THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE

Maneet kaur et al, The *Experiment, 2013 Vol. 15(4), 1084-1089*

OPTIMAL TWO STAGE OPEN SHOP SCHEDULING IN WHICH PROCESSING TIME, SET UP TIME ASSOCIATED WITH THEIR RESPECTIVE PROBABILITIES

ABSTRACT

The present paper is an attempt through heuristic method to obtain the optimal sequence for n jobs two stage open shop problem in which Set up time separated from processing times, each associated with respective probabilities.. The algorithm developed in this paper is very simple and easy to understand. A numerical illustration to clarify the algorithm is also given.

Keywords Open shop problem, Equivalent job, Elapsed time,.

INTRODUCTION

Job sequence and scheduling problem has a wider application in the industrial areas, which minimizing the manufacturing cost and time or optimizes effectiveness by selecting the most suitable sequence. The earliest results for flow shop scheduling problem was introduced by Johnson [7] in order to minimize the total idle time of the machines. Further the work was developed by Jackson.J.R.[8], Maggu and Das[9], Harbans[6], Yoshida and Hitomi[13], M.Deel'sAmico[10], D.Rebaine[2], Anup[1], Gupta and Singh [3,5,11], Rastogi and Singh [12], Gupta D; Sharma S.[4] by introducing different parameters such as transportation time ,break down interval, weightage etc. Maggu&Das[9] introduced the concept of equivalent job for a job block in which the priority to one job over another was taken into account. Anup[1] extended the study by associating probabilities with processing time as the processing time are always not exact. Open shop scheduling differ from flow shop in the sense that there are no restrictions placed on the order of the machines i.e. operations can be performed in any order A to B or B to A and not known in the advance. Gupta and Singh [5] studied the n*2 open shop problem to minimize the total idle time of the machines in which the probabilities associated with processing time. In this paper we have extended the study made by Gupta and Singh [5] by including the concept of set up time separated from processing times, each associated with respective probabilities .Thus the problem in the present paper has wider and practically more applicable and provides suitable results. An algorithm has been developed to minimize the maximum completion time (makespan). The algorithm is demonstrated through numerical example.

PRACTICAL SITUATION

Many applied and experimental situations occur in day to day working in factories and industrial concern. Open shop scheduling problem has wide engineering application in manufacturing . The practical situation of open shop scheduling may be taken in automobile repair , quality control center , semiconductor manufacturing , satellite communication , class assignment etc. For example in a automobile garage with specialized shop. A car may require the following work: Replacement of exhaust & muffler and alignment of wheels. These two tasks may be carried out in any order on the given machine but it is not possible to perform two tasks simultaneously . The reason is that the exhaust system and alignment are carried out in different shops. One can be performed in any order, even thought it is not possible to execute more than one task simultaneously , due to the nature of the job of restriction of resources . Similarly an airplane may be requiring repairs in engine and electrical circuit. These two tasks may be carried out in any order. In many manufacturing companies different jobs are planted at different places then the transportation time has a significant role in production concern.

THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE

Maneet kaur et al, The *Experiment, 2013 Vol. 15(4), 1084-1089*

NOTATIONS

A_i: Processing time of i^{th} job on machine A.

B_i: Processing time of ith job on machine B.

A'_i: Expected Processing time of ith job on machine A.

B'_i: Expected Processing time of ith job on machine B.

S_i^A: Expected set up time of ith job on machine A.

S_i^B: Expected set up time of ith job on machine B.

P_i: Probability associated to the processing time Ai of ith job on machine A.

Q_i: Probability associated to the processing time Bi of ith job on machine B.

G_i: Processing time of ith job on fictitious machine G.

H_i: Processing time of ith job on fictitious machine H.

PROBLEM FORMULATION

Let n jobs 1, 2, 3,…..n be processed through two machines A and B. Let A_i and $B_i$be the processing time of i^{th} job (i=1,2,3….n) on machine Aand B respectively. Let P_i and qi be the probabilitiesassociated with processing time AiandB_i respectively $0 \le P_i \le 1$, $\sum Pi=1$, $0 \le q_i \le 1$ and $\sum q_i = 1$. Let the setup times S_i^A and $S_i^B$are being separated from precessing time associated with respective probabilities r_i abs si on each machine.

The mathematical model of the problem can be stated in the matrix form as:

Jobs i	Machine A				Machine B			
	A_i	p_i	S_i^A	s_i	B_i	qi	S_i^B	r_i
1	A_1	p_1	S_1^A	S_1	B_1	q1	S_1^B	r_1
2	A_2	p_2	S_2^A	S_2	B_2	q2	S_2^B	r_2
3	A_3	p_3	S_3^A	S_3	B_3	q3	S_3^B	r_3
.	.	.	-	-	.	.	-	-
.	•	.	-	-	.	.	-	-
.	•	.	-	-	.	.	-	-
n	A_n	p_n	S_n^A	s_n	B_n	qn	S_n^B	rn

Tableau-1

THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE

Maneet kaur et al, The *Experiment*, *2013 Vol. 15(4), 1084-1089*

Our objective is to find the optimal schedule of all the jobs which minimize the total elapsed time of each machine, expected processing time may be in the terms of cost.

ALGORITHM

The heuristic algorithm for the problem discussed here, is as follow as:

Step1:: Define two fictitious machines G and H with processing time Gi and Hi as follows :-

(a) $A'i = Ai \times pi - S_i^B \times r_i$

(b) $B'_i = B_i \times q_i - S_i^A \times q_i$

Step2: Represent a new reduced problem with processing time $G_{'i}$ and $H_{'i}$ as per step 2&3

Step3: For the order G→H

Construct a set S_G of all the processing time G'_I where $G'_i \leq H'_i$ and S'_G of all the processing time G'_i where $G'_i \geq H'_i$.

Step4: Let S_1 denote a sub optimal sequence of jobs corresponding to non decreasing times SG and similarly a sequence S_2 corresponding to set S'_G.

Step5: The augmented ordered sequence (S_1, S_2) gives optimal or near optimal sequence for processing the jobs on machine A for the given problem.

Step6: For the order H→G

Construct the set S_H and S'_H of processing times H'_iWhereH$'_i \leq$ $G'_i$and of processing times H'_i where $H'_i \geq G'_i$respectively .

Step7: Let S_2 denote a sub optimal sequence of jobs corresponding to the non decreasing processing times in the set $S_{H.}$ similarlly S'_2 corresponding to S'_H.

Step8: The augmented ordered sequence (S'_1, S'_2) gives the optimal or near optimal sequence for processing the jobs on the machine B for the given problem.

Step9: Prepare in-out tables of sequences (S_1, S_2) and (S'_1, S'_2) in the order A →B and B→A respectively.

NumericalIllustration: Consider 5 jobs, 2 machines open shop problem with processing time and set up time associated with their respective probabilitiesas given in the table 2.

THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE

Maneet kaur et al, The *Experiment, 2013 Vol. 15(4), 1084-1089*

jobs	Machine A				Machine B			
i	A_i	Pi	S_i^A	s_i	B_i	q_i	S_i^A	r_i
1	20	0.2	3	0.3	14	0.2	2	0.1
2	18	0.1	4	0.1	17	0.2	5	0.3
3	13	0.1	1	0.2	12	0.1	6	0.2
4	22	0.3	5	0.1	23	0.2	7	0.2
5	10	0.2	4	0.2	18	0.2	3	0.1
6	19	0.1	3	0.2	13	0.1	2	0.1

Tableau-2 Our objective is to find the optimal/ near optimal sequence which minimizes the total elapsed time.

Solution:-

As per Step1: Define two fictitious machines G and H with their processing times Gi and Hi using: Gi

(a) $A'_i = A_i \times p_i - S_i^B \times r_i$

(b) $B'_i = B_i \times q_i - S_i^A \times q_i$

Jobs	G_i	H_i
1	3.8	1.9
2	0.3	3.0
3	0.1	1.0
4	5.2	4.1
5	1.7	2.8
6	1.7	0.7

Tableau-3

As per Step4: Construct a set S_G and S'_G,S_G= {0.3, 0.1, 1.7} S'_G = {3.8,5.2, 1.7}

As per Step5:S_1 = { 3, 2, 5} S'_1 = {6, 1, 4,}

As per Step6: Augmented ordered sequence ={ 3, 5,2,6, 1, 4}

For the order $H_{\rightarrow G}$: As per step1

Jobs	B'_i	A'_i
1	1.9	3.8
2	3.0	0.3
3	1.0	0.1
4	4.1	5.2
5	2.8	1.7
6	0.7	1.7

Tableau-5

ISSN-2319-2119

REVIEW ARTICLE

Maneet kaur et al, The *Experiment, 2013 Vol. 15(4), 1084-1089*

S_H = {1.9, 4.1, 0.7} S'_H = {3.0, 1.0, 2.8}

As per Step8: S_2 = {6, 1, 4}S'_2 = { 3, 5,2}

As per Step9: Augmented ordered sequence is = {6, 1, 4, 3,5,2}

This gives the exact or near optimal sequence of jobs when processed from A to B

Now we calculate the total production times on machine A and B for the sequence (3, 5, 2, 6, 1, 4) and(6, 1, 4, 6, , 3, 52)respectively.

As per Step10: In – Out table for the order A→B

For the order A→B		
Jobs	Machine A	Machine B
	In Out	In out
3	0 - 1.3	1.3 - 2.5
2	1.5 - 3.3	3.7 - 7.3
5	3.7 - 5.7	8.6 - 12.2
6	6.5 - 8.4	12.5 - 13.8
1	9.0–13.0	14.0 - 16.8
4	13.9 – 20.5	20.5 - 25.1

Tableau-7

In – Out table for the order B→A

For the order B→A		
jobs	Machine B	Machine A
	In Out	In Out
6	0.0 - 1.9	1.9 - 3.2
1	2.5 - 6.9	6.9 - 9.7
4	7.8 - 14.4	14.4 - 19.0
3	14.9 -16.2	20.4 - 21.6
5	16.4 - 18.4	22.8 - 26.4
2	19.2 - 21.0	26.7 - 30.1

Tableau-8

The total expected elapsed time when the order is from A to B for the sequence (3, 2, 5, 6, 1, 4) is 24.9 units and for the sequence (6, 1, 4, 3, 5, 2) is 30.1 units when order is B to A. Hence the optimal sequence of all the jobs which minimize the total elapsed time of each machine is (3, 2, 5,6,1, 4,) for the order A→B.

THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE

Maneet kaur et al, The *Experiment, 2013 Vol. 15(4), 1084-1089*

REFERENCES

1. Anup (2002) ,"On two machine flow shop problem in which processing time assume Probabilities and there exists equivalent for an ordered job block", JISSO, Vol XXIII No.1-4,pp.41-44.
2. D. Rebaine, V. A. Strusevich(1998),"Two machine open shop scheduling with special transportation times",CASSM R&D paper 15,University of Greenwich, London, UK.
3. Gupta Deepak & Singh. T. P.(2004) , " Optimal two stage production schedule with group job -restrictions having set up times separated from processing time, associated with probabilities", Presented and Published in the Proceedings of International conference on Industrial & Applied Mathematics at India International and published in the journal reflections des ERA JMS VOL 1 FEB 2006,pp 53-70.
4. Gupta D; Singla P; Sharma S et.al(2011) , **"**Minimizing Rental Cost for n-jobs 2-Machines flow shop scheduling , processing time association with probabilities including Transportation time and job block criteria", Information and Knowledge Management, ISSN 2224 5758(paper) ISSN 2224- 896x(online),Vol 1,No.3,2011.
5. Gupta Deepak, Singh T.P (2005),"On job block open shop scheduling ,the processing time associated with probability."J.Indian Soc. Stat. Opers. Res. Vol.XXVI, No.1-4.pp. 91-96.
6. HarbansLal and Maggu. P.L. (1989), "On job block open shop scheduling problem", PAMS, pp 45-51. Vol. XXIX.
7. Johnson. S.M. (1954), "Optimal two and three stage production schedule with set up times Included", Nay. Res. Log. Quart. Vol.1.pp -61-68.
8. Jackson, J.R.(1956) , "An extention of Johnson's result on job scheduling", Nav.Res.Log.Quar.,3, 201-203.
9. Maggu. P .L. & Das G.(1977), "Equivalent jobs for job block in job sequencing", Opsearch,Vol.14.No .4,pp.277-281(1977).
10. M. Dell'Amico(1996) , " Shop problems with two machines and time lags",Oper.Res.44,pp 777-787.
11. Singh T.P (1985),"On n*2 shop problem involving job block, transportation time & break down machine times", PAMS Vol. XXI, pp 1-2.
12. Singh T.P. &Rastogi V.K. (1998),"Group job –restrictions in a flowshop problem involvingseparated sequences independent set-up times and transportation time." The Mathematics Education Vol.XXXII.No.1.pp 12-16.
13. Yoshida and Hitomi(1979) , "Optimal two stage production schedule with set up time Separated", AIIE Transactions. Vol. II. Pp261-263.

Deepak gupta, Maneet kaur
Prof & Head of The Department, Mathematics, Maharishi Markandeshwar University, Mullana, Ambala