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Heuristic Approach For N- Job 3- Machine Weighted Flow Shop Scheduling Problem Involving break Down Time

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ABSTRACT

The present paper studies break down concept in especially N job 3 machine flow shop scheduling in which processing times are associated with weight of the job. The objective of the study is to get optimal or near optimal sequence of jobs in order to minimize the total weighted mean production flow time of the jobs. The algorithm is made clear by numerical example.

1. Introduction

Scheduling problems have been dealt by many authors when machines operating job are smooth, that is, when machines do not get predetermined or random break-downs. This assumption is not realistic. Practical importance of scheduling problem depends upon two factors together which are more practical. These two concepts were separately studied by different researchers as [1] Johnson (1954), [2] Jackson (1956), [3] Maggu and Das (1980).

They consider a two-machine flow shop make span problem where for solution of a scheduling problem involving weights of jobs and break-down times for machines.[4] Chandramouli (2005) considers a new simple heuristic algorithm for a '3-machine, n-job flow- shop scheduling problem in which jobs are attached with weights to indicate their relative importance and the transportation time and break-down intervals of machine. Other related problems have been studied by [5] Mitten (1959), [6] Maggu, Singhal, Mohammad and Yadav (1982), Langston (1987), Yu (1996) and Mittan (1959) presents a simple rule to solve a two-machine flow – shop make span problem in which each job has a starting time lag and a completion time lag.

The new method proposed by [7] P. Pandian and P. Rajendran., This method is very easy to understand and apply and also, will help managers in the scheduling related issues by aiding them in the decision-making process and providing an optimal scheduling sequence in a simple and effective manner. Determining a best schedule for given sets of jobs can help decision makers effectively to control job flows and to provide a solution for job sequencing. We have a plan to extend the proposed method to constrained flow-shop problems with m-machines.

A starting (completion) time lag forces the starting (completion) time of a job on the second machine to be at least some time later than that on the first machine. Clearly, if each job has either a starting time lag or a completion time lag, but not both, the resulting problem is then equivalent to the problem considered by Maggu and Das(1980), Maggu, Singhal, Mohammad and Yadav (1982) show that a simple rule can solve a more general problem that has both the features of the problem of Maggu and Das (1980) and those of the problem of Mitten(1959), Langston(1987) analyses some heuristics for k-station flow shop make span problem where each station has a number of machines that can be used to process jobs, and there is only one transporter with a capacity of one to transport jobs with transportation times dependent on the physical locations of the origin and destination machines. Yu (1996) considers various special cases of the problem studied by Maggu and Das (1980).

2. Classical Flow Shop Scheduling

The classical flow shop scheduling problem is one of the most well-known scheduling problems. Informally, the problem can be described as follows: there are set of jobs and a set of machines. Each job consists of chain of operation, each of which needs to be processed during an uninterrupted time period of a given length on a machine. Each machine can process at most one operation at a time.

A schedule is an allocation of operations to time intervals of the machines. The problem is to find the schedule of minimum length. This work tries to minimize the make span of processing machines in a flow shop. The processing times and the sizes of the jobs are known and non-identical. The machines can process a batch as long as its capacity is not exceeded. The processing time of a batch is the longest processing time among all the jobs in that batch. Sequencing refers to arranging items or events in a particular order. In other words, sequencing is a technique to order the jobs in a particular sequence.

3. PFSP With Break-Down Times

The pfsp with break-down times with n-jobs and m- machines is defined as follows:

i. All n-jobs are processed through m processing centers p1, p2, ..., pm in the same order (e.g., each job is processed first in center p1, then p2, ..., until pm).
ii. I represents the job in an arbitrary sequence, where i = 1,...,n. o all N
iii. Jobs are available to be processed at time zero.
iv. pi1, pi2, pi3, ..., pim, represents the processing time of job i in the processing center p1, p2, p3, ..., pm respectively. o the break-down interval is defined as (a, b), and the interval length is (b - a).
v. If break-down conditions take place and interruption of power supply occurs, the processing times of the centers may be affected accordingly to the type of center. These can be classified under three categories:
vi. U: processes that cannot be interrupted. in this case, breakdown time is applied and the process itself is postponed. this is common for processes as molding, casting, forging, and welding. the processing time in this case is modified and (b - s1) is added to the original processing time.
vii. V: processes that require power supply and, if break- down occurs between the process (which starts at time s1 and ends at time s2), can be resumed when power supply returns. processes that can be classified in this category are packing, machining, threading, and drilling. in this case, original processing times are modified as follows:
viii. if break-down starts between s1 and s2, (b - a) is added to the original processing time;
ix. if break-down starts before s1 and ends after s2, (b - s1) is added to the original processing time.
X. W: processes that do not require power supply can continue during the break-down time. thus, no modification in the original processing time is required.

Step 1:

Modify the problem into two machine flow-shop problem by introducing two fictitious machines G and H with processing time Gi and Hi respectively such that Gi = Ai + Bi and Hi = Bi + Ci

The modified in the tabular form is:

Job	Machine with Processing time Gi	Hi	Weight Job Wi
1	G1	H1	W1
2	G2	H2	W2
.	.	.	.
.	.	.	.
.	.	.	.
n	Gn	Hn	Wn

Step-2:
If max (Gi , Hi) = Hi then define Gi = Gi
and Hi = Hi – Wi
If max (Gi , Hi) = Gi then define Gi = Gi + Wi
and Hi = Hi
STEP-3:
Formulate a new problem as below:

Job	Machine with Processing time Gi	Hi
1	$\frac{G1}{W1}$	$\frac{Hi}{W1}$
2	$\frac{G2}{W2}$	$\frac{Hi}{W2}$
.	.	.
.	.	.
.	.	.
n	$\frac{Gn}{Wn}$	$\frac{Hn}{Wn}$

Step-4:
Apply Johnson's (1954) procedure to find optimal solution for the reduced problem in step 3.
Step-5:
One of the sequences thus obtained in step 4 is either optimal or near to optimal for the original problem minimizing the weighted mean flow-time and see the effect of break- down interval (a , b) on different jobs.
STEP-6:
Formulate a new problem with processing times , Ai, Bi and Ci where if break-down starts between s1 and s2, (b - a) is added to the original processing time;
i.e., Ai=Ai+(b-a), Bi=Bi+(b-a), Ci=Ci+(b-a).
if break-down starts before s1 and ends after s2, (b - s1) is added to the original processing time.
i.e., Ai=Ai+(b-s1), Bi=Bi+(b-s1), Ci=Ci+(b-s1)
Otherwise Ai=Ai, Bi=Bi, Ci=Ci.
Step-7:
Formulate a new problem with processing times Ai, Bi and Ci for the job A, B and C respectively and this sequence is either optimal or near optimal for the original problem. By this sequence we can determine the total elapsed time and weighted mean-flow time:

4. Numerical Illustration

Consider a "5-job, 3-machine" flow shop scheduling problem with weights as given in the following table.

Job	Machine with Processing time for Weighted of Job Ai	Bi	Ci	Wi
1	9	4	8	3
2	6	5	9	4
3	8	7	12	5
4	10	8	14	1
5	9	6	10	2

Find optimal sequence when the break-down interval is (a, b) = (30, 36). Also calculate the makespan and weighted mean-flow time.
Solution:
Here min Ai = 6, max Bi = 8, and min Ci = 8.

Since one of two conditions is satisfied by min Ci = max Bi, so the procedure adopted in section (i) can be followed. The equivalent problem, involving five jobs and two fictitious machines M and N, becomes:

JOB	Machine with Processing time for Weighted of Job		
	Gi	Hi	Wi
1	13	12	3
2	11	14	4
3	15	19	5
4	18	22	1
5	15	16	2

This new problem can be solved by the procedure stated in section IV and find the schedule minimizing the weighted mean flow-time. By step 1, of the algorithm,

(i).If max (Mi , Ni) = Ni then define Mi = Mi and Ni = Ni – Wi

(ii).If max (Mi , Ni) = Mi then define Mi = Mi + Wi and Ni = Ni

Max (M1, N1) = max (13, 12) =13. define N1 = 12 and M1 = 13+3=16.

Max (M2, N2) = max (11, 14) =14. define M2 = 11 and N2 = 14 - 4 = 10.

Max (M3, N3) = max(15, 19) = 15. define M3 = 15, and N3 = 19 – 5 = 14 .

Max (M4, N4) = max (18, 22) = 22 define M4 = 18 and N4 = 22 – 1 = 21

Max (M5, N5) = max (15, 16) = 16 define M5 = 15 and N4 = 22 – 1 = 21

Job	Machine with Processing time	
i	Gi	Hi
1	$\frac{16}{3} = 5.3$	$\frac{12}{3} = 4$
2	$\frac{11}{4} = 2.75$	$\frac{10}{4} = 2.5$
3	$\frac{15}{5} = 3$	$\frac{14}{5} = 2.8$
4	$\frac{18}{1} = 18$	$\frac{21}{1} = 21$
5	$\frac{15}{2} = 7.5$	$\frac{14}{2} = 7$

Using the steps 1 to IV and Appling Johnson technique for optimal sequence. we get the sequence (4, 5, 1, 3 and 2). now to check the effect of break-down interval (30,36) on sequence (4, 5, 1, 3 and 2) is read as follows;

Job	Machine with Processing time for Weighted of Job			
	Ai	Bi	Ci	Wi
4	0-10	10-18	**18-32**	1
5	10-19	19-25	**32-42**	2
1	19-28	**28-32**	42-50	3
3	**28-36**	36-43	50-62	5
2	36-42	43-48	62-71	4

Hence, with the effect of break-down interval the original problem becomes a new problem as per step

Job L	Machine with Processing time for Weighted of Job			
	Ai	Bi	Ci	Wi
1	9	**10**	8	3
2	6	5	9	4
3	**14**	7	12	5
4	10	8	**20**	1
5	9	6	**14**	2

Now, we solve the problem using the sequence(4, 5, 1, 3 and 2) which is the solution and find the table

Job L	Machine with Processing time for Weighted of Job			
	Ai	Bi	Ci	Wi
4	0-10	10-18	**18-38**	1
5	10-19	19-25	**38-52**	2
1	19-28	**28-38**	52-60	3

3	**28-42**	42-49	60-72	5
2	42-48	49-54	72-81	4

$$\text{Mean weighted flow time} = \frac{38X1 + 52X2 + 60X3 + 72X5 + 81X4}{1 + 2 + 3 + 5 + 4} = 67.07$$

Makespan = 81.

5. Conclusion

This method provides an optimal scheduling sequence for constrained flow-shop scheduling problems of n-jobs on 3-machines. This method is very easy to understand and apply and also, will help managers in the scheduling related issues by aiding them in the decision-making process and providing an optimal scheduling sequence in a simple and effective manner. Determining a best schedule for given sets of jobs can help decision makers effectively to control job flows and to provide a solution for job sequencing.

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