Flow Shop Scheduling Model for 5 machine without Job Block Criteria Using NEH Technique

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Abstract: The present paper describes no job block criteria using NEH technique in a Flow Shop Scheduling Model for five machines. In flow shop, constraints demand that the jobs passing the machine are same. The probabilities are associated with their respective processing times, in which the optimization criteria is the utilization of 5 machines. For a group of jobs in 5 machines, with no job block and No-wait time is considered in the paper. Our agenda is to reduce the total completion time and the shortest job sequence path using NEH algorithm. Sample numerical illustrations are provided to understand the NEH algorithm easily.

Keywords: Flow shop scheduling, Flow Time, Make span, NEH Algorithm.

Introduction
Flow-shop scheduling problem (FSP) is one of the most important problems in industries to develop the manufacturing level with certain period of time and improve the customer’s satisfactory level. The problem has a set of n jobs and a set of m machines. Each job should proceed in every m machines in the same order. In this paper, our objective is to find the optimal makespan in a flowshop scheduling problem. ¹Baskar, A., & Xavior, M. (2013) discussed Ruben Ruiz benchmark concepts for further development of obtain the makespan quickly in the usage NEH family of algorithms for scheduling problems. It has been usually general that, the NEH heuristic algorithm performs reasonably higher among the current easy heuristics. ²Fernandez-Viagas, V., & Framinan, J. M. (2014) concluded that tie breaking mechanism to select the job sequential order while they are used NEH and iterated Greedy method. ³Baskar, A., (2016) analyzed his paper, the job insertion technique employed by NEH algorithmic rule and proposes several new variants, the complexity level remains same. One hundred twenty numbers of downside instances planned by Taillard are used for the aim of validatory the algorithms. We referred Scheduling Theory, Algorithms, and Systems by ⁴Pinedo, M. L. (2012). He explained different concepts about flow shop problems in that book.⁵Kalkczynski, P. J., & Kamburowski, J. (2008) used concept of Johnson’s algorithm for developing the solution for scheduling problem and finally he concluded that new priority sequential order for problem for all number of problems. ⁶Gajpal and Rajendran (2006) have found the best solution when compared the solution with ant colony and existing heuristic for the permutation PFSP. ⁷Johnson’s (1954) provided best algorithm for researchers to solve the various types of machine problem. ⁸Campbell, Dudek, and Smith introduced heuristic algorithm to extend the Johnson’s problem which pick the minimum completion time out of the (m-1) enumerations. The effective method was introduced by ⁹Nawaz, M., Enscore, E. E., & Ham, I. (1983) which uses the nice job insertion technique after arranging the jobs in the non -increasing order of their total processing instances. In that method he Choose first two jobs as the initial partial sequence and other jobs are inserted one by one from the third job to
obtain a final optimal makespan and its corresponding sequence. Taillard (1990) explained in detail about the benchmark problem by analyzing simple heuristics and it was finalized that the NEH algorithm is a better one for different sizes of problems varying from 9 to 50 jobs. Improvements had been finished on the NEH set of rules through the years to reduce the makespan in addition to the computing time.

Practical Situation

1 Assumptions:

1. Initially to start a process all the jobs are available.
2. Processing time associated with probabilities are included with set-up time for the machines
3. Job on a particular machine will be allowed only after completing the same job on the previous machine
4. Machines may be idle.
5. Processing time of the jobs on the schedule is maintained independently
6. At a time, in a machine multiple jobs cannot be processed.

2 Notations:
We are given n jobs to be processed on two stage flowshop scheduling problem and we have used the following notations

\[ J_{ij} \] - Processing time for ith job on machine \( M_j \)

\[ P_{ij} \] - Probability associated to the processing time \( J_{ij} \)

3 Mathematical Development:
Consider \( n \) jobs say \( i=1, 2, 3 \ldots n \) are processed on five machines \( M_1, M_2, M_3, M_4 \& M_5 \). A job \( J(i=1,2,3\ldots n) \) has processing time \( J_{i1}, J_{i2}, J_{i3}, J_{i4} \& J_{i5} \) on each machine respectively, assuming their respective probabilities \( P_{i1}, P_{i2}, P_{i3}, P_{i4} \& P_{i5} \) such that \( 0 \leq P_{ij} \leq 1, \Sigma P_{ij} = 1 \)

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 |
|-----|------------|------------|------------|------------|------------|
| i   | Ji1        | P11        | Ji2        | P12        | Ji3        | P13        | Ji4        | P14        | Ji5        | P15        |
| 1   | J11        | P11        | J12        | P12        | J13        | P13        | J14        | P14        | J15        | P15        |
| 2   | J21        | P21        | J22        | P22        | J23        | P23        | J24        | P24        | J25        | P25        |
| 3   | J31        | P31        | J32        | P32        | J33        | P33        | J34        | P34        | J35        | P35        |
| 4   | J41        | P41        | J42        | P42        | J43        | P43        | J44        | P44        | J45        | P45        |
| 5   | J51        | P51        | J52        | P52        | J53        | P53        | J54        | P54        | J55        | P55        |

| n   | -          | -          | -          | -          | -          | -          | -          | -          | -          |

Our objective is to find the shortest makespan path by using NEH Algorithm
NEH Algorithm:
Step1: Calculate expected value of processing time on five machines $A_{ij}$

\[
\sum_{i=1}^{4} \sum_{j=1}^{5} A_{ij}, \quad j = 1, 2, 3, 4 & 5.
\]

Step2: Arrange the jobs by non increasing order
Step3: Select first 2 subsequence job from result of step 2
Step4: Choose the best sequence having minimum makespan.
Step5: Continue the process until all the jobs are available in the best sequence

Numerical Illustration:
Consider 4 jobs 5 machine flow shop problem whose processing time of the jobs on each machine is given below.

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 |
|-----|------------|------------|------------|------------|------------|
| i   | Ji1        | Pi1        | Ji2        | Pi2        | Ji3        | Pi3        | Ji4        | Pi4        | Ji5        | Pi5        |
| 1   | 15         | 0.4        | 50         | 0.2        | 30         | 0.3        | 55         | 0.2        | 50         | 0.4        |
| 2   | 50         | 0.2        | 40         | 0.1        | 55         | 0.2        | 20         | 0.1        | 45         | 0.2        |
| 3   | 50         | 0.2        | 10         | 0.5        | 20         | 0.3        | 30         | 0.3        | 35         | 0.2        |
| 4   | 25         | 0.2        | 45         | 0.2        | 45         | 0.2        | 20         | 0.4        | 15         | 0.2        |

Solution: As per step1 the expected processing times for machines M1, M2, M3, M4 & M5 are as follow:

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 | Sum $\sum_{i=1}^{4} \sum_{j=1}^{5} A_{ij}$ |
|-----|------------|------------|------------|------------|------------|----------------------------------|
| i   | Ai1        | Ai2        | Ai3        | Ai4        | Ai5        | 38                               |
| 1   | 6          | 10         | 9          | 11         | 2          |                                  |
| 2   | 10         | 4          | 11         | 2          | 9          | 36                               |
| 3   | 10         | 5          | 6          | 9          | 7          | 37                               |
| 4   | 5          | 9          | 9          | 8          | 3          | 34                               |

As per Step2, Arrange the jobs in non increasing order 1-3-2-4
As per Step3, select first 2 jobs from the above sequence
The possible sequence are 1-3 and 3-1

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 |
|-----|------------|------------|------------|------------|------------|
| 1   | 0-6        | 6-16       | 16-25      | 25-36      | 36-38      |
| 3   | 6-16       | 16-21      | 25-31      | 36-45      | 45-52      |
Table 5

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 |
|-----|------------|------------|------------|------------|------------|
| 3   | 0-10       | 10-15      | 15-21      | 21-30      | 30-37      |
| 1   | 10-16      | 16-26      | 26-35      | 35-46      | 46-48      |

The minimum makespan is 48, Hence the optimal sequence is 3-1

As per Step 4, Insert the job 2 in the above optimal sequence
The possible sequence are 2-3-1, 3-2-1 and 3-1-2

Table 6

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 |
|-----|------------|------------|------------|------------|------------|
| 2   | 0-10       | 10-14      | 14-25      | 25-27      | 27-36      |
| 3   | 10-20      | 20-25      | 25-31      | 31-40      | 40-47      |
| 1   | 20-26      | 26-36      | 36-45      | 45-56      | 56-58      |

Table 7

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 |
|-----|------------|------------|------------|------------|------------|
| 3   | 0-10       | 10-15      | 15-21      | 21-30      | 30-37      |
| 2   | 10-20      | 20-24      | 24-35      | 35-37      | 37-46      |
| 1   | 20-26      | 26-36      | 36-45      | 45-56      | 56-58      |

Table 8

| job | Machine M1 | Machine M2 | Machine M3 | Machine M4 | Machine M5 |
|-----|------------|------------|------------|------------|------------|
| 3   | 0-10       | 10-15      | 15-21      | 21-30      | 30-37      |
| 1   | 10-16      | 16-26      | 26-35      | 35-46      | 46-48      |
| 2   | 16-26      | 26-30      | 35-46      | 46-48      | 48-57      |

The minimum makespan is 57, Hence the optimal sequence is 3-1-2

Insert Job 4 in the above optimal sequence and the possible sequences are
4-3-1-2, 3-4-1-2, 3-1-4-2 and 3-1-2-4

The minimum makespan is 62, Hence the optimal sequence is 4-3-1-2.

**Pascal’s Triangle Algorithm**

Step1: Find the product of processing time of the machine with Pascal’s triangle number.

Step2: Find the sum of the product.

Step3: ‘n’ job, ‘m’ machine problem is converted into ‘n’ job, ‘2’ machine problem.

Step4: Apply Johnson’s algorithm to find the optimal solution.

New Imaginary machines Gi and Hi are arrived from Table 3 as per Pascals algorithm
Table 9

| job | Gi | Hi |
|-----|----|----|
| 1   | 74 | 72 |
| 2   | 57 | 52 |
| 3   | 52 | 57 |
| 4   | 67 | 63 |

By Johnson’s rule, the total completion time is 67 and the corresponding optimal sequence is 3-2-1-4.

CDS algorithm

Step1: Convert five machine into two fictitious machines

Step2: Apply Johnson’s algorithm to find the optimal solution

New machines MH1 and MH2 are arrived from Table 3 as per CDS algorithm

Table 10

| job | MH1              | MH2              |
|-----|------------------|------------------|
| 1   | M1+M2+M3+M4     | M2+M3+M4+M5     |
| 1   | 36               | 32               |
| 2   | 27               | 26               |
| 3   | 30               | 27               |
| 4   | 25               | 29               |

Applying Johnson’s algorithm, The optimal sequence is 1-4-3-2 and the Completion time is 69.

The below comparison shows NEH algorithm provides the best optimal sequence with minimal completion time
Conclusion
The objective was to minimize the total completion time and also satisfies the customer’s satisfactory. This paper concludes that after using five machines without job block by using NEH method which minimizes the total elapsed time. The above illustration does not have any tie breaking scenarios. Tie breaking mechanism are applied to break the Tie.

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