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Model Hybrid Flowshop 2 Stage with Johnson's Rule Dispacthing to Minimize Makespan

Case Study: Fish Net Company in Bandung

[1]Asep Anwar, Didit Damur Rochman, Arief Rahmana.

Abstract---*Hybrid Flowshop (HFS) is a development scheduling model of flowshop scheduling problems. Currently PT. XX which is a manufacturing company that produces MT (Mono Twine) mesh products using the HFS production concept. The HFS process at PT XX is the Ringrope (Stage 1) and Netting (Stage 2) process. The Ringrope process consists of 2 machines arranged in parallel which then the results will be processed Netting. The settlement method in this research is the optimization method by making a mathematical model by sorting using the Johnson method. The results of the study showed the sequence of processes on stage 1 and on stage 2 with makespan was 1354.51 hours.*

Keywords---*Hybrid Flowshop, Optimization, scheduling, Makespan minimization*

I. INTRODUCTION

The problem of scheduling has grown rapidly nowadays. Starting with scheduling for single machines, parallel machines and others. According to Baker & Trietsch, (2009) scheduling are something that can explain or tell something that should happen or should be done, but also can indicate a plan of time for certain activities. Therefore it can be interpreted that scheduling is a process of determining the use of limited resources to do one or a lot of work by determining when the work will begin and when it is completed.

PT. XX is a company engaged in the production of fish nets. Various products for fishing purposes are produced in this company. One such product is the MT (Mono Twine) mesh which goes through several processes. At present the scheduling method has not been carried out optimally on the MT mesh production floor, so this study focusing on how to make the scheduling model method so that the MT product process can be measured. The purpose of this study is to determine the scheduling model that can solve scheduling problems at PT. XX. The scheduling model in PT. XX is a Hybrid Flowshop scheduling model.

II. LITERATURE REVIEW

[1]*asep.anwar@widyatama.ac.id, diditdr@widyatama.ac.id, Arief.Rahamana@widyatama.ac.id*
Production System Laboratorium
Industrial Engineering
Widyatama University Bandung

Scheduling Process arises because of the limited resources available so that there needs to be an effective and efficient use of these resources. According to Baker (1974) scheduling can be divided into several conditions, namely:

1. Machines in scheduling can be single or multiple machines.
2. Process flow patterns can be in the form of identical or arbitrary flow.
3. The pattern of work arrivals can be dynamic or static.
4. The nature of information in scheduling can be deterministic or stochastic.

One of the problems that arise in production activities is to make arrangements for the work and placement of the work to the available machines. One method used to solve the problems of scheduling flowshop machines is the Johnson rule method (1954).

The development problem of scheduling flowshop form is Hybrid Flowshop scheduling. According to Karthik & Prabaharan, (2014) and Linn & Zhang (1999) hybrid flowshop is a flowshop flow system that consists of several stages installed serially where at all stages or at least in one stage there are machine processes that are carried out in parallel.

III. PROBLEM STATEMENT

MT mesh produced by PT XX are processed in several production processes including Spinning, Ringrope and Netting. The production process for Spinning has been discussed in Anwar & Rochman (2019) research for parallel machine scheduling. The next process in this research is the Ringrope and Netting process. The Ringrope process is carried out by two identical machines (a = 1..2) installed in parallel (stage 1) which will then be processed in the next process which is Spinning. The Spinning process is carried out on one machine (Stage 2). The complete process is shown in Figure 1

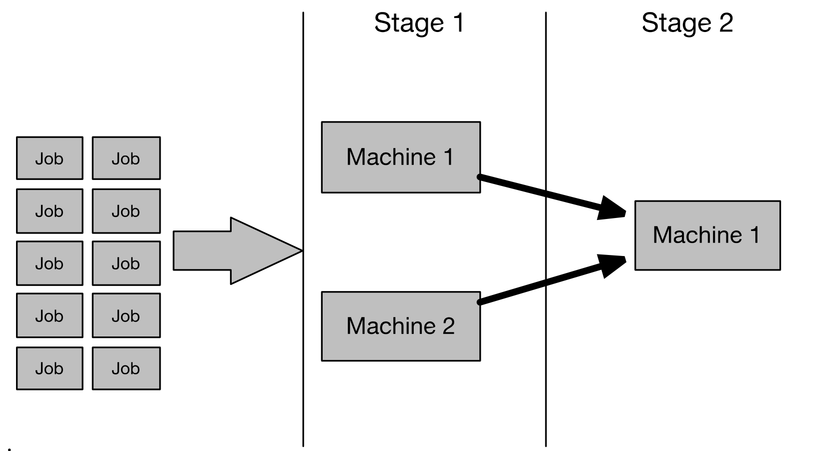

Figure 1: Production process for MT Product

This research will count for 10 MT mesh products (j = 1 ... 10). The process in the first stage has setup time for each job change and processing time, in the second stage there is only processing time. The processing data is in Table 1.

Table 1: Time Processing for MT Product

Order	***Tipe***	***Spesifikasi***	***Ringrope (Jam)***	***Netting (Jam)***

			Setup	***Proses***	***Proses***
1	MT	1.5 x 12	0.92	54.65	126.12
2	MT	1.5 x 12	0.92	54.96	126.83
3	MT	1.7 x 20	1	73.61	245.37
4	MT	1.5 x 10	0.55	9.43	70.73
5	MT	1.5 x 12	0.75	34.85	61.50
6	MT	1.7 x 20	1	74.51	248.35
7	MT	1.5 x 10	0.7	30.32	181.93
8	MT	1.5 x 12	0.65	24.18	39.21
9	MT	1.5 x 12	0.75	35.07	61.88
10	MT	1.5 x 10	0.7	30.44	182.61

The model used is based on the model of the Gupta & Tunc (1988) model of hybrid flowshop 2 stage. The method of solving the model uses the Heuristic method.

Notation:

j = job.
w = job sceduled.
a = Machine in stage 1
S_j = Setup time job (j) for machine a.
P_j = processing time job (j) in stage 1.
t_j = processing time job (j) in stage 2.
$K_{j,a}$ = Completion time job (j) in stage 1.
$M_{j,a}$ = Starting time job (j) in stage 1.
B_j = Starting time job (j) in stage 2.
C_j = completion time job (j) in stage 2.
$X_{j,a} = \begin{cases} 1, If\ job\ j\ assigned\ on\ \ machine\ a \\ 0, if\ job\ j\ unassigned\ on\ machine\ a \end{cases}$

Objective Function:

$$MIN\ Z = Max(C_j) \quad (1)$$

Constraint :

$$\sum_{a=1}^{A} X_{j,a} = 1 \qquad \begin{array}{l} j = 1 \ldots J \\ a = 1 \ldots A \end{array} \qquad (2)$$

$$K_{j,a} = \left(M_{j,a} + S_j + P_j\right) \times X_{j,a} \qquad \begin{array}{l} j = 1 \ldots j \\ w < j \\ a = 1 \ldots A \end{array} \qquad (3)$$

$$M_{j,a} \geq K_{w,a} \qquad \begin{array}{l} j = 1 \ldots J \\ a = 1 \ldots A \end{array} \qquad (4)$$

$$B_j \geq K_{j,a} \qquad \begin{array}{l} j = 1 \ldots J \\ a = 1 \ldots A \end{array} \qquad (5)$$

$$B_j \geq C_w \qquad \begin{array}{l} j = 1 \ldots J \\ w < j \end{array} \qquad (6)$$

$$C_j = B_j + t_j \qquad j = 1 \ldots J \qquad (7)$$

$$X_{j,a} = \{0,1\} \qquad \begin{array}{l} j = 1 \ldots J \\ a = 1 \ldots A \end{array} \qquad (8)$$

$$K_{j,a}, M_{j,a}, K_{w,a}, B_j, C_w, C_j \geq 0 \qquad (9)$$

Equation (1) shows the objective function, which is to minimize the makespan. Equation (2) ensures that the job is done by only one machine on stage 1. Equation (3) determines the completion time on stage 1. Equation (4) ensures that the next job start time is done after the previous job is done. Equation (5) ensures the start time of a job on stage 2 is done after the job is done on stage 1. Equation (6) ensures that the job start time on stage 2 is done after the job process after it is done in stage 2. Equation (7) to determine the completion time job on stage 2. Equation (8) values to ensure the decision to place a job on the machine. Equation (9) ensures that all values are positive values.

IV. RESULT AND DISCUSSION

SEQUENCE PROSES

The process of sorting jobs that will be processed in research will follow Johnson's rules. This ordering is intended to place the process to be scheduled on the machine at the first stage. The algorithm for the johnson rule is:

Step 1 For all tasks l, find the minimum of $t_{i,1}$ and $t_{i,2}$, the processing time of the first and second processors.

Step 2 If the minimum time is on processor 1 (ie, $t_{i,1}$), then scheduling the task at the next available position, starts at the beginning of the sequence. Proceed to step 3. If the minimum time is in process 2 (that is, $t_{i,2}$), then scheduling the task at the next available position, starting from the end of the sequence. Bonds can be separated by changing.

Step 3 Remove scheduled tasks from the list. If the tasks still exist, return to step 1, if there are no more then stop it.

The results of ordering using the johnson rule are:

Table 2: Result sequence job from Johnson's Rule

Job	**Stage 1**		**Stage 2**
	Setup	***Proses***	***Proses***
4	0,55	9,43	70,73
8	0,65	24,18	39,21
7	0,70	30,32	181,93
10	0,70	30,44	182,61
5	0,75	34,85	61,50
9	0,75	35,07	61,88
1	0,92	54,65	126,12
2	0,92	54,96	126.83
3	1,00	73,61	245,37
6	1,00	74,51	248,35

V. COMPUTATION

Model computation using LINGO optimization software with i5 GHz with 16GB RAM. The settlement process is done by using the programming language in lingo which represents a mathematical model that has been formed.

```
model:
sets:
job/1..10/:p1,p2,M2,C2,S;
jobw/1..10/;
Mesin1/1..2/;
JT1(job,Mesin1):X1,C1,M1;
endsets
data:
p1=9.43, 24.18, 30.32, 30.44, 34.85, 35.07, 54.65, 54.96, 73.61, 74.51;
p2=70.73, 39.21, 181.93, 182.61, 61.50, 61.88, 126.12, 126.83, 245.37, 248.35;
S=0.55, 0.65, 0.70, 0.70, 0.75, 0.75, 0.92, 0.92, 1, 1;
enddata
MIN=@max(job(j):C2(j));
@for(job(j):@sum(Mesin1(a):X1(j,a))=1);
@for(job(j):@for(Mesin1(a):C1(j,a)=(M1(j,a)+S(j)+p1(j))*X1(j,a)));
@for(job(j):@for(jobw(w)|w#LT#j:@for(Mesin1(a):M1(j,a)>=C1(w,a))));
```

```
@for(job(j):@for(Mesin1(a):M2(j)>=C1(j,a)));
@for(job(j):@for(Jobw(w)|w#LT#j:M2(j)>=C2(w)));
@for(job(j):C2(j)=M2(j)+p2(j));
@for(job(j):@for(Mesin1(a):@BIN(X1(j,a))));
@for(job(j):@for(Mesin1(a):C1(j,a)>=0));
@for(job(j):C2(j)>=0);
end
```

The final results of calculations using LINGO software:

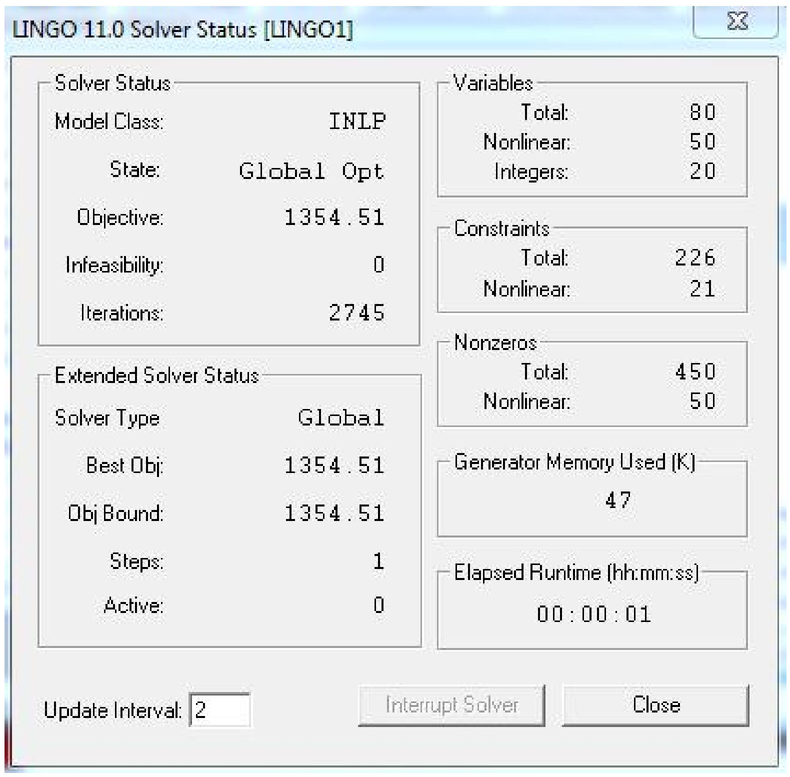

Figure 2: Result of LINGO

The table shows the sequence of processes in stage 1 and stage 2 resulting from the calculation.

Stage	Machine	Sequencing	Maks. Completion Time
1	1	1,5,6,7,8,10	268,36
	2	2,3,4,9	161,6
2	1	1,2,3,4,5,6,7,8,9,10	1354,51

Table 3: List Assigned Job to Machine

VI. CONCLUSION

The results of this study are mathematical models that can be used to solve scheduling problems with the Hybrid Flowshop 2 stage model. The completion of this model uses LINGO software with a total calculation time of 1 second. The results of calculations for 10 MT product jobs can be completed in 1354.51 hours with the sequence of processes shown in table 2.

The research resulted in an optimal solution to the problems of Hybrid flowshop scheduling from MT mesh production problems.

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