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MAKESPAN MINIMIZATION IN BATIK MURNI SMEs WITH PALMER, CAMPBELL DUKDEK SMITH, AND HEURISTIC POUR ALGORITHM

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ABSTRACT

Batik Murni is one of the Small and Medium Enterprises (SMEs) in Madiun that produces batik tulis and batik cap. This SMEs still uses intuition to make the production schedule. This condition can give disadvantages for the SMEs, overstock and stockout will be happened. In this study, the researchers want to offer a solution for the scheduling problems so Batik Murni can increase their productivity performance. Researchers offer three production scheduling methods aim to minimize the makespan of Batik Tulis. Makespan is used as a parameter in this study because when it can be minimized so the each time (processing time, setup time, flow time, ect) in the workstation can be minimized too. In this case, the best method that have the minimum makespan has the important role to know when the job can be started and ended. The three methods used are Palmer, Champbell Dukdek Smith (CDS), and Heuristic Pour Algorithm. From this research, it can be concluded that the best production scheduling optimization at Batik Murni SMEs is obtained from the Palmer method. With makespan of 4837 minutes or 11 days so the makespan can be minimized 54,2%. In the order of the production process is batik sejuta bunga – batik batik turi tabur - batik seger arum - batik pecel.

INTRODUCTION

Batik Murni is one of Small and Medium Enterprises (SMEs) in Madiun East Java that produces some *batik* patterns such as *Batik Tulis, Batik Cap*, and *Batik Printing*. This SMEs has the iconic pattern called *Corak Pecel* and has ordered overseas. Batik Murni generates turnover 70 million a month with the production rate is 70 pieces. Nowadays, Batik Murni still uses intuition to make the production schedule. Batik Murni produce the fabrics in two ways: Make

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to Stock and Make to Order. Pre ordered *batik* will be produced and served earlier (First in First Out) (Hidayat & Al Amin, 2019). The Batik Industry is one of the industries whose running fast and is one of the leading and high-value works of art (Purwaningsih, Susanto, & Yudha, 2016). In 2012, the export rate of Batik is USD 246 Million. There are four factors that can effect the batik design: fabric material, colouring, dyeing, and waxing (Luthfianto, 2014). The high value of Batik and supported by recognation from UNESCO that *batik* is the original heritage of Indonesia makes IKM Batik evolving fast. But, majority of the *batik* SMEs in Indonesia still use intuition to manage the produciton no exception for Batik Murni. In the Make to Stock production, Batik Murni still uses intuition to make the production scheduling. This intuition in production scheduling can cause stockout and overstock (Isnaini, 2018). Because of this condition, Batik Murni needs some methods to make the production scheduling better amid limitations in machinary, materials, and human resources.

The production scheduling is one of the big problems in production system related to how product scheduling can be made so that orders can be completed in accordance with the time and available resources (Sulaksmi, Kesy Garside, & Hadziqah, 2014). One of the aims of production shceduling is to decrease the job lateness that have the work time limitation so the budget can be minimized (Nadia, Retno, Dewi, & Sianto, 2010).The success of a good production scheduling can be measured from the makespan. Makespan is the total of complation time from the first workstation until the last workstation.

There are some methods that have been used in previous study to minimize makespan in optimizing production scheduling. Lesmana used Branch and Bound method to optimize the production scheduling and had 7,46% the makespan minimazion (Lesmana, 2017). Non Delay Algorithms can also be used to minimize the makespan as Setyo et al (2016) has done in CV Bima Mebel. Production Scheduling with this method can save processing time by 3 days. Campbell Dukdek Smith (CDS) methods many used in several research because of the good peformance in makespan optimizatoin and easy to use. CDS method is the development of Johnson Rule where every processed job must go through the same process and machine (Risa, Helmi, & Aritonang, 2015). Imannuel used CDS method to make the production shceduling in PT Iskandar Indah Printing Textile and got the makespan in 105,41 days (Immanuel, Iskandar, Printing, Surakarta, & Iskandartek, 2017). Other than that, Saputro used Dannenbring, Palmer, and CDS for minimize the job lateness and CDS methods gave the best result. In addition to some of the scheduling methods, there are scheduling methods namely Heuristic Pour Algorithm which is alse widely used in previous studies (Saputro & Mundari, 2017). Sulaksmi used Heuristic Pour Algorhithm as a alternative to do the scheduling in One Way Convection (Sulaksmi et al., 2014) . This method could give better makespan. Nova et al compared 3 methods to find the optimum makespan, the methods are CDS, Heuristic Pour, and Palmer. The optimum result are CDS and Heuristic Pour Algorithm (Nova, Ilhami, & Kulsum, 2017).

The difference of this study are in the used of methods and the object of the research. Different from the previous research that only used one or two method to minimize the makespan, this study will compare 3 methods of production scheduling there are Palmer, CDS, and Heuristic Pour Algorithm. This methods will be used because of the fitnees with Batik Murni Madiun in the way to use easily and has Flow Shop production system. There are some production scheduling classification for example Flow Shop, Job Shop, and Mixed Flow Shop. Each production scheduling classification has each criterion depend on the production flow. Flowshop production system has the same route in every product (Hasbullah, Kholil, AlBayhaki, & Riyadi, 2015). Production Scheduling in Batik Murni SMEs become important to optimize the resources and avoid the losses.It also challenging, when the research is in SMEs, because researcher has some data limitation and need some contraints. Makespan is used as a parameter in this study because when it can be minimized so the each time (processing time, setup time, flow time, ect) in the workstation can be minimized too. In this case, the best method that have the minimum makespan has the important role to know when the job can be started and ended (Ong, 2013).

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RESEARCH METHOD

For collecting production scheduling data at Batik Murni Madiun, the research method used is a quantitative method with interviews and observations. The research was conducted at the Batik Murni Madiun Gallery which addressed at Jl. Halmahera No.21, Oro-oro Ombo, Kec. Kartoharjo, Madiun City, East Java 63119. Batik Murni is the center of typical Madiun batik making centers. In Batik Murni Madiun there are three types of batik that are produced, namely Batik Tulis, Batik Cap, dan Batik Printing. The object of this research is Batik Tulis with several patterns: pecel, Seger Arum, Turi Tabur and Sejuta Bunga. This is because Batik Tulis requires a longer time in the production process when compared with Batik Printing and Batik Cap and with consideration of the four patterns are in great demand by consumers. Based on the data that has been obtained, the data is processed using the Palmer method, the CDS Method (Chambell Dudek Smith) and the Heuristic Method.

1. Palmer

D.S Palmer develops scheduling techniques based on slope indexes that are sorted descending. Palmer believes that the priorities for the strongest jobs tend to shorten the time spent sorting operations. Formulation used as shown in equation (1).

$$Sj = \sum_{k=1}^{M} \frac{2k-M-1}{2} tjk \quad (1)$$

M= Number of Machines
Sj= *Slope index* in job j
tijk= processing time job j in machine k

2. Campbell Dukdek Smith

The first sequence in CDS is $t_{i,1} = t^*_{i,1}$ dan $t^*_{1,2} = t_{i,m}$ as the processing time in the first and the last workstation. The second sequence has the formulation as shown in equation (2).

$$t^*_{i,1} = t_{i,1} + t_{i,2} \quad (2)$$
$$t^*_{i,2} = t_{i,m} + t_{i,m-1}$$

as the processing time in 2 machinary in the first and 2 machinary in the last for k-sequence as shown in equation 3.

$$t^*_{i,1} = \sum_{k=1}^{k} t_{i,k} \quad (3)$$

$$t^*_{i,2} = \sum_{k=1}^{k} t_{i,m-k+1}$$

3. Heuristic Pour Algorithm

Steps to find the best result of heuristic pour alghoritm are

a. Choose random jobs as first order
b. Place other jobs in to the next
c. Choose the minimum processing time in each machine
d. Sum the processing time in Pi besides minimum Pij before
e. Sum the completion time
f. Sort Ci by rules increasing job to put in the order after the job already selected for first place
g. After a temporary sequence is obtained, then calculate the Fmax.
h. Repeat the steps in point a up to g for each existing job until Fmax is obtained the most minimum, which will be placed as the first order of the order job
i. Repeat the steps in points a until h all jobs are at work order

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RESULTS AND DISCUSSION

This study has 4 research objects, there are *Batik Tulis Pecel*, *Seger Arum*, *Turi Tabur*, and *Sejuta Bunga*. This 4 objects have the same process and machinary sequencess (Pt, Kurnia, & Sejati, 2018). Or it can be said that the four jobs are a flowshop production system.

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Figure 1 shows the sequence of the jobs.

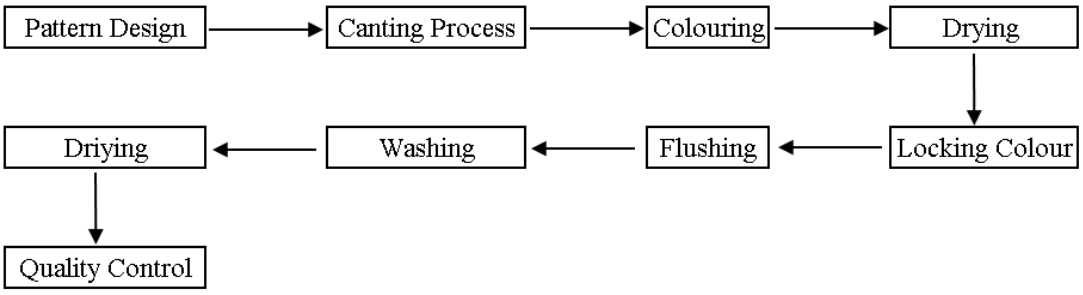

Figure 1. Job Process Sequence

Every job in every production process have to wait the previous job to be finished then can be continued to the next production process. Except in the drying process. Where batik that has been completed in the coloring before drying without waiting for other batik motifs finished in coloring. From the results of interviews and observations obtained the actual processing time as shown in Table 1.

Table 1. Actual Processing Time

***BATIK TULIS* (minutes)**									
Jobs	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**
Batik Pecel	240	10080	90	1080	5	7	5	180	5
Batik Turi Tabur	120	6720	60	1080	5	7	5	180	5
Batik Seger Arum	120	6720	60	1080	5	7	5	180	5
Batik Sejuta Bunga	60	3360	120	1080	5	7	5	180	5

Note :
M1 : Pattern Design
M2 : Canting process
M3 : Colouring
M4 : Driying
M5 : Locking Colour
M6 : Flushing
M7 : Washing
M8 : Driying
M9 : Quality control

Batik Murni has actual makespan in 24 days. The data above will be proceed with 3 methods there are Palmer, Campbell Dukdek Smith (CDS), and Heuristic Pour Algorithm.

1. Palmer

The method proposed by Palmer is a slope index scheduling technique. Slope index is used to sort jobs to produce a minimum total completion time. Slope index sorting procedure gives priority to jobs with maximum processing time first. Table 2 showed the results of calculating the slope value with processing time in each M.

In the order of the production process is batik sejuta bunga - turi tabur - batik seger arum - batik pecel. Table 3 shows the calculation of the makespan with Palmer method.

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Table 2. Slope Point Batik Tulis

Slope Point Batik Tulis										
	k = 1	k =2	k = 3	k = 4	k = 5	k = 6	k = 7	k = 8	k = 9	
	-4	-3	-2	-1	0	1	2	3	4	
	S * Ijt									Total
Batik Pecel	-960	-30240	-180	-1080	0	7	10	540	20	-31883
Batik Turi Tabur	-480	-20160	-120	-1080	0	7	10	540	20	-21263
Batik Seger Arum	-480	-20160	-120	-1080	0	7	10	540	20	-21263
Batik Sejuta Bunga	-240	-10080	-240	-1080	0	7	10	540	20	-11063

Job Sequences = *Batik sejuta bunga>Batik Turi Tabur > Batik Seger Arum > Batik Pecel*

Table 3. Makespan with Palmer Method

Job	M1	M2	M3	M4	M5	M6	M7	M8	M9
Sejuta bunga	60	3420	3540	4620	4625	4632	4637	4817	4822
Turi tabur	180	10140	3600	5700	4630	4639	4642	4997	4827
Seger arum	300	16860	3660	6780	4635	4646	4647	5177	4832
Pecel	540	26940	3750	7860	4640	4653	4652	5357	4837

The Makespan with Palmer Method is 4837 minutes or 11 days.

2. Campbell Dukdek Smith (CDS)

The method proposed by Campbell, Dudek and Smith in 1965 is the development of the Johnson Rule. Every job that is processed must go through the process of each machine. The Johnson Rule is used to search for job sequences involving two groups of machines as a process tool for incoming work. Jobs that are processed must go through two engine groups namely 1 M' machines and continue on 2 M machines until completion. The calculation results of the Champbell Dukdek Smith method obtained the following sequence of production processes: Batik sejuta bunga – batik seger arum – batik turi tabur – batik pecel. With eight iterations it gets the following makespan as shown in Table 4.

Table 4. Makespan with CDS Method

K	M1'	M2'
1	240	300
2	10.320	13.740
3	10.440	13.980
4	11.520	16.140
5	11.525	16.149
6	11.532	16.164
7	11.537	16.174
8	11.717	16.359

The Makespan with CDS Method is 16,359 minutes or 34 days.

3. Heuristic Pour Algorithm

The results of research by Soetanto and Palit shows that the Pour heuristic algorithm provides a fairly good performance in solving flowshop scheduling problems with the aim of minimizing makespan when compared to one of the Mixed Integer Programming (MIP) optimization methods (Soetanto, Palit, & Munika, 2004). With the heuristic pour

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method, four simulations are performed with the results of the makespan of each simulation as follows in Table 5.

Table 5. Makespan in Heristic Pour Algorithm Simulation

Simulation	Makespan
1st Simulation Sequences : *batik pecel – batik sejuta bunga – batik turi tabur – batik seger arum*	32583 minutes
2nd Simulation Sequences : *batik turi tabur - batik sejuta bunga - batik seger arum - batik pecel*	23875 minutes
3rd Simulation Sequences : *batik seger arum – batik sejuta bunga – batik turi tabur - batik pecel*	23878 minutes
4th Simulation Sequences : *batik sejuta bunga – batik pecel – batik turi tabur – batik seger arum*	32878 minutes

The smallest composition in the Heuristic Pour method is found in the second simulation in the order of the production process, namely *Batik Turi Tabur – Batik Sejuta Bunga – Batik Seger Arum – Batik Pecel*. The Makespan with Heuristic Pour Algorithm Method is 23875 minutes or 50 days.

Table 6. shows the makespan comparison between actual, palmer, CDS, and Heruistic Pour Alghoritm.

Table 6. Makespan Comparison

Makespan Comparison (days)			
Actual	**Palmer**	**CDS**	**Heuristic Pour**
24	11	34	50

CONCLUSIONS

From this research it can be concluded that the best production scheduling optimization at Batik Murni SMEs is obtained from the Palmer method. With makespan of 4837 minutes or 11 days so the makespan can be minimized 54,2%. In the order of the production process is batik sejuta bunga – batik batik turi tabur - batik seger arum - batik pecel.

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