# The Heuristic algorithm for flow shop scheduling problem with TET objective

G. Vasudevan[1*] and S. Jayakumar[2]

**Abstract**
In this paper, we have focused our attention on minimizing the TET for solving flow shop scheduling. We have given a simple heuristic algorithm to solve the permutation flow shop scheduling problem. The analysis and result indicates that our algorithm performs better than the algorithms available in the literature. In fact our algorithm is simple and easy to use when compared with others.

**Keywords**
Flow Shop, Heuristic,Total Elapsed Time, Scheduling, TET.

**AMS Subject Classification**
68Wxx.

[1,2] *PG and Research Department of Mathematics, Arignar Anna Government Arts College, Cheyyar-604407, Tamil Nadu, India.*
***Corresponding author**: [1]go.vasudevan@gmail.com; [2]sundarajayakumar@gmail.com

## Contents

## 1. Introduction

The purpose of sequencing problem is to sequence the job to the machines in such way that the TET (total elapsed time) is to be minimized. Sequencing problems may be classified into two categories:

The category of first is to deal with $n$ jobs to be carryout on $m$ different machines. In order to process each job on every machine is carried out in the following way. For example, every jobs are to be process first on first machine $(M_1)$, after that process on second machine $(M_2)$ and thereafter on third machine $(M_3)$ i.e., in the sequence of machines $M_1$, $M_2$, $M_3$. Processing time of each job on each machine is known in advance. We have to select the jobs for processing on machine so that we get $n!^m$ theoretically feasible options. For example, from the first job on the first machines to the last job on last machine the total elapsed time must be minimized; including idle time. Each job should be perform over the m machines. The technologically of manufacturing processes renders many sequence technologically infeasible. For example, a part must be degreased before it is painted; similarly, a hole must be drilled before it is threaded.

Because of large number of computations it is always possible to select the better sequence through testing each one of the sequence involved. For example if there are 4 jobs to be processed on 4 machines each i.e., $n = 4$, $m = 4$ then the total number of sequence will be $4!^4 = 3,31,776$. Of course, as already said, some of them may not be feasible because the required operations must be performed in a specified order. Obviously, any technique which helps us arrive at an optimal (or at least approximately so) sequence without trying all or most of the possibilities will be quite valuable.

In the $2^{nd}$ category it deals with jobs having a number of machines and a list of tasks to be performed. Each and every time when task is accomplished next which tasks to be chosen for processing. When fresh orders are received, the list of tasks will change. For both types of problems are intrinsically tough. While solutions are possible for a few easy cases of the first, only a few experimental rules have been promoted for the second type till now.

### 1.1 Sequencing Problems

While sequence problems, when there are two or more jobs to be done (or customers to be served) and more than one machine (facilities) available for processing. The various optimality criteria normally resorted to are:

1. Tardiness criteria.

2. Lateness criteria.

3. Due date criteria.

4. Minimizing TET.

5. Number of tardy jobs.

6. Number of weighted lateness, tardiness criteria.

7. Minimizing the mean flow time.

8. Minimizing the resource idle time.

9. Minimizing work in-process inventory cost.

## 2. Literature Review

Johnson is the prior in the area of flow shop scheduling and introduced the FSSP in the year 1954 for the 2 machine case with the objective of finding the TET. Later 1965 Palmer introduced a heuristic of slope index of sequence the jobs. Later the year 1970 Cambell, Dudek and Smith developed an heuristic algorithm with total elapsed time as their objective for minimization. Later during the year 1971 Gupta suggested algorithm for solving flow shop scheduling problem taking into account the attractive facts about optimality of Johnson's algorithm for the three machine case.

During the year 1977, Dannenbring developed a Heuristic algorithm namely RA (rapid access) which associates the merits of the Palmers slope index algorithm and the CDS Heuristic algorithms. Its result is to give a best solution as fast and simply as feasible. As an options of determine $m-1$ artificial 2 machines problems, it determines only one artificial problem using Johnson's method (1954) in which the process times are conclude from the stand by pattern. In the year 1983 Nawaz, Enscore, and Ham (NEH) algorithm is depends on theory that a job with long total processing time on all the machines would be given high preference than job with low total processing time. Jayakumar et. al. (2016) solved the two machine $n$ job flow shop scheduling problem with TET objective. Later on Jayakumar et. al. (2019) solved the permutation flow shop scheduling problem with a heuristic approach. In this paper also a simple Heuristic approach is used to solve the flow shop scheduling problem with the objective of minimizing the TET.

## 3. Assumptions in Sequencing Problems

The following simplifying assumptions are usually made while dealing with sequencing problems:

(i) Only one operation is carried out on a machine at a particular time.

(ii) Each operation, once started, must be completed. i.e., pre-emption not allowed

(iii) An each operation must be completed before its succeeding operation can start.

(iv) Only one machine of each type is available.

(v) A job is processed as soon aspossiblebut onlyin the order specified.

(vi) Processing the time are independent of order of performing the operations i.e., No parallel processing

(vii) The transportation's time i.e., the time required to transport jobs from one machine to another is negligible.

(viii) Jobs are completely known and are ready for processing when the period under consideration starts.

## 4. Jayvasu Algorithm

For the $n$ job $m$ machine case, with the objective of minimizing total elapsed time, Johnson's algorithm fails when both condition that of Minimum of $M_1$ is greater than or equal to maximum of $M_2, M_3, \ldots M_{m-1}$ and Minimum of $M_m$ is greater than or equal to maximum of $M_2, M_3, \ldots M_{m-1}$ under such circumstances Heuristic plays a predominant role. Here we have developed one model using Heuristic approach which yield excellent output with in a quick time rather than using NEH, CDS Algorithms. Our algorithm has been compared with Palmer, CDS, Gupta, RA, NEH algorithms and yields better result using Jayvasu algorithm.

### 4.1 Jayvasu Algorithm

**Step 1:** Assume rows are jobs and columns are machines
**Step 2:** Find the maximum processing times on each columns.
**Step 3:** More than two columns have maximum and same number of processing times. This is tie for select most two.
**Step 4:** Make all possible pair of columns(Machines) to consider as two machine problem.
**Step 5:** Using Johnson's Algorithm to find optimum sequence of all the sequences.

Problem solved using Jayvasu Algorithm. Maximum process-

**Table 1.** Numerical problem

| · | $M_1$ | $M_2$ | $M_3$ | $M_4$ | $M_5$ |
|---|---|---|---|---|---|
| $J1$ | 3 | 2 | 1 | 4 | 5 |
| $J2$ | 6 | 2 | 5 | 3 | 4 |
| $J3$ | 4 | 5 | 3 | 1 | 2 |
| $J4$ | 7 | 6 | 4 | 2 | 3 |
| $J5$ | 3 | 5 | 1 | 3 | 6 |

ing times of columns are 7, 6, 5, 4, 6. Choose two machines associated with the most processing time.

**Table 2**

| No. of observations | Technique | Optimal sequence | Total elapsed time | No. of alternative sequence |
|---|---|---|---|---|
| 01 | Palmer | $J_1, J_5, J_2, J_3, J_4$ | 38 | 1 |
| 02 | CDS | $J_1, J_2, J_5, J_4, J_3$ $J_1, J_5, J_2, J_4, J_3$ | 36 | 2 |
| 03 | Gupta | $J_1, J_3, J_5, J_2, J_4$ | 38 | 1 |
| 04 | RA | $J_1, J_5, J_2, J_4, J_3$ | 36 | 1 |
| 05 | NEH | $J_1, J_5, J_2, J_4, J_3$ | 36 | 1 |
| 06 | Jayvasu | $J_1, J_5, J_2, J_4, J_3$ $J_5, J_1, J_2, J_4, J_3$ | 36 | 2 |

Here 7 in $M_1$ and 6 in $M_2$ and $M_5$, the possible pairs are $M_1$ & $M_2$, $M_1$ & $M_5$. Now using Johnsons algorithm we get the total elapsed time associated with the sequence. The total elapsed time of $M_1$ & $M2$ is $41 \, (J_5, J_3, J_4, J_2, J_1)$ and $39 \, (J_5, J_3, J_4, J_1, J_2)$. The total elapsed time of $M1 \& M5$ is $36 \, (J_1, J_5, J_2, J_4, J_3)$ and $36 \, (J_5, J_1, J_2, J_4, J_3)$.

## 5. Result Analysis

Comparison of the result using Jayvasu and others such as Palmer, CDS, NEH, RA and Gupta.

Using Jayvasu algorithm we have got two alternative near optimal sequence having the same total elapsed time whereas in other algorithms such as CDS gives only two alternative sequence with the same total elapsed time and RA & NEH gives only one alternative sequence and Gupta and Palmer yield total elapsed time as 38 which is higher than our algorithm.

## 6. Conclusion

Based on the result obtained, it has been found that Jayvasu algorithm yields better result in simple method compare to other algorithm found in the literature. We conclude that whenever Johnson method fails to solve n job m machine case our algorithm is suitable one to solve when compared to others.

## References

[1] K. R. Baker, *Introduction to Sequence and Scheduling,* Wiley, 1974.

[2] H. G. Campbell, R. A. Dudek and M. L. Smith, A heuristic algorithm for the *n*-job, mmachine sequencing problem. Management Science, 16(1970), B630-B637.

[3] D. Dannenbring, An evolution of flow shop scheduling heuristics. Manage Science, 23(11)(1977), 1174-1182.

[4] J. N. D. Gupta, A functional heuristic for the flow-shop scheduling problem, *Operational Research Quarterly*, 22(1971), 39-47.

[5] S. Jayakumar, et. al., An Heuristic Approach for Solving two machine *n*-job flow shop scheduling problem with Makespan objective, *IOSR journal of Mathematics,* 12(3)(2016), 23-26.

[6] S. Jayakumar, et. al., An Heuristic Approach for Solving Permutation Flow Shop Scheduling Problem, *International Journal of Emerging Technology and advanced Engineering*, 6(4)(2019), 144-146.

[7] S. M. Johnson, Optimal two and three stage production schedules with setup times included, *Naval Research Logist Quarterly,* 1(1)(1954), 61-68.

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

[9] D. S. Palmer, Sequencing jobs through a multi stage process in the minimum total time - a quick method to obtaining a near optimum, *Operational research quarterly*, 16(1)(1965), 101-107.

[10] A. K. Sahu, *Efficient heuristics for scheduling tasks on a flow shop environment to optimize make span,* National Institute of Technology, Rourkela, INDIA (2009).