay Algorithm Scheduling Analysis

This study uses a machine job shop scheduling with a non-delay algorithm for multiple machines. Because there is more than one machine on the Cabinet Side and many processes use the same machine even though they have different cabinets. There are more than one machine owned by the Cabinet Side, namely 8 rotary press machines, 2 edge former machines, 2 orbitals, and 2 table saws. The division of machine use is based on information obtained from the Cabinet Side section with consideration of the type of cabinet. The grouping of several machines is done based on the type of cabinet, for example,a sidearm with different models can be processed on the same machine. So that the distribution is easier and more orderly for each cabinet requirement on the machine. Multiple machine sharing for defined cabinets helps process optimization. The scheduling using a non-delay algorithm provides a fairly optimal solution with the result that the total time to complete all job cabinet models B1 and B3 is 277.31 minutes or 4 hours 37 minutes. Where the last completed job is job 1 on machine 6, namely the Side Arm B1 cabinet. Details of the makespan scheduling using the non-delay algorithm are described in table 12 below.

Table 12. Details of Makespan Scheduling Algorithm non delay

Sequence	Job	Model	*Makespan* (Minutes)
1	J8	Pedal Rail B3	10,78
2	J3	Pedal Rail B1	21,88
3	J5	Side board B3	155,57
4	J7	Side Base B3	65,68
5	J6	Leg B3	166,25
6	J2	Side Board B1	206,32
7	J4	Side arm B3	247,79
8	J1	Side Arm B1	277,31

Based on table 12, it is known that the final completion time of the non-delay scheduling algorithm for 277.31 minutes is obtained based on the sequence of processing processes J8-J3-J5-J7-J6-J2-J4-J1.

4.15.Comparison of Company's Actual Production Completion With Proposed Scheduling Using Non-Delay Algorithm

The best scheduling is obtained when it produces a small total final completion time. Comparison of company scheduling and scheduling using non-delay algorithms is carried out to determine the best scheduling results between the two schedules. The smaller the time produced, the less time it will take to work on the cabinet other than those scheduled in this study. This means that the faster the final completion time, the more products will be produced so that the target will be easily achieved and the company's profits will increase. In table 13 the following is the result of a comparison between company scheduling or initial scheduling with scheduling using a non-delay algorithm or proposed scheduling.

Table 13. Comparison of Results of Initial Scheduling and Proposed Scheduling

Criteria	Company's Actual Production Completion	Proposed Scheduling Using Non-Delay Algorithm
Sequence	J3-J8-J7-J5-J6-J2-J1-J4	J8-J3-J5-J7-J6-J2-J4-J1
Makespan	321,66 minutes	277,31 minutes

Viewed from table 13, it can be seen that the initial scheduling has a makespan of 321.66 minutes and the proposed scheduling has a makespan of 277.31 minutes. This means that the proposed scheduling can reduce makespan by 44.35 minutes. So that the proposed scheduling can further optimize work on the Cabinet Side. The proposed scheduling results in better makespan results with the same number of machines and operators. The order of job priority that distinguishes these results is the order of completion of J8-J3-J5-J7-J6-J2-J4-J1. Thus the scheduling of the proposal is good to be applied to the company.

Another comparison is made using the efficiency index parameter. The result is that the proposed scheduling has a better performance than the company's actual completion. It can be seen from the efficiency index value greater than 1 (E > 1). The EI value obtained from the proposed scheduling is 1.16. Therefore, the proposed scheduling is also good to be applied in the light of the resulting efficiency index.

V. Conclusion

Based on the analysis of the results of the discussion that has been described, conclusions can be drawn to answer the objectives of the research, as follows:

1. The non-delay algorithm method is applied to the proposed scheduling design resulting in a scheduling proposal that is better than the actual completion of the process applied by the company. The order of job completion applied by the company is J3-J8-J7-J5-J6-J2-J1-J4 with a makespan value of 321.66 minutes. Scheduling the proposed non-delay algorithm method produces a makespan value of 277.31 minutes with the job completion sequence J8-J3-J5-J7-J6-J2-J4-J1. So that the proposed scheduling can reduce the makespan by 13.78% or 44.35 minutes.
2. Proof of the proposed scheduling using the non-delay algorithm method results that the proposed method has a better performance value than the company's actual settlement. This can be seen from the efficiency index value that is greater than 1 (E > 1), which is 1.16.

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