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MACHINE SCHEDULING PROPOSED FOR MINIMIZING MAKESPAN AT PT ADIPERKASA ANUGRAH PRATAMA

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ABSTRACT

PT Adiperkasa Anugrah Pratama is a manufacture company that processes raw materials such as brasses and metals to become finish goods. The company has been operating for 3 years from 2009 and it's been growing quite fast, which can be found with the growing number of incoming orders. A big total number of incoming orders cause the company to use semi-manual scheduling production processes that is less effective in scheduling production processes. PT AAP hasn't applied a suitable and correct method in scheduling production, because the PPC division is planning the scheduling production by longest time needed for completing production processes or the largest number of time in incoming orders. So the effective method for scheduling production must be made and applied. The methods that been used are Campbell, Dudek and Smith ; Nawaz, Enscore and Ham, and the Gupta Heuristic method. These three methods are used for minimalizing makespan by choosing the best sequence of production processes. After comparing with the original makespan of the company, which is 1.245.000 seconds, CDS method produces makespan of 1.238.234 seconds, NEH method which produces makespan of 1.217.366 seconds, and Gupta Heuristic method which produces makespan of 1.245.200 seconds. The conclusion is that the NEH method produces smallest makespan and the original makespan of the company can be reduced by 27.834 seconds.

Keywords : *makespan, CDS, NE,Gupta Heuristic*

1. INTRODUCTION

PT. Adiperkasa Anugrah Pratama is located in Tangerang was founded in 2009, the company's managing raw materials such as brass and metal to be processed into various products, such as cashing cover, burner, body valve, drain case, and spare parts for Honda. From this wide range of products that are made, the main product which has so much demand is always been made by factory is cashing cover.

To produce products effectively and efficiently, then the company needs to establish appropriate scheduling method, but the company already did production scheduling based only on the longest processing time or the high demand for most products. This high risk condition of the company because of the lack certainty of scheduling methods. Based on these considerations, the research conducted to establish how proper scheduling method for companies to product completion time can be reduced by using the method of Campbell, Dudek, and Smith, Nawaz method, Enscore, and Ham, and Gupta Heuristic methods

The limitation of the study for the production scheduling for cashing cover consist of: cashing cover 1 (job 1), cashing cover 2 (job 2), cashing cover 3 (job 3), cashing cover 4 (job 4). Demand data is captured and processed requests in September 2012, the cycle time is taken directly on the production floor with stopwatch, the state of the machine and the operator works under normal circumstances, the transfer time of goods is excluded because the items are available to be processed before process takes place, the level of accuracy that is used by 5%, and the confidence level used is 95%.

By knowing the background of the problem and the extent of the problem, it is expected that this study can reduce the production time of cashing cover to determine the most optimum job sequence

using three proposed methods, because the main focus of this study was to compare the initial makespan with three makespan using CDS, NEH method, and the method Heuristic Gupta.

2. LITERATURE STUDY

There are some scheduling definitions, one of which defines a scheduling adjustment activity with limited resources to maximize customer satisfaction, utilization of production, and minimize operating costs. Decisions made in the scheduling of jobs includes sequencing (sequencing), start time and end time job (release and timing), and the sequence of operations of a job (routing). Scheduling problem is always related to the production sequencing (sequencing) so scheduling is defined as the determination of the sequences of the arrival of a variety of work to be completed within a specified period. (Morthon 1993) Meanwhile, according to Baker, scheduling is defined as a process of resource allocation / existing machinery to carry out the tasks that exist within a certain time (Baker 1974).

Some of the objectives to be obtained with the implementation of scheduling is (Baker 1974).:

1. Increase Productivity of machine, namely by reducing idle time o machine.
2. Reduce the work in process product with reducing average number of waiting time which queue of busy machine.
3. Reduce delays due to have exceeded the time limit by:
   a. Reducing the maximum delay.
   b. Reducing the number of late jobs

Some of Terminology used in the scheduling problems (Daihani, 2001) :

1. Processing time = $\mathbf{t_j}$ is time span needed to finish an operation at job **j**.
2. Ready Time ($\mathbf{r_j}$) is a start time of job **j** to be done.
3. Due Date ($\mathbf{d_j}$) is a finish time of a job to be done. If overdue, the job can be stated as a tardy job.
4. Completion time = $\mathbf{C_j}$) time needed until job **j has** finished.
5. Flow time = $\mathbf{F_j}$) time need from job **j** in the production floor.
6. Lateness ($\mathbf{L_j}$) deviation finished job time from the job due date job. Lateness calculated wih equation $L_j = C_j - d_j$.
7. $L_j < 0$, finished the job in time (earliness).
8. $L_j > 0$, finished the job over due (tardiness).
9. Slack ($\mathbf{SL_j}$) available time for a job. The value of slack can be calculated in equation $SL_j = d_j - t_j$.
10. Tardiness ($\mathbf{T_j}$) is overdue time for a job compare to the job due date.
11. Makespan (**Ms**) span of a whole processing time to be finished in the production floor.

Campbell, Dudek, and Smith method is a scheduling method for series machines with Johnson rules. Procedure of CDS's method as follows (Daihani, 2001):

1. Determine the some alternative steps as much as n machines -1
2. In each alternative step, then calculated the processing time for t_1 dan t_2.
3. In all scheduling jobs, determine the smallest processing time from each jobs.
4. With Johnson's rules, place the sort of jobs in the left side for the smalles processing time machine 1 (t_1), and if the smallest processing time for machine 2 (t_2), place it in the right side.
5. Made a series sort jobs in each available alternative
6. Then calculated makespan in every available alternatives.
7. Choose the alternative with the smallest makespan dan flowtime.

Nawaz, Enscore, and Ham Method is being used to calculate every processing time for every job job and to reduce production time. Procedures for NEH are as follows (Herjanto, 1991) :

1. Calculated processing time for every job.
2. Do sort jobs based on Longest Processing Time rule.
3. Then try 2 job sort from LPT rule (J1, J2) and (J2, J1). Calculate makespan from this 2 job sort and choose the smallest makespan between those two job sort, for example (J2, J1)
4. Continue the calculation based next job, for example J3, so the new sort job could be such as (J2, J1, J3), (J2, J3, J1), (J3, J2, J1), then calculate makes pan from

the new value of three job sort, choose the smallest makespan.

5. Do all the possible calculations and choose the smallest makespan.

Heuristik Gupta Method was found by Gupta 1972. The procedure of Gupta Method are as follows:

1. Calculate the processing time for every job in every work station.
2. Totalize the processing time every job between 2 sort machine.
   For example $(P_{1j} + P_{2j})$, $(P_{2j} + P_{3j})$,…until $(P_{(m-1)i}, P_{mi})$
   When, P_{ij} = job j time at i machine.
   m = total work station
3. Choose the smallest value from all the calculations.
4. Determine the value of e_{ei} :
   If P_{i1} , P_{im}, then $e_i = 1$
   If $P_{i1} \geq P_{im}$, then $e_i = -1$
5. Calculate the value of S_i from every job with devide the value of e_i at the above procedure no 4 with minimal value has been chosen at the procedure no 3
6. Do sort S_i value from every job. Job with the biggest S_i value get the first job sort, and continue until the latest job with smallest S_i value.
7. From all sort job calculation, then calculate the makespan value for every new sort.
8. Choose the smallest makespan.

3. RESEARCH METHODOLOGY

The methodology for this research is as figure 1.

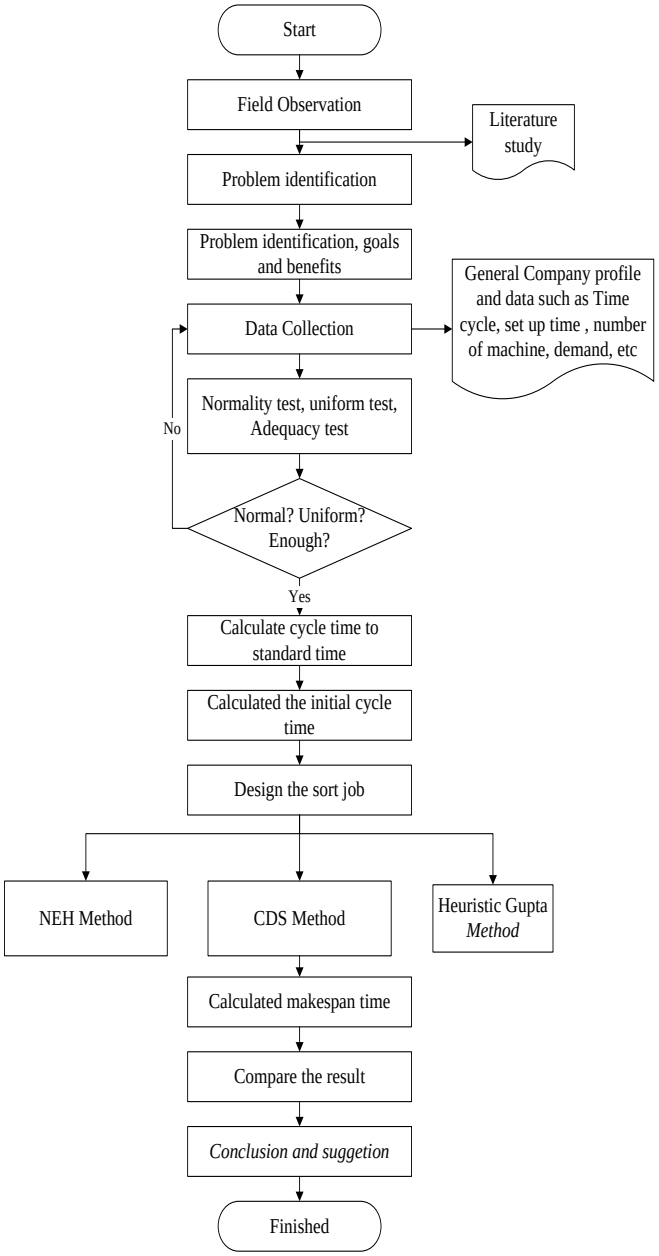

Figure 1 : Research Methodology

4. DATA CALCULATION AND DATA ANALYSIS

The calculation data starts with normality test, uniformity test and adequacy test for cycle time data. Normality test has been done with SPSS 20 software with Kolmogorov Smirnov technique, uniformity test done with manual calculation with Upper control limit (UCL), and lower control limit (LCL), and adequacy test with N' equation (if N' < N, then all the data needed are enough) (Askin, 2003).

After all the data tests, then calculate the cycle time to normal time with

Westinghouse adjustment, then calculate the normal time to standard time with 8 allowances. After having the standard time, then calculate the processing time for every job by multiply the demand with standard time. All the standard time and processing time can be seen at Table 1 (in second).

Table 1 Standard processing time for every job

Department	Standard time (second)				Processing time (second)			
	Job 1	Job 2	Job 3	Job 4	Job 1	Job 2	Job 3	Job 4
Cutting (P1)	8,57	7,50	8,57	8,57	77430	45300	20868	5442
Forging (P2)	12,68	12,89	11,91	14,50	114978	78222	29493	9603
Triming (P3)	5,35	5,70	7,94	7,94	48154	34176	19046	4762
Restric (P4)	5,81	5,38	5,39	6,87	52301	32256	12933	4124
Shotblash (P5)	4,00	4,00	4,00	4,00	36000	24000	9600	2400
Machining OP 1 (P6)	7,81	7,47	9,91	10,97	70295	44806	23774	6584
Machining OP 2 (P7)	70,74	70,59	66,08	79,87	636651	423520	158587	47922
Boring (P8)	11,12	11,53	11,91	12,91	100120	69182	28592	7746
Champer (P9)	7,48	7,41	8,14	8,77	67338	44474	19544	5262
Painting (P10)	16200	16200	16200	16200	14101	9400	3760	940
Demand (pcs)	9000	60000	2400	600				

Table 2. Initial makespan Calculation

Job	P1 (2 Machine)		P2 (2 Machine)		P3 (2 Machine)		P4 (2 Machine)		P5 (2 Machine)	
	Start	Finish	Start	Finish	Start	Finsih	Start	Finish	Start	Finished
1	0 (M1)	77430	105264 (M2)	220242	220242 (M1)	268395	268395 (M2)	320696	320696 (M2)	356696
2	0 (M2)	45300	45300 (M1)	123522	123522 (M2)	157698	157698 (M1)	189954	189954 (M1)	213954
3	45300 (M2)	66168	66168 (M2)	95661	95661 (M1)	114708	114708 (M2)	127641	127641 (M2)	137241
4	66168 (M2)	71610	95661 (M2)	105264	105264 (M2)	110026	110026 (M1)	114150	114150 (M1)	116550

Continue…. Table 2

P6 (2 Machine)		P7 (2 Machine)		P8 (2 Machine)		P9 (2 Machine)		P10 (1 Machine)	
Start	Finish	Start	Finish	Start	Finish	Start	Finish	Start	Finish
356696 (M2)	426990	426990 (M2)	1063641	1063641 (M2)	1163761	1163761 (M2)	1231099	1231099 (M1)	1245200
213954 (M1)	258760	258760 (M1)	682279	682279 (M1)	751462	751462 (M1)	795936	795936 (M1)	805336
137241 (M2)	161015	161015 (M2)	319603	319603 (M2)	348194	348194 (M2)	367738	367738 (M1)	371498
116550 (M1)	123133	123133 (M1)	171056	171056 (M1)	176317	176317 (M1)	181579	181579 (M1)	182519
								Makespan	1245200
								FlowTime	2604554

Time at painting department for processing 10.340 pieces is 16.200 second, so the processing time for each pieces for job 1 = (9000/10.340) X 16.200 second = 14.101 second, and so on with the others.

After having processing time, calculate the makespan value for company based on sort job, is job 1,2,3,4. Makespan value = 1.245.200 second, flowtime = 2.604.554 second, mean flowtime (2.604.554/4) =

651.138,5 second. All the makespan value can be seen at Table 2.

Makespan calculation at table 2 is based on available machine. Job sort at the company is 1,2,3,4. Then all of the calculations are as follows:

1. For P1 available 2 machines, job 1 enter machine 1 (M1) at P1 process at 0, then job 2 enter to M2 at P2 process at 0.
2. At job done totalize the starting time with processing time, until the job 1 done = 77.430 second, and job 2 = 45.300 second
3. Select both time, which one is smallest and finished earlier at P1 process.
4. Job 2 has a smallest time than job 1, until M2 enter job 3 at 45.300 second, job 3 done = 66168 second.
5. If job 1 done at M1 is smallest from job 3 at M2, then job 5 can be process at M1, unfortunately the time done M1 > M2, so job 4 enter M2 at 66.168 second, or after job 3 finished at M2 processing.
6. Repeat step 1 until 5 for each job and each machine.

Determine the sort job with the smallest CDS method based on literacy procedure. After all of the procedures the alternative job sort Y= m-1, Y=10-1, Y = 9. The calculation result of makespan = 1.238.234 second with the job schedule 4,3,2,1. The makespan summary with CDS method can be seen at Table 3.

Next, we calculate makespan with NEH method based on literature procedure. With 3 iteration, at 1st iteration calculate the makespan for job 1,2, and job 2,1, the result is the same makespan, then the selection come out randomly with job 1,2. The 2nd iteration for job 1,2,3, job 1,3,2, dan job 3,1,2, then smallest makespan is job 1,3,2. The 3rd iteration for job 1,3,2,4, job 1,3,4,2, job 1,4,3,2, job 4,1,3,2. Then the best result are job 1,4,3,2 or job 4,1,3,2 with smallest makespan = 1.217.366 second and flow time = 618.859,25 second. Makespan summary with NEW Method can be seen at Table 4.

Table 4. Makespan Summary with NEH Method

Job sort	1,3,2,4	1,3,4,2	1,4,3,2	4,1,3,2
Makespan (second)	1.221.148	1.217.366	1.217.366	1.217.366
Mean Flowtime	633.626	622.715,75	618.859,25	618.859,25

Then we sort the job with Gupta Method and show a new makespan. With all the Gupta Method's Procedure, we can calculate total 2 processing time sorted job, based on value of ei and Si. Processing time with Heuristic Gupta Method can be seen at table 5.

After calculating all the above components, then all jobs can be sorted from the biggest Si value to the smallest Si value. The result of Job sorted is 1,2,3,4 job. The new sorted is the same with initial company's makespan = 1.245.200 second.

Table 3. Makespan Summary with CDS Method

Y	Y=1	Y=2	Y=3	Y=4	Y=5	Y=6	Y=7	Y=8	Y=9
Job sort	1,2,3,4	1,2,3,4	1,2,3,4	4,3,2,1	4,3,2,1	4,3,2,1	1,2,3,4	1,2,3,4	1,2,3,4
Makespan	1.245.200	1.245.200	1.245.200	1.238.234	1.238.234	1.238.234	1.245.200	1.245.200	1.245.200
Flowtime	2.604.554	2.604.554	2.604.554	2.469.995	2.469.995	2.469.995	2.604.554	2.604.554	2.604.554

Table 5. Summary of Processing time with Heuristik Gupta Method

Job	P1+P2	P2+P3	P3+P4	P4+P5	P5+P6	P6+P7
1	192408	163131	100454	88301	106295	706946
2	123522	112398	66432	56256	68806	468325
3	50361	48540	31980	22533	33374	182362
4	15045	14364	8886	6524	8984	54506

P7+P8	P8+P9	P9+P10	min	ei	Si
736771	167458	81439	81439	-1	-1,22792E-05
492702	113657	53875	53875	-1	-1,85616E-05
187179	48135	23304	22533	-1	-4,43791E-05
55669	13008	6202	6202	-1	-0,000161244

Table 6. Summary of Three Methods Comparison

Scheduling Method	Job Sort	Makespan (second)	Mean Flowtime (second)
CDS	4,3,2,1	1.238.234	617.498,75
NEH	**1,4,3,2 or 4,1,3,2**	**1.217.366**	**618.859,25**
Gupta	1,2,3,4	1.245.200	651.138,50

In Table 6 shows the best method for machine scheduling is NEH Method that gives the best makespan time. The comparison from NEH Method and Company's initial makespan can be found at Table 7.

Table 7. Makespan and Flowtime comparison from Company Real time and NEH Method

Scheduling Method	Job Sort	Makespan (second)	Mean Flowtime (second)
Company's real data	1,2,3,4	1.245.200	651.138,50
NEH Method	1,4,3,2 or 4,1,3,2	**1.217.366**	**618.859,25**

NEH method gives the best result reducing makespan at 2.24% and reducing mean flowtime at 5%.

5. CONCLUSION

All the calculation prove that initial makespan from PT AAP = 1.245.200 second, intial mean flowtime = 651.138,50 second and the the best method from CDS, NEH and Gupta is NEH method. NEH method shows new makespan = 1.217.366 second, reducing makespan = 27.834 second or 2,24%, new mean flowtime 618.859, 25 second, reducing mean flowtime = 32. 278 second or 5 %.

6. LITERATURE

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