ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

*International Journal of Mechanical Engineering*

# Insertion of Tie – Breaking Mechanism for Flow Shop Scheduling Problem

E. Janaki
Panimalar Institute of Technology, Chennai, India

A. Mohamed Ismail
Sathyabama Institute of Science and Technology, Chennai.

A. Thiruppathi
Panimalar Institute of Technology, Chennai, India.

***Abstract* - This paper deals with Tie – Breaking mechanism applied in NEH technique for four machines and four job problem in a Flow Shop Scheduling. To get an ideal succession in NEH strategy Tie-Breaking system assumes a crucial part. Work successive request is same for all machines in Permutation stream shop planning problem (PFSP). The conceivable number of grouping is (n!)m. Since the quantity of machine is four, the issue can be taken as NP-complete. Mathematical outlines are given to comprehend the NEH calculation without any problem.**

*Keywords* – Flow shop scheduling, Makespan, NEH Algorithm, Tie-Breaking rule.

## INTRODUCTION

Flow-shop planning downside (FSP) is one in every of the foremost wide studied combinatorial optimization issues with industrial application to get the satisfactory level to cut back the create span time. It deals with a collection of n jobs J and a collection of m machines M to seek out the best makespan victimization flow-shop planning problem. every job ought to proceed in each m machines within the same order. A new vision of approximate methods for the permutation flowshop used by [1]Fernandez-Viagas and [5]Framinan explained the methd of NEHKK1 inserting. [4]Janaki (2019) explained Tie breaking mechanism using NEH algorithm.[2]Weibo Liu, Yan Jin provides (2017) a new improved NEH heuristic for permutation flowshop scheduling problems [14]Nawaz et al. (1983) projected the NEH formula that uses the simplest job insertion technique when composition the roles within the degressive order of their total process times. Select 1st 2 jobs because the initial partial sequence and alternative jobs square measure inserted one by one from the third job to get a final best makespan and its corresponding sequence. [17]Taillard (1990) explained very well concerning the quality level and also the quality of some earlier easy heuristics and it had been over that the NEH formula could be a higher one for various sizes of issues variable from nine to fifty jobs.[10] Framinan et al. (2003) known 176 approaches for each objective perform, considering twenty two totally different| completely different} approaches and eight different sorting criteria. an equivalent was over by a groundwork conducted by[12] Kalczynski and Kamburowski (2007). combinational NEH family of heuristics method were analysed by [3]Baskar, A., & Xavior, (2013). The SPIRIT formula of [19]Widmer and Hertz (1989) is additionally a constructive heuristic supported the well-known roadman downside. some alternative constructive heuristic algorithms like method Rajendran (1993),[11] Gajpal and Rajendran 2006) additionally use the NEH to get the simplest sequence of jobs. [6]Liu, G., Song, S., Wu (2012). Explains about Two techniques NEH algorithm for flowshop scheduling problems, also [7]Liu derived new heuristic to minimize system idle time and [8]Liu, G., Song, S., Wu, C explained heuristic for permutation flow-shop problems with bicriteria of makespan and machine idle time. Comparing three-step heuristics for the permutation Flow shop problem analysed by [9] Ribas, I., Companys, R., and Tort-Martorell, X.[15]Pinedo, M.L. (2012). Explained Theory, 1808–1822 enhancements are performed on the NEH formula over the years to attenuate the makespan furthermore because the computing time. [20]Campbell et al. (1970) projected CDS formula that is that the extension of Johnson's formula to decide on the smallest makespan out of the (m-1) list. Over the decades, several variants and enhancements are recommended by the researchers. some claims are evidenced to be false additionally.

## PRACTICAL SITUATION

*Assumptions*

1. Initially to begin an interaction every one of the positions are accessible.
2. Processing time related with probabilities are incorporated with set-up an ideal opportunity for the machines.
3. Job on a specific machine will be permitted solely after following through with a similar task on the past machine
4. Machines might be inactive.
5. Processing time of the positions on the timetable is kept up with freely
6. At a period, in a machine numerous positions can't be handled.
7. Total float of the basic occasion should zero.

*Notations*

We are given n responsibilities to be handled on two phase Flow shop Scheduling issue and we have utilized the accompanying documentations

$J_{ij}$ - Processing time for $i^{th}$ worl on machine $M_j$

$P_{ij}$ - Probability related to the handling time $J_{ij}$.

$C_{ij}$ – Completion time for $i^{th}$ job on machine $M_{jj}$

$TF_i = LF_i - EF_i$, Total Float of the i $^{th}$ event

## MATHEMATICAL DEVELOPMENT

The following table denotes n jobs &m machines with probability.

TABLE 1

OUR GOAL IS TO OBSERVE THE MOST LIMITED MAKE RANGE WAY BY UTILIZING NEH ALGORITHM

| job | Machine $M_1$ | | Machine $M_2$ | | | | Machine $M_m$ | |
|---|---|---|---|---|---|---|---|---|
| i | $J_{i1}$ | $P_{i1}$ | $J_{i2}$ | $P_{i2}$ | - | - | $J_{im}$ | $P_{im}$ |
| 1 | $J_{11}$ | $P_{11}$ | $J_{12}$ | $P_{12}$ | - | - | $J_{1m}$ | $P_{1m}$ |
| 2 | $J_{21}$ | $P_{21}$ | $J_{22}$ | $P_{22}$ | - | - | $J_{2m}$ | $P_{2m}$ |
| | - | - | - | - | - | - | - | - |
| n | - | - | - | - | - | - | - | - |

*Algorithm*

* Calculate expected value of processing time on four machines
* Arrange the positions by non increasing order
* Select first 2 subsequence job
* Choose the best sequence having minimum makespan.
* Continue the interaction until every one of the positions are accessible in the best grouping.
* If Tie happen then eliminate the Tie by utilizing heuristic calculation

*Proposed Algorithm*

Our proposed algorithm explains Tie- breaking rule to find the exact position' k' for inserting the unallocated job 'r'while tie occur

- Calculate Total float = amount of time an event can be late without delaying the project completion period= $LS_{i,k+1} - EF_{i,k-1}$
- Find the mean value of ratio of processing time of unscheduled job k and total float.

mean value $\overline{X}_k = \frac{1}{m}\sum_{i=1}^{m}\frac{p_{ir}}{LS_{i,k+1} - EF_{i,k-1}}$ where $X_k = \frac{p_{ir}}{LS_{i,k+1} - EF_{i,k-1}}$

- Find the second order moment about the mean (central moment) which is called variance $E(X_k - \overline{X}_k)^2$
- Variance $J_k == \sum_{i=1}^{m}\frac{(X_k - \overline{X}_k)^2}{n-1}$
- Select the Minimum value of variance to insert the unallocated job at the exact position.
- Now insert the job in that position

*Numerical Illustration*

Consider the the following example.

TABLE 2

| **Job** | **Machine $M_1$** | | **Machine $M_2$** | | **Machine $M_3$** | | **Machine $M_4$** | |
|---|---|---|---|---|---|---|---|---|
| i | $J_{i1}$ | $P_{i1}$ | $J_{i2}$ | $P_{i2}$ | $J_{i3}$ | $P_{i3}$ | $J_{i4}$ | $P_{i4}$ |
| 1 | 4 | 0.5 | 35 | 0.2 | 20 | 0.3 | 15 | 0.2 |
| 2 | 15 | 0.2 | 20 | 0.1 | 15 | 0.2 | 25 | 0.2 |
| 3 | 10 | 0.2 | 50 | 0.4 | 30 | 0.1 | 40 | 0.1 |
| 4 | 20 | 0.1 | 10 | 0.3 | 25 | 0.4 | 20 | 0.5 |

*Solution:*

TABLE 3

| **job** | **Machine $M_1$** | **Machine $M_2$** | **Machine $M_3$** | **Machine $M_4$** | **Sum** |
|---|---|---|---|---|---|
| i | $A_{i1}$ | $A_{i2}$ | $A_{i3}$ | $A_{i4}$ | $\sum_{i=1}^{4} A_{ij}$ |
| 1 | 3 | 2 | 3 | 5 | 13 |
| 2 | 2 | 7 | 6 | 3 | 18 |
| 3 | 2 | 20 | 3 | 4 | 27 |
| 4 | 2 | 3 | 10 | 10 | 25 |

TABLE 4

| **job** | **Machine $M_1$** | **Machine $M_2$** | **Machine $M_3$** | **Machine $M_4$** | **Sum** |
|---|---|---|---|---|---|
| i | $A_{i1}$ | $A_{i2}$ | $A_{i3}$ | $A_{i4}$ | $\sum_{i=1}^{4} A_{ij}$ |
| 1 | 3 | 2 | 3 | 5 | 13 |
| 2 | 2 | 7 | 6 | 3 | 18 |
| 3 | 2 | 20 | 3 | 4 | 27 |
| 4 | 2 | 3 | 10 | 10 | 25 |

* Sequential order 3-4-2-1
* Select first 2 jobs from the above sequence

The possible sequence are 3-4and 4-3

| **Job** | **Machine $M_1$** | **Machine $M_2$** | **Machine $M_3$** | **Machine $M_4$** |
|---|---|---|---|---|
| 3 | 0-2 | 2-22 | 22-25 | 25-29 |
| 4 | 2-4 | 22-25 | 25-35 | 35-45 |

TABLE 5

| **Job** | **Machine $M_1$** | **Machine $M_2$** | **Machine $M_3$** | **Machine $M_4$** |
|---|---|---|---|---|
| 4 | 0-2 | 2-5 | 5-15 | 15-25 |
| 3 | 2-4 | 5-25 | 25-28 | 28-32 |

The least makespan is 32 Hence the ideal grouping is 4-3.
After inserting the job 2 in the above optimal sequence the possible sequence are 2-4-3, 4-2-3 &4-3-2

TABLE 6

| Job | Machine $M_1$ | Machine $M_2$ | Machine $M_3$ | Machine $M_4$ |
|---|---|---|---|---|
| 2 | 0-2 | 2-9 | 9-15 | 15-18 |
| 4 | 2-4 | 9-12 | 15-25 | 25-35 |
| 3 | 4-6 | 12-32 | 32-35 | 35-39 |

TABLE 7

| Job | Machine $M_1$ | Machine $M_2$ | Machine $M_3$ | Machine $M_4$ |
|---|---|---|---|---|
| 4 | 0-2 | 2-5 | 5-15 | 15-25 |
| 2 | 2-4 | 5-12 | 15-21 | 25-28 |
| 3 | 4-6 | 12-32 | 32-35 | 35-39 |

TABLE 8

| Job | Machine $M_1$ | Machine $M_2$ | Machine $M_3$ | Machine $M_4$ |
|---|---|---|---|---|
| 4 | 0-2 | 2-5 | 5-15 | 15-25 |
| 3 | 2-4 | 5-25 | 25-28 | 28-32 |
| 2 | 4-6 | 25-32 | 32-38 | 38-41 |

Now there exist tie. To break the Tie will apply some heuristic algorithm. Our proposed algorithm explains Tie- breaking rule to find the exact position' p' for inserting the unallocated job while tie occur.

- Find the Variance $J_k = \sum_{i=1}^{m} \frac{\left(X_k - \bar{X}_k\right)^2}{n-1}$

TABLE 9

| Position | Mean ($\bar{X}_k$) | Variance ($J_k$) | S.D | Minimum |
|---|---|---|---|---|
| First(k=1) | 0.5774 | 0.153133 | 0.3913 | |
| Middle(k=2) | 0.6632 | 0.151666 | 0.3894 | |
| Last(k=3) | 0.27201 | 0.029066 | 0.1704 | * |

Insert job 2 in the last position. Hence job sequence is 4-3-2.
Finally insert the unallocated job 1 in above sequence. Choose the best from all possible sequence after inserting the job.
Suppose job1 is inserted in the first position, then

TABLE 10

| job | Machine $M_1$ | Machine $M_2$ | Machine $M_3$ | Machine $M_4$ |
|---|---|---|---|---|
| 1 | 0-3 | 3-5 | 5-8 | 8-13 |
| 4 | 3-5 | 5-8 | 8-18 | 18-28 |
| 3 | 5-7 | 8-28 | 28-31 | 31-35 |
| 2 | 7-9 | 28-35 | 35-41 | 41-44 |

Suppose job1 is inserted in the third position, then

TABLE 11

| job | Machine $M_1$ | Machine $M_2$ | Machine $M_3$ | Machine $M_4$ |
|---|---|---|---|---|
| 4 | 0-2 | 2-5 | 5-15 | 15-25 |
| 1 | 2-5 | 5-7 | 15-18 | 25-30 |
| 3 | 5-7 | 7-27 | 27-30 | 30-34 |
| 2 | 7-9 | 27-34 | 34-40 | 40-43 |

Suppose job1 is inserted in the last position, then

TABLE 12

| Job | Machine $M_1$ | Machine $M_2$ | Machine $M_3$ | Machine $M_4$ |
|---|---|---|---|---|
| 4 | 0-2 | 2-5 | 5-15 | 15-25 |
| 3 | 2-4 | 5-25 | 25-28 | 28-32 |
| 1 | 4-7 | 25-27 | 28-31 | 32-37 |
| 2 | 7-9 | 27-34 | 34-40 | 40-43 |

Now again tie exist. To remove the tie, by previous algorithm.

TABLE 13

| Job | Machine $M_1$ | Machine $M_2$ | Machine $M_3$ | Machine $M_4$ |
|---|---|---|---|---|
| 4 | 0-2 | 2-5 | 5-15 | 15-25 |
| 3 | 2-4 | 5-25 | 25-28 | 28-32 |
| 2 | 4-6 | 25-32 | 32-38 | 38-41 |
| 1 | 6-9 | 32-34 | 38-41 | 41-46 |

Hence insert job 1 at third position. The optimal sequence is 4-3-1-2 and total completion time is 43.

TABLE 14

| Position | Mean ( $\overline{X}_k$ ) | Variance ( $J_k$ ) | S.D | Minimum |
|---|---|---|---|---|
| First(k=1) | 0.5132 | 0.10810 | 0.32878 | |
| second(k=2) | 0.8125 | 0.140625 | 0.37500 | |
| third(k=3) | 0.78125 | 0.066406 | 0.25769 | * |
| Fourth(k=4) | -0.19085 | 0.237365 | 0.48720 | |

## CONCLUSION

The goal was to limit the all out fulfillment time and furthermore fulfills the client's good. Inclusion of Tie-Breaking Mechanism for Flow-shop Scheduling Problem utilizing NEH technique limits the all out passed time is closed by this article.

## REFERENCES


[1] Fernandez-viagas, V., Ruiz, R., Framinan, J.M., (2017). A new vision of approximate methods for the permutation flowshop to minimise makespan: State-of-the-art and Computational evaluation. *Eur. J. Oper. Res., 257*, 707–721.

[2] Liu, W., Jin, Y., & Price, M. (2017). A new improved NEH heuristic for permutation flowshop scheduling problems. *International Journal of Production Economics*, *193*, 21-30.

[3] Baskar, A., & Xavior, M. (2013). Optimization of makespan in flow shop scheduling problems using combinational NEH family of heuristics-An analysis. *International Journal of Applied Engineering Research, 8*(10), 1205-1217.

[4] Janaki, E., & Ismail, A.M. (2019). Flow Shop Scheduling Model for 5machine without Job Block Criteria Using NEH Technique. *In Journal of Physics: Conference Series* (Vol. 1377, No. 1, p. 012020). IOP Publishing.

[5] Fernandez-Viagas, V., & Framinan, J.M. (2014). On insertion tie-breaking rules in heuristics for the permutation flowshop scheduling problem. *Computers & Operations Research*, *45*, 60-67.

[6] Liu, G., Song, S., & Wu, C. (2011). Two techniques to improve the NEH algorithm for flow-shop scheduling problems. *In International Conference on Intelligent Computing*. Springer, Berlin, Heidelberg, 41-48.

[7] Liu, W., Jin, Y., & Price, M., (2014). A new heuristic to minimize system idle time for flowshop scheduling. *In: Poster Presented at the 3rd Annual EPSRC Manufacturing the Future Conference.* Glassogw, September 23–24.

[1] Liu, W., Jin, Y., & Price, M. (2016). A new Nawaz–Enscore–Ham-based heuristic for permutation flow-shop problems with bicriteria of makespan and machine idle time. *Engineering Optimization*, *48*(10), 1808-1822.

[2] Ribas, I., Companys, R., & Tort-Martorell, X. (2010). Comparing three-step heuristics for the permutation flow shop problem. *Computers & Operations Research, 37*(12), 2062-2070.

[3] Framinan, J. M., Leisten, R., & Rajendran, C. (2003). Different initial sequences for the heuristic of Nawaz, Enscore and Ham to minimize makespan, idletime or flowtime in the static permutation flowshop sequencing problem. *International Journal of Production Research*, *41*(1), 121-148.

[4] Gajpal, Y., & Rajendran, C. (2006). An ant-colony optimization algorithm for minimizing the completion-time variance of jobs in flowshops. *International Journal of Production Economics, 101*(2), 259-272.

[5] Kalczynski, P.J., & Kamburowski, J. (2007). On the NEH heuristic for minimizing the makespan in permutation flow shops. *Omega, 35*(1), 53-60.

[6] Kalczynski, P.J., & Kamburowski, J. (2008). An improved NEH heuristic to minimize makespan in permutation flow shops. *Computers & Operations Research, 35*(9), 3001-3008.

[7] Nawaz, M., Enscore, E.E., & Ham, I. (1983). A heuristic algorithm for the m-machine, n-job flow-shop sequencing problem. *Omega, 11*(1), 91-95.

[8] Pinedo, M.L. (2012). *Scheduling: Theory, Algorithms, and Systems.* Springer Science & Business Media.

[9] Rajendran, C. (1993). Heuristic algorithm for scheduling in a flowshop to minimize total flowtime. *International Journal of Production Economics, 29*(1), 65-73.

[10] Taillard, E. (1990). Some efficient heuristic methods for the flow shop sequencing problem. *European journal of Operational research, 47*(1), 65-74.

[11] Taillard, E. (1993). Benchmarks for basic scheduling problems. *European Journal of Operational Research, 64*(2), 278-285.

[12] Widmer, M., & Hertz, A. (1989). A new heuristic method for the flow shop sequencing problem. *European Journal of Operational Research, 41*(2), 186-193.

[13] Campbell, H. G., Dudek, R. A., & Smith, M. L. (1970). A heuristic algorithm for the n job, m machine sequencing problem. *Management Science, 16*(10), B-630.