ISSN 2278-3083

Volume 2, No.4, July – August 2013
International Journal of Science and Applied Information Technology
Available Online at http://warse.org/pdfs/ijsait01242013.pdf

HEURISTIC APPROACH FOR BICRITERIA IN TWO STAGE OPEN SHOP SCHEDULING PROBLEM

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ABSTRACT

This Paper is an attempt to obtains an optimal solution for minimizing the bicriteria so as to minimize the total rental cost of the machines subject to obtain the minimum makespan for n-jobs 2 machines open shop scheduling problem in which the processing times of machines are given.Numerical illustration is given to justify the proposed algorithm.

Keywords: Open shop scheduling, Rental policy, Processing time, Latest time, Utilization time, elapsed time.

1. INTRODUCTION

Scheduling is one of the optimization problem found in real industrial content for which several heuristic procedures have been successfully applied. Scheduling is a form of decision making that plays a crucial role in manufacturing and service industries. It deals with allocation of resources to tasks over given time periods and its goal is to optimize one or more objectives. Flow shop scheduling problem has been one of the classical problem in production scheduling since Johnson [12] proposed the well known Johnson's rule in the two stage flow shop makespan scheduling problem. The work was developed by Jackson J.R [13], Smith [16], Maggu and Das [15], Yoshida and Hitomi [17], D.Rebaine [6],Chandasekharan [4], Anup [1]and Gupta Deepak [8] by considering various parameters such as Transportation time, Breakdown Interval,setup time, Weightage etc.Open shop scheduling differ from flowshop scheduling in the sense that there are no restriction placed on the order of the machines i.e, operations can be performed in any order first machine to second machine or second machine to first machine and not known in the advances. Hence the order of the machines can be selected arbitrarily. Maggu P.L and Harbans lal [14] introduced the concept of n*2 Open shop scheduling problem including job-block criteria.Gupta Deepak and Singh T.P [7] have studied two stage Open shop scheduling problem to minimizing the idle time of the machines in which processing time are associated with their respective probabilities including job block criteria. further work was extended by gupta Deepak and renuka [11] by associated transportation time and weightage of jobs.

Recently Scheduling, so as to approximate more than one criterion received considerable attension. The bicriteria scheduling problems are motivated by the fact that they are meaningful from practical point of view. The bicriteria scheduling problems are generally divided into three classes. In the first class, the problem involved minimizing one criterion subject to the constraint that the other criterion to be optimed. In the second class, both criteria are considered equally important and problem involves finding efficient schedules. In third class, both criteria are weighted differently and an objective function as the sum of the weighted function is defined. The problem considered in this paper belong to the first class.Chandrasekhran Rajendra [4]introduced the concept "two stage flowshop scheduling problem with bicriteria". This work was extended by Bagga P.C & Bhambani. A[3], Chakarvarthy K & Rajendra C [5], Gupta.D & Singh T.P[7], Gupta.D & Sharma.S [8] by considering various parameters.In this present paper we have developed a new heuristic algorithm which gives minimum possible rental cost while minimizing total elapsed time simultaneously in two stage open shop scheduling problem.

2. PRACTICAL SITUTION

Open shop scheduling problems arise in several industrial situations. For example, consider a large aircraft garage with specialized work-centers. An airplane may require repairs on its engine and electrical circuit system. These two tasks may be carried out in any order but it is not possible to do these tasks on the same plane simultaneously. Other applications of open shop scheduling problems are in automobile repair, quality control centers, semiconductor manufacturing, teacher-class assignments, examination scheduling, and satellite communications etc. In the era of globalization or global uncertainties, to meet the challenges of the business, one does not always have enough funds to invest in advanced machines to update the technology. Under such circumstances the machines has to be taken on rent. Rental of machines is an affordable and quick solution for having the equipment and up gradation to new technology

3. NOTATION

S	:Sequence of jobs 1,2,3,.....,n
M_j	:Machine, j=1,2,3.....
A_i	: Processing time of i^{th} job on machine A
B_i	:Processing time of i^{th} job on machine B
C_j	:Rental cost per unit time of machine j
$CT(S_K)$	:Total completion time of the jobs for sequence S_K
$CT(S_{K'})$	: Total completion time of the jobs for sequence $S_{K'}$
$L_2(S_k)$	:Latest time when second machine is taken on rent for sequence S_K
$L_2(S_{K'})$	:Latest time when second machine is taken on rent for sequence $S_{K'}$
$U_2(S_K)$	:Utilization time of second machine for sequence S_K
$U_2(S_k')$	:Utilization time of second machine for sequence S_K'
$R(S_K)$	:Rental cost for sequence S_K
$R(S_{K'})$	:Rental cost for sequence $S_{K'}$

4. RENTAL POLICY

The machines will be taken on rent as and when they are required and are returned as and when they are no longer required.

5. PROBLEM FORMULATION

Let n jobs 1,2,……..,n be processed on two machines M_1 and M_2 in any order i.e. the jobs will be processed first on M_1 and then on M_2 or first on M_2 and then on M_1 under the specified rental policy . Let A_i be the processing time of i^{th} job on machine M_1 and B_i be the processing time of i^{th} job on machine M_2 Our aim is to find the optimal or near optimal sequence $\{S_K\}$ of the jobs which minimizing the rental cost of machines.

Tableau-1

Jobs	Machine M_1	Machine M_2
i	A_i	B_i
1	A_1	B_1
2	A_2	B_2
3	A_3	B_3
-	-	-
n	A_n	B_n

Mathematically, the problem is stated as: Minimize

$$R(S_K) = \sum_{i=1}^{n} A_i(S_K) \times C_1 + U_2(S_K) \times C_2$$

Subject to constraint: Rental Policy(P).

Our objective is to minimize rental cost of machines while minimizing the utilization time.

6. ASSUMPTION

1. Two jobs cannot be processed on a single machine at a time.
2. Jobs are independent to each other.
3. Per-emption is not allowed i.e. once a job started on a machine, the process on that machine cannot be stopped unless the job is completed.
4. Let n jobs be processed through two machines M_1 and M_2 in order $M_1 \rightarrow M_2$ and in order $M_2 \rightarrow M_1$.
5. Machine break down is not considered.

7. ALGORITHM

Step1:For order $M_1 \rightarrow M_2$
Construct a Set S_A of all processing time A_i where $A_i \leq B_i$ and Set S_A’ of all processing time A_i where $A_i \geq B_i$.
Step 2: Let S_1 denote a sub optimal sequence of jobs corresponding to non-decreasing time in set S_A ,Similarly S_1’ corrosponding to set S_A’.
Step 3: The augmented ordered sequence $S_K = (S_1, S_1')$ are optimal/or near optimal sequence for processing the jobs on machine M_1 which given the minimum rental cost for given problem.
Step 4: For order $M_2 \rightarrow M_1$
Construct a Set S_B of all processing time B_i where $B_i \leq A_i$ and Set S_B’ of all processing time B_i where $B_i \geq A_i$.
Step 5: Let S_2 denote a sub optimal sequence of jobs corresponding to non-decreasing time in set S_B ,Similarly S_2’ corrosponding to set S_B’.
Step 6: The augmented ordered sequence $S_K' = (S_2, S_2')$ are optimal/or near optimal sequence for processing the jobs on machine M_2 which given the minimum rental cost for given problem.
Step 7: Prepare in-out table of sequence $S_K = (S_1, S_1')$ and$S_K' = (S_2, S_2')$ in the order $M_1 \rightarrow M_2$ and $M_2 \rightarrow M_1$ respectively.
Step 8: Compute the total completion time $CT(S_K)$ and $CT(S_K')$ by computing in-out table for sequence S_K and S_K’ respectively.
Step 9: Calculate latest time at which second machine is taken on rent as follow:

$$L_2(S_K) = CT(S_K) - \sum_{i=1}^{n} B_i$$

$$L_2(S_K') = CT(S_K') - \sum_{i=1}^{n} A_i$$

Step 10: Prepare in-out table for sequence S_K and S_K’ having latest time on second machine is $L_2(S_K)$ and $L_2(S_K')$ respectively.
Step 11: Compute utilization time $U_2(S_K)$ and $U_2(S_K')$ of second machine as follow:

$$U_2(S_K) = CT(S_K) - L_2(S_K)$$

$$U_2(S_K') = CT(S_K') - L_2(S_K')$$

Step 12: Find rental cost for sequence S_K and S_K’ as follow:

$$R(S_K) = \sum_{i=1}^{n} A_i(S_K) \times C_1 + U_2(S_K) \times C_2$$

$$R(S_K') = \sum_{i=1}^{n} B_i(S_K') \times C_2 + U_2(S_K') \times C_1$$

Where C_1 and C_2 are the rental cost per unit time of machine M_1 and M_2 respectively.

8. NUMERICAL ILLUSTRATION

Consider 5 jobs and 2 machines open shop problem to minimize the rental cost. The Processing time of these jobs are giveb as follow. Rental cost per unit time for machine M_1 and M_2 are 10 and 15 respectively.

Tableau-2

Jobs	Machine M_1	Machine M_2
i	A_i	B_i
1	22	18
2	28	30
3	32	16
4	17	21
5	20	25

Our objective is to obtain optimal schedule and order to minimize total elapsed subject to minimize the total rental cost of the machines,under the rental policy P.

SOLUTION:

For order $M_1 \rightarrow M_2$

Tableau-3

Jobs	Machine M_1	Machine M_2
i	A_i	B_i
1	22	18
2	28	30
3	32	16
4	17	21
5	20	25

As per step 1:

Construct a set S_A and S_A'

S_A = { 28,17,20 } S_A' = { 22,32 }

As per step 2:

S_1 = { 4,5,2 } S_1'={ 1,3 }

As per step 3:

Augmented ordered sequence S_K = { 4,5,2,1,3 }

As per step 7:

In-out table of sequence S_K for order $M_1 \rightarrow M_2$ as follow in table-4

Tableau-4

Jobs	Machine M_1	Machine M_2
4	0-17	17-38
5	17-37	38-63
2	37-65	65-95
1	65-87	95-113
3	87-119	119-135

As per step 8 and 9:

Total completion time for sequence S_K is $CT(S_K)$ = 135

Latest time at which second machine is taken on rent for sequence S_K

$L_2(S_K)$ =135-110

= 25

As per step 10:

In- out table for sequence S_K having latest time on second machine is 25 as follow in Table-5

Tableau-5

Jobs	Machine M_1	Machine M_2
4	0-17	25-46
5	17-37	46-71
2	37-65	71-101
1	65-87	101-119
3	87-119	119-135

As per step 11 and 12:

Utilization time of second machine for sequence S_K

$U_2(S_K)$ = 135-25

=110

Rental cost $R(S_K)$ = 119×10 + 110×15

=2840

Total Elapsed time = 135

Order $M_2 \rightarrow M_1$

Tableau-6

Jobs	Machine M_2	Machine M_1
i	B_i	A_i
1	18	22
2	30	28
3	16	32
4	21	17
5	25	20

As per step 4 and 5:

Construct a set S_B and S_B'

S_B = { 18,16 } S_B' = { 30,21,25 }

S_2 = { 3,1 } S_2'={ 4,5,2 }

As per step 6:

Augmented ordered sequence S_K' = { 3,1,4,5,2 }

As per step 7:

In-out table of sequence S_K' for order $M_2 \rightarrow M_1$ as follow in table-7

Tableau-7

Jobs	Machine M_2	Machine M_1
3	0-16	16-48
1	16-34	48-70
4	34-55	70-87
5	55-80	87-107
2	80-110	110-138

As per step 8 and 9:

Total completion time for sequence S_K' is $CT(S_K')$ = 138

Latest time at which second machine is taken on rent for sequence S_K'

$L_2(S_K')$ =138-119

= 19

As per step 10:

In- out table for sequence S_K' having latest time on second machine is 19 as follow in table-8

Tableau-8

Jobs	Machine M_2	Machine M_1
3	0-16	19-51
1	16-34	51-73
4	34-55	73-90
5	55-80	90-110
2	80-110	110-138

As per step 11 and 12:

Utilization time of second machine for sequence S_K'

$U_2(S_K') = 138-19$

$=119$

Rental cost $R(S_K') = 110 \times 15 + 119 \times 10$

$=2840$

Total elapsed time= 138

Total rental cost when the order is from M_1 to M_2 for the sequence (4,5,2,1,3) is 2840 units and total elapsed time=135 and when order M_2 to M_1 for sequence (3,1,4,5,2) rental is 2840 and total elapsed time is 138. Hence order M_1 to M_2 is optimal order which minimize total elapsed time and rental cost simultaneously.

9. REMARKS

1. Operations can be performed in any order first machine to second machine or second machine to first machine and not known in the advances.
2. The work may further be exrented for n jobs 3 machines open shop problem.
3. The study can further be extended by considering various parameters such as transportation time, job-block, setup time, breakdown intervals etc

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