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Retraction

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Minimization of Hiring cost for n-Jobs, 2-Machines Flow Shop Scheduling: Processing Time Associated with Probabilities with Transportation Time including Break down interval.

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Abstract. This paper examines a heuristic programmed algorithm for the problem of two-stage flow shop scheduling in which the time to process their respective probabilities and to minimize the cost of hiring machines under a given rental policy. Furthermore, it takes into account the transfer time from one device to another system. The algorithm is very easy to understand and also offers an significant technique for decision-making.

Keywords: Flow shop, transportation time, rental policy, Breakdown gap.

1. Introduction

Flow shop scheduling theory difficulties confirms the determination of the order in which two or more jobs should be processed on two or more pre- ordered machines in order to optimize some measure of effectiveness. The theory of Flow Shop Scheduling is an algorithm by [1] to plan jobs in a flow shop for two machines to reduce the period when all jobs are done. [2] introduced a practical branch and binding approach to achieve an order that minimizes the total flow time. [3] introduced the concept moving time of jobs. The best possible algorithm for two machine flow shop scheduling was derived, taking into account the different limitations and parameters [4].

[5] addressed n-2 general flow shop issue to minimize the cost of hiring under a predefined rental policy under which the probabilities of processing time on each computer with a breakdown gap is linked. Here we have expanded the research done by [6-10] who explored the scheduling issue concerning the notion of transport time. An algorithm is also developed to minimize the hiring cost of the machines.

2. Symbolizations

S : Order of jobs 1,2,3,….,n
M_j : Machine j, j=1,2,……
C_i: Time to process the machine's work C.

D_i: Time to process the machine's work D.
C'_i: The approximate time to process the C machine's work.
D'_i: The average time it takes to process the work on machine D.
p_i : Probability of the production-related time to process C_i of i^{th} work on machine C.
q_i: Probability of the production-related time to process D_i of i^{th} work on machine D.
t_i: Transfer the work time from machine C to machine D
L: Length of the distance in the break-down.
C'_i: Estimated time after break-down impact on machine C to process the i^{th} task.
D'_i: Estimated time after break-down impact on machine D to process the i^{th} task.
S_i: Series to reduce recruiting costs derived from Johnson's method.
C_j: Cost of recruitment per machine unit time j.
U_i: Consumption time of D for each S_i series (2nd machine) Si.
$t_1(S_i)$: Sequence Completion Time S_i's Last machine Job C.
$t_2(S_i)$: Time of sequence completion S_i's Last machine Job D.
$R(S_i)$: Total rate of recruitment of all S_i series machines.
$CT(S_i)$: 1^{st} job completion time on machine C of each Si order.

3. Problem Formulation

Let there be n jobs which should be treated on two machines C and D. Let the time to process each job on machine C and D respectively be C_i and D_i (i = 1,2.....n). Let ti (i= 1,2,....n) be the transport time to transfer the work from machine C to machine D. Let p_i & q_i be the probabilities related to their respective C_i and D_i processing time. It is possible to represent the mathematical model of the given problem as shown in Table 1

Table 1. Problem Formulation

Jobs	Machine C		t_i	Machine D	
I	C_i	p_i		D_i	q_i
1	C_1	P_1	t_1	D_1	q_1
2	C_2	P_2	t_2	D_2	q_2
3	C_3	P_3	t_3	D_3	q_3
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
N	C_n	P_n	t_n	D_n	q_n

In order to break down machines, Enable the machine to stop working in the time gap (a, b) for the period of time L = (b-a). [7-12]Now, our task is to discover the best possible job schedule in order to minimalize the hiring charge under the predefined rental policy since all machines are taken for rent, when needed and returned for processing when it is no longer required.

4. Algorithm

Step1: Describe expected time to process C_i' and D_i' on machine C and D as follows:

$$C_i' = C_i \times p_i$$

$D_i' = D_i \times q_i$

Step2:With time to process G_i & H_i for job i on G &H machine correspondingly, describe two fictitious machines G & H :

$G_i = C_i' + t_i$ & $H_i = t_i + D_i'$

Step 3: Use Johnson's (1) approach to find the best possible work plan.

Step 4: Build a table of flow times the effect of break- down (a,b) on the – (T.P.Singh) for the order obtained in step 1 and read lines on different jobs.

Step 5: Render C_i and D_i a reduced issue with time to process.

If the role is influenced by the break-down distance (a, b), then I will

$C_i' = C_i + L$ & $D_i' = D_i + L$ where $L = b – a$,

Period of difference in break-down.

If there is no impact on work from the break-down distance (a, b), then I will

$C_i' = C_i$, $D_i' = D_i$

Step 6: Using Johnson's two machine algorithm , Repeat the process, as in step 2, to get the order S_i.

Step 7: Analyze the processing time on the first A computer for the 1st S_1 task. Let it be α.

Step 8: Find all of the workers that have time to process on A greater than α .Placed these tasks in the 1st position of order S_1, one by one in the same sequence. Let us consider these commands as $S_2, S_3, \ldots, S_r$.

Step 9: Create an in-out flow table simply for the sequence S_i (i=1,2,...r) and assess the overall completion period of each order's last work., .i.e. $t_1(S_i)$ & $t_2(S_i)$ on the respective C_i & D_i machine.

Step 10 Calculate the CT (S_i) completion period of 1 st of each of the above selected Si orders on the C_i machine

Step 11: Measure the U_i consumption time of the 2nd machine for each S_i order selected above as:

$U_i = t_1(S_i) – CT(S_i)$ for - (i=1, 2 , 3,…r)

Step 12: i=1, 2,...r ,find for Min $\{U_i\}$. Assume i = m and S_m is the best possible order for the minimum cost of recruiting. Min hiring cost= $t_1(S_m) = C_1 + U_m \times C_2$, where C_1 & C_2 is the hiring price of 1st and 2nd machines per unit time, respectively.

5. Numerical design

To minimize the hiring cost, let us consider the problem of 5 jobs and 2 machines. [13-20]The time to process the transportation time from a single machine to another machine is as shown below and their associated probabilities are given in Table 2.

Table 2. Transportation time

Jobs	Machine C		t_i	Machine D	
I	C_i	p_i		D_i	q_i
1	12	0.2	6	8	0.1
2	16	0.3	5	12	0.2
3	13	0.3	4	14	0.3
4	18	0.1	3	17	0.2
5	15	0.1	4	18	0.2

Hiring charges per unit time for M_1 & M_2 machines are Rs 12 & Rs14 respectively. It is also considered that the break-down difference is (2,4).

Solution: Step 1: Table 3 indicates the projected processing time for two machines.

Step2&3 as per: Using Johnson's technique, the best possible order is $S_1 = 4,5,3,2,1$ is in table 4
As per step4 &5: Now in view of the break down gap effect (2,4), the revised C'_i and D'_i processing times of C_i and D_i machines are in table 5 & table 6.
As per step6&7 : Using Johnson's technique, the best possible order is $S_1 = 5,3,2,1,4$
As per step8: Other best possible order for reducing hiring price, are
$S_2 = 3,5,2,1,4$
$S_3 = 2,5,3,1,4$
$S_4 = 1,5,3,2,4$
$S_5 = 4,5,3,2,1$
As per step9&10&11: The order S_1 in- out table is represented in table 7
The entire elapsed time = 26.4 units and consumption time for D_i = 26.4-7.5 =18.9 units.
The in- out tableau for the order S_2 is represented in table 8
The entire elapsed time = 24.8 units and consumption time for D_i = 24.8-7.9 =16.9 units.
The in- out tableau for the order S_3 is represented in table 9
The entire elapsed time = 24.8 units and consumption time for D_i = 24.8-9.8 =15.0 units.
The in- out tableau for the order S_4 is represented in table 10
The entire elapsed time = 25.4 units and consumption time for D_i = 25.4-8.4 =17.0 units.
The in- out tableau for the order S_5 is represented in table 11
The entire elapsed time = 25.2 units and consumption time for D_i = 25.2-6.8 =18.4 units.
As per step12: The complete consumption of the C machine is set at 18.4 units and the least consumption time of the D machine for order S_3 is 15.0 units. Therefore, $S_3 = 2,5,3,1,4$ and overall recruiting expense = $18.4 \times 12 + 15.0 \times 14 = 430.8$ units are the best possible orders.

Tables
As per step1

Table 3. The expected time to process for two machines are:

Jobs	C'_i	t_i	D'_i
1	2.4	6	0.8
2	4.8	5	2.4
3	3.9	4	4.2
4	1.8	3	3.4
5	1.5	4	3.6

As per step2

Table 4. Johnson's technique

Jobs	G	H
1	8.4	6.8
2	9.8	7.4
3	7.9	8.2
4	4.8	6.4
5	5.5	7.6

As per step3&4

As per step 5

Table 5. break down gap effect

Jobs	C_i'	t_i	D_i'
4	0-1.8	3	4.8-8.2
5	1.8-3.3	4	8.2-11.8
3	3.3-7.2	4	11.8-16.0
2	7.2-12.0	5	17.0-19.4
1	12.0-14.4	6	20.4-21.2

As per step6

Table 6. best possible order

Jobs	C_i'	t_i	D_i'
1	2.4	6	0.8
2	4.8	5	2.4
3	3.9	4	4.2
4	3.8	3	3.4
5	3.5	4	3.6

As per step 7

Table 7. tableau for the order S_1

Jobs	C_i'	t_i	D_i'
5	0-3.5	4	7.5-11.4
3	3.5-7.4	4	11.4-14.3
2	7.4-12.2	5	17.2-19.6
1	12.2-14.6	6	20.6-23.0
4	14.6-18.4	3	23.0-26.4

As per step 8

Table 8. tableau for the order S_2

Jobs	C_i'	t_i	D_i'
3	0-3.9	4	7.9-12.1
5	3.9-7.4	4	12.1-15.7

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2	7.4-12.2	5	17.2-19.6
1	12.2-14.6	6	20.6-21.4
4	14.6-18.4	3	21.4-24.8

As per step 9

Table 9: tableau for the order S_3

Jobs	$C_i^{'}$	t_i	$D_i^{'}$
2	0-4.8	5	9.8-12.2
5	4.8-8.3	4	12.3-15.9
3	8.3-12.2	4	16.2-20.4
1	12.2-14.6	6	20.6-21.4
4	14.6-18.4	3	21.4-24.8

As per step 10

Table 10: tableau for the order S_4

Jobs	$C_i^{'}$	t_i	$D_i^{'}$
1	0-2.4	6	8.4-9.2
5	2.4-5.9	4	9.9-13.5
3	5.9-9.8	4	13.8-18.0
2	9.8-14.6	5	19.6-22.0
4	14.6-18.4	3	22.0-25.4

As per step 11

Table 11: tableau for the order S_5

Jobs	$C_i^{'}$	t_i	$D_i^{'}$
4	0-3.8	3	6.8-10.2
5	3.8-7.3	4	11.3-14.9

3	7.3-11.2	4	15.2-19.4
2	11.2-16.0	5	21.0-23.4
1	16.0-18.4	6	24.4-25.2

6. Conclusion

This paper provides a heuristic algorithm which reduces hiring charge of the machines due to unavailability of the machines for n×2 flow shop scheduling model with their probabilities and transport time.

1. The analysis can be further expanded by adding different criteria, such as job weighting, etc.
2. The work can be extended for n by 3 flow shop scheduling model.

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