An Heuristic Approach for Solving Permutation Flow Shop Scheduling Problem

Jayakumar Sundaramoorthy1, Sathiya Shanthi Ramesh Babu2, Meganathan Rangaraji3
1Department of Mathematics, Arignar Anna Govt. Arts College, Cheyyar, Tamil Nadu.
2 & 3Department of Mathematics, Shanmuga Industries Arts & Science College, Tiruvannamalai, Tamil Nadu.

Abstract - Scheduling n jobs on m machines in the flow shop environment is NP-hard and also finds prominent place in the field of production scheduling. In this paper, scheduling of n jobs on m machines in a permutation flow shop environment with makespan minimization objective is considered. One of the methods available in the literature is modified and comparison is made with our algorithm. It was found that our algorithm is superior to the earlier one.

Keywords – Scheduling, permutation, Flow shop Scheduling, heuristics, makespan.

I. INTRODUCTION

Flow shop scheduling is a decision making procedure that is used on a regular basis in many manufacturing and services industries. Its aim is to optimize one or more objectives with the allocation of resources over given periods of time. The resources may be machines in a workshop, crews at a construction site and runways at an airport and so on. The jobs may be operations in a production process, stages in a construction project, take–offs and landings in an airport and so on. Flow shop scheduling place an important role in most manufacturing and service systems as well as in most information processing environments. It is difficult to find an optimum solution in polynomial time. So it is important to improve the flow shop scheduling algorithms for reducing the running time of the machines which is useful in the area of production scheduling.

There are so many objectives to be minimized for a flow shop scheduling problems such as makespan, total job completion time, total flow time, mean flow time and tardiness and so on. In this paper, we considered the permutation flow shop scheduling problem with makespan objective.

II. LITERATURE REVIEW

Over the last half century, most of the heuristics were developed for the objective of makespan minimization in flow shop scheduling problems. In 1954, Johnson was the one who formulated first the flow shop scheduling problem and developed a heuristic algorithm for n-jobs 2-machine production scheduling problem with the objective of minimizing the throughput time (makespan) of all jobs. After him, so many researchers found different heuristic algorithms for makespan minimization in the flow shop scheduling for machine problems.

In 1965, Palmer developed a heuristic algorithm which can be applied to the large- sized problems by giving priority to the jobs so that jobs with processing times that tends to increase from machine to machine will get higher priority and known as Palmer’s slope index method. Cambell, Dudek and Smith (1970) extended Johnson’s algorithm for the m – machine flow shop scheduling problem with makespan objective which is called CDS method. In that, Johnson’s algorithm was applied in all the m-1 stages of the m-machine problem and an optimal sequence was chosen from the m-1 sequences obtained from m-1 stages.

Similar to the Palmer’s slope index method, Gupta (1971) provided another heuristic by defining the slope index in a different way by taking into account some attractive facts about the optimality of Johnson’s algorithm. To provide a good solution as easily and quickly as possible, Dannenbring (1977) suggested a procedure called rapid access (RA heuristic) in which the processing times of the two hypothetical machines are the sum of the products of the weights of a particular machine and the processing time of the corresponding machine of a particular job. Nawaz, Enscore and Ham (1983) follows the priority rule in which a job with high total processing time on all machines should be given higher priority than job with low total processing time. Based on this, they developed a heuristic algorithm (NEH heuristic) which finds the optimal sequence in a constructive way so that adding a new job at each step and finding the best partial solution. In recent years, the above said algorithms are the basically used to compare with the new algorithms often by many researchers.

Sahu (2009) made a comparative study of Gupta’s, RA, CDS and Palmer’s heuristics for 8 – jobs 3 – machines, 10 – jobs 8 – machines and 10 – jobs 10 – machines flow shop scheduling problems and concluded that RA heuristic performs well than other heuristics. Shu-Hui Yang Ji-Bo Wang (2011) developed a branch-and-bound algorithm for two machine flow shop scheduling to minimize the total weighted completion time problem. Several dominance properties and two lower bounds are derived to speed up the elimination process of branch- and – bound algorithm. Also they proposed a heuristic algorithm to solve the inefficiency of the branch – and - bound algorithm. Based on profile fitting approach, Quan-Ke Pan and Ling Wang (2012) provided two simple constructive heuristics, namely weighted profile fitting (wPF) and PW. Also they developed three improved constructive heuristics, called PF-NEH, wPF-NEH and PW-NEH by combining the PF, wPF and PW with the NEH heuristics algorithm. Baskar and Antony Xavior (2012) developed a new heuristic algorithm using Pascal’s triangle to determine more than one parameter like makespan, total flow time and makespan obtained by this method is much lower than the makespan we have obtained in the older algorithm.

While many algorithms deals with the single objective of makespan, a few researchers like Rajendran (1995), Allahverdi and Al-Anzi (2008), Ming- Cheng Lo, Jen-Shing Chen and Yong – Fo Chang (2010) had worked on flow shop scheduling with multi-objective of minimizing more than one parameter like makespan, total flow time and mean completion time. Tang and Zhao (2008) suggested an algorithm for scheduling a single continuous batching machine with the bi-criteria objective of makespan and total completion time. The concept of learning effect plays an important role in production engineering. Eren and Guner (2008) developed a bi-criteria flow shop scheduling problem with a learning effect for the two machine problem where the objectives were makespan and weighted sum of completion time. Chia and Lee (2009) developed the total completion time problem in a permutation flow shop with a learning effect. They evaluated the performance of so many well known heuristics when the learning effect is present.

III. STATEMENT OF THE PROBLEM

In a flow shop problem, a set of n jobs has to be processed on m different machines in the same order. Each job j, j=1, 2... n, must processed on machines i, i= 1, 2, ..., m, with a non negative processing time. Each machine can processes at most one job and each job can be handled by at most one machine at any given time. The machines process the jobs in a first come first served manner. The permutation schedule is considered in this paper.

In the present work, the objective is to find a sequence that minimizes the maximum completion time that is makespan. An attempt has been made for comparing two heuristics for makespan minimization in flow shop scheduling.

IV. OUR ALGORITHM

G. Krishna and P. Vijay (2013) proposed an algorithm to provide a solution for permutation flow shop scheduling makespan problem. Based on its idea, a new heuristic algorithm is presented here to deal with the flow shop makespan problem. A formal expression of our algorithm is given in this section.

Step 1:- Reduce the given m-machine problem into m-1 machine problem by adding processing times of M_1 & M_2, M_2 & M_3, M_3 & M_4, …… and so on.

Step 2:- The least process time of the first column is identified and transforms the respective row bearing the least number to the first row.

Step 3:- Similarly find the least process time in the last column and shift the entire row down. Repeat the procedure and applying this to the entire table we arrive at a processing time matrix where we have upper triangle arranged in ascending order and lower triangle arranged in descending order.

The makespan obtained by this method is much optimal than the makespan we have obtained in the older methods.

V. COMPARISON WITH THE EXISTING METHOD

Comparison of our algorithm with the existing algorithm by V. G. Krishna and P. Vijay (2013) is given in this section with an example.

5.1. Example

Consider a FSP with 5 jobs and 5 machines.

<table>
<thead>
<tr>
<th>JOBS</th>
<th>M/C1</th>
<th>M/C2</th>
<th>M/C3</th>
<th>M/C4</th>
<th>M/C5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>13</td>
<td>9</td>
<td>6</td>
<td>4</td>
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<td>2</td>
<td>14</td>
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<td>5</td>
<td>3</td>
<td>9</td>
<td>5</td>
<td>13</td>
<td>8</td>
</tr>
</tbody>
</table>

After applying step 1 of our algorithm, the 5- machine problem is reduced as 4- machine problem as follows.

<table>
<thead>
<tr>
<th>JOBS</th>
<th>M/C1</th>
<th>M/C2</th>
<th>M/C3</th>
<th>M/C4</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>22</td>
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<td>10</td>
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<td>2</td>
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<td>11</td>
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<tr>
<td>5</td>
<td>12</td>
<td>14</td>
<td>18</td>
<td>21</td>
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By applying step 2 & 3 of our algorithm, we get the sequence for the problem as 5-4-2-3-1.
A Functional hop me in Two istics
A discrete firefly meta istics algorithm based on the
ational
Theory,‖, Wiley, 46.

JOBS options of job sequences that can be implemented for
makespan objective.
proposed for the flow shop scheduling problem with
algorithm by V. G. Krishna and P. Vijay

5
CDS method to this problem, the optimal sequence is
makespan value for that sequence is 77. Also if we apply
algorithm proposed by V. G. Krishna and P. Vijay
sequence
5
1
2
4
3
5
1

From the above table, we observe that the makespan for the 5- machine flow shop scheduling problem to the
sequence 5-4-2-3-1 is 74. But when we apply the algorithm proposed by V. G. Krishna and P. Vijay (2013), the optimal sequence is 5-4-2-1-3 and the makespan value for that sequence is 77. Also if we apply CDS method to this problem, the optimal sequence is 5-2-3-4-1 and the makespan value for that sequence is 79.

VI. CONCLUSION

In this paper, a new heuristics algorithm based on the
algorithm by V. G. Krishna and P. Vijay (2013) is
proposed for the flow shop scheduling problem with makespan objective. From the analysis, the heuristics algorithm proposed by the authors is for superior than the other two found in the literature and hence we have more options of job sequences that can be implemented for greater production.

REFERENCES


Calculation of time in- time out table for the sequence 5-4-2-3-1.

<table>
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<th>M/C3</th>
<th>M/C4</th>
<th>M/C5</th>
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