

An Heuristic Approach $N \times 3$ Flow Shop Scheduling Problem In Which Processing Time Are Associated With Probabilities Including With Transportation Time And Job-Block Criteria

Deepak Gupta

Prof. & Head, Deptt. of Mathematics
Maharishi Markandeshwar University Mullana, Ambala, India
guptadeepak2003@yahoo.co.in

Manjeet Kaur, Poojadeep Sehga, Payal Singla

Research Scholar, Dept. of Mathematics
Maharishi Markandeshwar University Mullana, Ambala, India
²manjeetkaur2489@gmail.com, poojadeepsehgal13@gmail.com, payalsingla86@gmail.com

Abstract- This paper is an attempt to study the $n \times 3$ flow shop scheduling problem, where processing time are associated with their respective probabilities including the job-block criteria and transportation time. The objective of the study is to get an algorithm to minimize the total elapsed time. The method is clarified with the help of numerical illustration.

Key Words- Flow shop scheduling, Processing time, Transportation time, Optimal sequence, Job-block.

I. Introduction

Flow shop scheduling problem concerned with the sequencing of jobs through a series of machine in exactly the same order with aim to optimized the objective. The research into flow shop problem has drawn a great attention in the decades with the aim to increase the effectiveness of industrial production. A vast amount of research about scheduling has been conducted during the past several decades by the academic community. Optimization algorithm for 2&3 machine flow shop problem in order to minimize the makespan, has been developed by Johnson(1954), Ignall and Schrage(1965), Combell(1970), Maggu and Das(1977), Yoshida and Hitomi(1979), Nawaz(1983), Bansal(1986), Sing T.P(1995), Narain and bagga(1998), Rajendran(2010), Gupta Deepak and Sharma Sameer(2011,2012).

Recently, Gupta Deepak and singla payal(2012) made to attempt to study constrained n-job, 3-machine flow shop scheduling problem with transportation time to minimize the total elapsed time under some special structure condition. The present paper is further an extension of the study made by Gupta Deepak and single payal (2012) in the sense here that it is now associated the probability with the processing time and further these concept of job block criteria has been included considered. Thus the study make here the concept of equivalent job for a job-block is meaning full when the situation of giving priority of one job over another aries, may be for the purpose of improving productivity of by virtue of some technology constrains. The problem is discussed here is wider and more applicable to practical situation.

II. Practical Situation

We consider and example of a book which we has to pass through three machine of composing, binding and printing. Here we suppose that these three machines are located at different situations to execute. Now we shall introduced respective probabilities and transportation time in the problem.

III. Notations

- S :Sequences of jobs 1,2,3,.....,n
- A_i :Processing time of job ith on machine A
- B_i : Processing time of job ith on machine B
- C_i : Processing time of job ith on machine C
- P_i :probability associated to the processing time A_i of ith job on machine A
- q_i :probability associated to the processing time B_i of ith job on machine B
- r_i :probability associated to the processing time C_i of ith job on machine C
- t_i :Transportation time of ith job from machine A to to machine B
- g_i : Transportation time of ith job from machine B to C
- β : Equivalent job for job block

IV. Problem Formulation

Let n jobs are to be processed on three machines A, B and C. Let A_i , B_i and C_i ($i=1,2,3,\dots,n$) be the processing time of each job on machine A,B and C respectively. Let t_i and g_i ($i=1,2,3,\dots,n$) be the job-block with transportation time of job i from machine A to machine B and machine C respectively. The mathematical model of the given problem in matrix can be stated as:

Table 1

Jobs	Machine A			Machine B			Machine C	
	a_i	p_i		t_i	b_i	q_i	g_i	c_i
1	a_1	p_1	t_1	b_1	q_1	g_1	c_1	r_1
2	a_2	p_2	t_2	b_2	q_2	g_2	c_2	r_2
3	a_3	p_3	t_3	b_3	q_3	g_3	c_3	r_3
4	a_4	p_4	t_4	b_4	q_4	g_4	c_4	r_4
5	a_5	p_5	t_5	b_5	q_5	g_5	c_5	r_5
.
.
.
.
n	a_n	p_n	t_n	b_n	q_n	g_n	c_n	r_n

V. Algorithm

STEP 1: Define expected processing time A_i , B_i and C_i on machine on machine A, B and C respectively as follows:-

$$A_i = a_i * p_i$$

$$B_i = b_i * q_i$$

$$C_i = c_i * r_i$$

Step 2: Compute, the processing time by creating two fictitious machine G & H with their processing time G_i & H_i respectively as follows:-

$$G_i = |A_i + B_i + t_i + g_i| \text{ and } H_i = |C_i + B_i + t_i + g_i|$$

Either

$$\min(A_i + t_i) \geq \max(B_i + t_i)$$

if or

$$\min(C_i + g_i) \geq \max(B_i + g_i)$$

or

both

STEP 3: Take equivalent job $\beta=(k,m)$ define processing time as follows.

- (i) $G_\beta = G_k + G_m - \min(G_m, H_k)$
- (ii) $H_\beta = H_k + H_m - \min(G_m, H_k)$

STEP 4: Define a new reduced problem with processing time A,B as defined in step1 & job(k,m) are replaced by single equivalent job β with processing time G_β & H_β as defined in step 3 above.

STEP 5: Apply johnson's(1954) technique and find an optimal schedule of given jobs.

STEP 6: Compute the in out table for the sequence in step 5.

VI. Numerical illustration

Let 5 jobs be processed on three machines A,B and C with processing time associated with their respective probabilities including transportation time .

Table 2

Jobs	Machine A		t_i	Machine B		g_i	Machine C	
	a_i	p_i		b_i	q_i		c_i	r_i
1	12	0.2	4	3	0.3	5	11	0.3
2	14	0.3	3	7	0.2	6	13	0.3
3	11	0.1	4	5	0.1	4	14	0.1
4	13	0.1	4	3	0.2	3	10	0.1
5	16	0.3	1	2	0.2	7	12	0.2

Our objective is to obtain a sequence of job which minimize the total elapsed time.

Solution:

Step 1: define expected processing time A_i, B_i & C_i on machine A, B and C respectively in table 3.

Table 3

Jobs	A_i	B_i	C_i
1	2.4	0.9	3.3
2	4.2	1.4	3.9
3	1.1	0.5	1.4
4	1.3	0.6	1.0
5	4.8	0.4	2.4

Step 2: Here $\min(A_i+t_i) > \max(B_i+t_i)$ is satisfies therefore. Let us create two fictitious machine G and H with their processing time G_i & H_i using $G_i = |A_i + B_i + t_i + g_i|$ and

$H_i = |C_i + B_i + t_i + g_i|$ as follows

Table 4

Jobs	G_i	H_i
1	12.3	13.2
2	14.6	14.3
3	9.6	9.9
4	8.6	8.6
5	13.2	10.8

Step 3: The corresponding processing time for $\beta=(2,5)$ on machine G_i & H_i follows:

$$\begin{aligned}
 G_\beta &= G_k + G_m - \min(G_m, H_k) \\
 &= 14.6 + 13.2 - \min(13.2, 14.3) \\
 &= 14.6 + 13.2 - 13.2 \\
 &= 14.6
 \end{aligned}$$

$$\begin{aligned}
 H_\beta &= H_k + H_m - \min(G_m, H_k) \\
 &= 14.3 + 10.8 - \min(13.2, 14.3)
 \end{aligned}$$

=14.3+10.8-13.2

=11.9

Step 4: Represent new reduced problem in table 4 with processing time as per step 2 & 3

Table 5

Job	G_i	H_i
1	12.3	13.2
β	14.6	11.9
3	9.6	9.9
4	8.9	8.6

Step 5: on applying jhonson (1954) , technique the optimal schedule (3 ,1 , β ,4)

i.e. 3,1,2,5,4.

Step 6: The optimal sequence (3, 1, 2, 5, 4) is the optimal schedule for the original problem.

Table 6

Jobs	Machine A	Machine B	Machine C
i	In-out	In-out	In-out
3	0-1.1	5.1-5.6	9.6-11.0
1	1.1-3.5	7.5-8.4	13.4-16.7
2	3.5-7.7	10.7-12.1	18.1-22.0
5	7.7-12.5	13.5-13.9	22.0-24.4
4	12.5-13.8	17.8-18.4	24.4-25.4

Total elapsed time=25.4.

VII. Conclusion

The study may further be extended by introducing different parameters such as setup time separated from their processing time,break down interval etc.

References

- [1] Johnson[1954], Optimal two & three stage production schedules with set –up times included, Nav. Res. Log. Quart. Vol1.pp 61-68
- [2] Ignall E and Schrage, L[1965], Application of the branch and bound technique to some flow shop scheduling problems, Operation research 13, 400-41
- [3] Maggu P.L & Dasa G[1977], Equivalent jobs for job-block in job sequencing opsearch volume No 141 pp 227-281
- [4] Yoshida and Hitomi[1979], Optimal two stage production scheduling with set-up times separated,AIET ransactions, Vol.II.pp 261-263
- [5] Narian L & Bagga P.C.[2005]. Scheduling problems in rental situation, Bulletin of pure and applied science section E, Mathematics and Statistics. Vol.24.
- [6] Gupta Deepak & Sharma Sameer(2011), minimizing rental cost under specified rental policy in two stage flow shop, the processing time associated with probabilities including breakdown interval and job-block criteria, European journal of business and Management, Vol.3 No.2, pp.85-103.
- [7] Singh T.P.(1995), On 2 x n flow-shop problem involving job-block, transportation time,arbitrary time and breakdown machine time, PAMS,(1995), Vol XXI, No. 1-2 March.
- [8] Nawaz, Ensore & Ham(1983), A heuristics algorithm for the m-machine, n-job flow-shop sequencing problem, OMEGA, pp.91-95.
- [9] Singh T.P., Rejindra K& Gupta Deepak(2005), Optimal three stage production schedule the processing time ans set up times associated with probabilities including job block criteria, Proceeding of National Conference FACM-(2005), pp 463- 470.
- [10] Gupta Deepak, Singla Payal(2012), Constrained n-job, 3-Machine flow shop scheduling problem with transportation time, Vol 2, Issue 2(2012).
- [11] Barer K.R.(1974), Introduction of sequencing and scheduling, John Wiley and sons, New York.
- [12] Bansal S.P.(1986), Resultant job in restricated two machine flow shop problem, IJOMAS, Vol.2, pp. 35-45.
- [13] Bellman R.(1956), Mathematical aspects of scheduling theory, J. Soc. Indust. Appl. Math, Vol.4, pp. 168-205.
- [14] Belwal and Mittal(2008), n jobs machine flow shop scheduling problem with breakdown of machines,transportation time and equivalent job block, Bulletin of pure & Applied Science-mathematics, jan-june, source Vol.27,source Issue 1.
- [15] Chandramouli A.b.(2005), Heuristic approach for n jobs, 3-machines flow shop scheduling problem involving transportation time, breakdown time and weights of jobs, mathematical and computational Application, Vol.10,pp.301-305.
- [16] Heydari(2003), On flow shop schedule problem with processing of jobs and string of disjoint job block fixed and arbitrary order jobs, JISSOR Vol. XXIV No. pp.1-4.
- [17] Jeckson J.R.(1956), An extension of Johnson results on job scheduling, Nav. Res. Log. Quar., Vol.3, pp.201-203.
- [18] Johnson S.M.(1954), Optimal two stage and three stage production schedule with set-up times included, Nav. Res. Log. Quar.,1,pp.61-68.
- [19] D. Gupta, S. Sharma, S. Bala(2012), Optimal Two Stages Specially Structured Flow Shop Scheduling: Minimize the Rental Cost with Independent Setup Time, Vol. 2, No. 3, pp. 31-43, Autumn 2012.