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HEURISTIC APPROACH FOR N-JOB, 3-MACHINE FLOW SHOP SCHEDULING PROBLEM INVOLVING TRANSPORTATION TIME, BREAK DOWN TIME AND WEIGHTS OF JOBS

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Abstract- This paper provides 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 are given. A heuristic approach method to find optimal or near optimal sequence minimizing the total weighted mean production flow time for the problem has been discussed.
Keywords - Break down time, Weights of jobs.

1. INTRODUCTION

The practical importance of scheduling problem depends upon three factors i.e. job transportation time, relative importance of a job over another job and break down machine time. These three concepts were separately studied by various researchers as Johnson [1], Jackson [2], Bellman [3], Miyazaki and Nishiyama [4], Bansal [5]. But in the present communiqué we have discussed all the three factors together which are more practical. The object of the paper pertains to determination of an optimal or near optimal sequence for n-job × 3- machine flow shop problem which associates 'weight' with a job in the sense of relative importance in the process and includes transportation time and break-down machine time minimizing the total weighted mean production flow-time.

Many applied and experimental situations exist in our day-to-day working in factories and industrial production concerns etc. The practical situation may be taken in a paper mill or sugar factory where various types of paper or sugar are produced with relative importance i.e. weight in jobs. The transportation time (which includes loading time, moving time and unloading time etc.) for the job and break-down of machine (due to failure of electric current or due to non-supply of raw material or other technical interruptions) which have been neglected in Johnson's [1] scheduling paper and which have a significant role in production concern.

2. FLOW-SHOP MODEL AND NOTATION

The flow-shop model can be stated as follows:

(a)Let n-job be processed through three machines A, B and C in the order A BC. Let "i" denote the job in S where S is an arbitrary sequence. All jobs are available for processing at time zero.

(b)Let each job be completed through the same production stage, i.e. ABC. In other words, passing is not allowed in the flow shop.

(c)Let A_i, B_i, C_i denote the processing time of job "i" on machine A, B, and C respectively t_i and g_i denote the transportation time of job "i" from A to B and from B to C respectively.

(d)Let job "i" be assigned with a weight w_i according to its relative importance for performance in the given sequence.

(e)The performance measure studied is weighted mean flow time defined by

$$\bar{F}_w = \frac{\sum_{i=1}^{n} w_i f_i}{\sum_{i=1}^{n} w_i}$$,Where f_i is flow time of i- th job.

(f)Let the break down interval (a,b) is already known to us, i.e. a deterministic nature. The break down interval length (b – a) which is known.

Then our aim is to find out optimal or near optimal sequence of jobs so as to minimize the total elapsed time.

The given problem in the tabular form may be stated as follows.

Job	Machines with Processing time and Transportation time					Weight of jobs
i	A_i	t_i	B_i	g_i	C_i	w_i
1	A_1	t_1	B_1	g_1	C_1	w_1
2	A_2	t_2	B_2	g_2	C_2	w_2
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
n	A_n	t_n	B_n	g_n	C_n	w_n

3. ALGORITHM

Suppose that either one or both of the following structural conditions involving the processing time and transportation time of jobs hold.

Structural conditions :

(I) $\min_i (A_i + t_i) \geq \max_i (t_i + B_i)$

(II) $\min_i (g_i + C_i) \geq \max_i (t_i + B_i)$

Then, the following steps of algorithm are :

STEP I : Modify the problem into two machines flow-shop problem by introducing two fictitious machine **G** and **H** with processing time G_i and H_i respectively such that

$G_i = A_i + t_i + B_i + g_i$ and $H_i = t_i + B_i + g_i + C_i$

The modified problem in the tabular form is

Job i	Machines with processing time G_i	 H_i	Weights of jobs w_i
1	G_1	H_1	w_1
2	G_2	H_2	w_2
-	-	-	-
-	-	-	-
-	-	-	-
n	G_n	H_n	w_n

STEP II : Find min (G_i , H_i)

(a)If min (G_i, H_i) = G_i then define $G_i' = G_i - w_i$ and $H_i' = H_i$.

(b)If min (G_i, H_i) = H_i then define $G_i' = G_i$ and $H_i' = H_i + w_i$.

STEP III : Define a new reduced problem in the tabular form as :

Job I	Machines with processing time G_i'	 H_i'
1	G_1'/w_1	H_1'/w_1
2	G_2'/w_2	$H'_2\,/w_2$
-	-	-
-	-	-
-	-	-
n	G_n'/w_n	H_n'/w_n

Where G_i' and H_i' are defined as per step II

STEP IV : Determine the optimal sequence by using Johnson's algorithm for the new reduced problem obtained in step III and see the effect of break-down interval (a, b) on different jobs.

STEP V : Formulate a new problem with processing time A_i', B_i' and C_i' where

$$\left.\begin{aligned} A_i' &= A_i + (b-a) \\ B_i' &= B_i + (b-a) \\ C_i' &= C_i + (b-a) \end{aligned}\right| \text{ If (a, b) affected on job i.}$$

$$\left.\begin{aligned} A_i' &= A_i \\ B_i' &= B_i \\ C_i' &= C_i \end{aligned}\right|$$

If (a, b) has no effect on job i.

STEP VI : Now repeat the procedure to get the optimal sequence.

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.

For clarification, the following numerical example is given below:

4. NUMERICAL EXAMPLE

Consider a four job and three machine problem with processing time, transportation time and the weight of jobs is given as:

Job	Processing time of job i with Transportation time					Weight of job
I	A_i	t_i	B_i	g_i	C_i	w_i
1	13	1	7	2	5	3
2	8	3	6	5	9	5
3	7	2	3	4	5	4
4	5	5	2	1	6	2

Find optimal or near optimal sequence when the break-down interval is (a, b) = (18, 25). Also calculate the total elapsed time and weighted mean-flow time.

SOLUTION : Now Min $(A_i + t_i) = 9$

Max $(t_i + B_i) = 9$

Hence, (I) structural condition is satisfied. Then, using the steps I to IV and applying Johnson technique for optimal and near optimal sequence we get the sequence (2, 3, 4, 1),

Now to check the effect of break down interval (18, 25) on sequence (2, 3, 4, 1) is read as follows:

Job i	A_i	t_i	B_i	g_i	C_i	w_i
2	0-8	3	11-17	5	**22-31**	5
3	8-15	2	**17-20**	4	31-36	4
4	**15-20**	5	25-27	1	36-42	2
1	**20-33**	1	34-41	2	43-48	3

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

Job i	A_i'	t_i	B_i'	g_i	C_i'	w_i
1	20	1	7	2	5	3
2	8	3	6	5	16	5
3	7	2	10	4	5	4
4	12	5	2	1	6	2

Now, repeating the procedure we get the sequence (2, 3, 4, 1) which is optimal or near optimal and the final table is:

Job i	A_i'	t_i	B_i'	g_i	C_i'	w_i
2	0-8	3	11-17	5	**22-38**	5
3	8-15	2	**17-27**	4	38-43	4
4	**15-27**	5	32-34	1	43-49	2
2	27-47	1	48-55	2	57-62	3

Mean weighted flow time

$$= \frac{38 \times 5 + (43-8) \times 4 + (49-15) \times 2 + (62-27) \times 3}{5+4+2+3}$$

$$= 32 \cdot 35$$

Hence, the total elapsed time is 62 hrs and mean weighted flow time is $32 \cdot 35$ hrs.

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