Journal of Interdisciplinary Mathematics
ISSN: 0972-0502 (Print), ISSN: 2169-012X (Online)
Vol. 26 (2023), No. 1, pp. 1–10
DOI : 10.47974/JIM-1641

Flowshop scheduling problem with objective of minimizing TCT

R. Durgadevi *
S. Jayakumar †
Department of Mathematics
Arignar Anna Government Arts College
Cheyyar 604407
Tamil Nadu
India

R.Vijayaragavan §
Department of Mathematics
Thiruvalluvar University
Vellore
Tamil Nadu
India

Abstract

In manufacturing industries, scheduling problems are the origin. Particularly flowshop scheduling problem occurs in time table algorithm, operatory theory and combinatorial optimization problem with the total completion time (TCT) minimizing is a herculean task to obtain near optimal solution. Researchers are interested in solving these types of problems with the objective being that TCT is quite fashionable. Comparing the solution with existing one is quite logical to arrive the conclusion which algorithm performance better than the other. The heuristic approach developed by us, Jayakumar and Vasudevan performs better compare with other algorithms found in the literature.

Subject Classification: *90-05.*

Keywords: *Heuristic, Flowshop scheduling problem, TCT, Jayavasudev.*

* *E-mail:* **durgadevi.apagri@gmail.com (Corresponding Author)**
† *E-mail:* **sundarajayakumar@gmail.com**
§ *E-mail:* **rvijayaraagavantvu@gmail.com**

1. Introduction

Flowshop scheduling problem (FSSP) is a combinatorial optimization problem. In a general FSSP, we are given '*n*' jobs j_1, j_2, ..., j_n of varying processing times, which should be scheduled on 'm' machines with shifting preparing power, while attempting to minimize the TCT – the absolute range about every schedule (that is, the point at which every one of the jobs have got done with handling). In the particular variation known as flow shop planning, contains each job precisely m-operations. The i^{th} machine should be executed on the i^{th} operation of the job. At the same time, no machine can perform more than one operation. Execution time is determined, for every operation of each job. The optimal order (sequence) shows the base time wherein jobs, gear, individuals, materials, offices and any remaining assets are organized to help the creation schedules to give low expenses and high uses. In the event that n jobs are to be performed, and the genuine (or expected) time needed by the jobs on every one of the machine are given, then, at that point the general sequencing issue is to discover a sequence out of $(n!)^m$ potential sequences, which minimize the completion time between the beginning of the job on machine fist and finish of the keep going job on the machine last. Specifically, in case n=5 jobs are to be performed and m=5 machines were to be utilized, then, at that point the possible sequences of total number are $(5!)^5 = 24,883,200,000$. Hypothetically, it could be possible to track down the optimum sequence yet this would require a great deal of computational time. Consequently, one ought to embrace the sequencing strategy. To track down the sequence, we first need to compute the total elapsed time for every one of the possible sequences.

In a manufacturing interaction, scheduling is the way toward controlling, organizing and optimizing work and responsibility. Flowshop scheduling where there is a severe request, everything being equal, to be performed on all jobs. Despite the fact that, flowshop scheduling as the starting point of manufacture enterprises. It accepts do generally utilized current assistance area. We have been focusing in this article, in finding TCT. The choice of request the jobs will do prepared (or sequenced) known as sequencing issue. That continues a request into generate powerful use about accessible supplies. Man-made or machine made this sort of issue as endless supply of resources. This issue about discovering the sequence with every $[n!]^m$ - Sequences as handling every job that provide least TCT.

2. Literature Review

Flow shop scheduling was presented by Johnson [3] with the goal of minimizing the makespan. Later on such countless specialists discovered diverse heuristic calculation of FSSP to minimize the makespan. In the year 1965, Palmer [8] gave heuristic algorithm. This tends to remain tested into every enormous measured issue through offering need into every job and is called palmers slope- index method. In the year 1971, Gupta [2] recommended another heuristic which was like Palmer's heuristic. He characterized the slope index in an alternate way by considering some appealing realities around optimized of Johnson standard as 3 machine issues. Later on, during the year 1977, Dannenbring [1] fostered a heuristic algorithm called to RA(rapid access) which joins the benefits of palmer's heuristic(slope index) and the CDS algorithm. This gives a finest arrangement just as quick as well as essentially practical. An option about addressing 'm-1' artificial two machine issues, it tackles just a single artificial issue utilizing Johnson's algorithm which preparing times are choose from a backup conspire. In the year 2016, S. Jayakumar et. al., ,[4] to track down a Heuristic Approach for Solving two machine n-job flowshop scheduling problem with makespan objective. And furthermore in the year 2019, S. Jayakumar et. al., [6], tracks down an algorithm for Solving FSSP along makespan objective. In the year 2019, Jayakumar and Vasudevan [5], to track down the Heuristic algorithm for permutation flow shop scheduling objective.

In the year 2020, Jayakumar and vasudevan[10] algorithm it was discovered that their algorithm is prevalent than Palmers heuristic Algorithm and furthermore his algorithm discovered the arrangement in fast time when contrasted with CDS algorithms. Thus they presume that the Horizontal rectangular matrix problem to minimize the makespan, their algorithm performs better. Around the same time, Jayvasu[9] algorithm it has discovered that his algorithm yields better outcome in basic method contrast with other algorithm as palmer, CDS, Gupta, RA and NEH problems to minimizing the makespan. In the year 2020, Jayavasudev[11] algorithm performs better compared to the algorithms as Johnson's, palmer, CDS, Gupta, RA and NEH heuristic and Jayavasudev algorithm is the best reasonable algorithm for settling FSSP with the target of limiting the makespan. In the year 2021, JJV[7] algorithm performs better compared to Palmer, Gupta, JV and Nagamelleswara Rao et. al., algorithms gives close to the minimize solution as opposed to the optimal one for minimizing the makespan.

3. Various Heuristics

Following survey out of writing, this one was tracked down the few algorithms were utilized then produced as minimization of TCT for n-job m-machines FSSP. Effective algorithms were as yet an issuing in support of FSSP and then the current worked, an endeavor accepts that contrasting five algoithms for minimization of TCT in FSSP. In this current experiment do the expansion of performance and looked at the heuristics analyzed viz. Palmer's, Gupta's, RA, Jayakumar Vasudevan, Jayvasu, Jayavasudev & JJV algorithm in Flowshop scheduling on 'n' jobs and 'm' machines where 'n' is less than or equal to 'm' problems.

4. Assumptions

The comparative investigation has been finished by considering a few suspicions which are:

1. Each job must be handled on every machines in request (j = 1,2,...,m).
2. Each machine measures just each job in turn.
3. Each job is handled on each machine in turn.
4. The times assigned to each job's setup are noted and used in the preparation process.
5. It is not permissible to pre-empt.
6. Machines never independent and are open all through every arranging interval.
7. It is assumed that the main machine will be ready for whatever task is assigned to it initially.
8. Some machines may be inactive (idle) depending upon the nature of the problem.

5. Comparision of Outcomes for Annexure

n - job m - machine ($n \leq m$) Problems given in Annexure were solved using the algorithms Namely Palmer, Gupta, RA, JayakumarVasudevan, JayVasu, Jayavasudev and JJV. Solved TCT values are tabled as given below

S. No	Nxm (n- job, m- machine) n ≤ m	Palmer	Gupta	RA	Jayakumar Vasudevan	Jayvasu	Jayavasudev	JJV
		TCT	TCT	TCT	TCT	TCT	TCT	TCT
1	3x3	**52**	**52**	**52**	**52**	**52**	**52**	57
2	3x4	**70**	78	78	78	78	76	**70**
3	3x7	110	110	106	**103**	107	111	107
4	4x4	79	**70**	**70**	**70**	98	86	98
5	4x5	118	110	117	**109**	110	113	116
6	4x5	**92**	116	116	116	95	95	103
7	4x6	128	133	**124**	**124**	142	128	148
8	4x6	142	143	142	142	142	139	**133**
9	5x5	**128**	165	132	136	137	132	129
10	5x5	183	183	183	181	181	**180**	189
11	5x6	269	263	**252**	**252**	263	262	262
12	5x6	**208**	254	237	239	222	216	212

6. **Result Analysis**

Comparison of TCT result of above problem stated in annexure among Palmer's, Gupta's, RA, Jayakumar Vasudevan, Jayvasu, Jayavasudev and JJV.

Conclude the following

5 out of 12 problems Palmer's algorithm performs well when contrasted with other algorithms given in the literature.

2 out of 12 problems Gupta's algorithm performs well when contrasted with other algorithms given in the literature.

4 out of 12 problems RA algorithm performs well when contrasted with other algorithms given in the literature.

6 out of 12 problems JayakumarVasudevan algorithm performs well when contrasted with other algorithms given in the literature.

1 out of 12 problems JayVasu algorithm performs well when contrasted with other algorithms given in the literature.

2 out of 12 problems Jayavasudev algorithm performs well when contrasted with other algorithms given in the literature.

2 out of 12 problems JJV algorithm performs well when contrasted with other algorithms given in the literature.

7. Conclusion

The problems given in the annexure were tested for the n-job m-machine case, and found that Jayakumar Vasudevan algorithm is good to compare more heuristic construct in the literature. Here we conclude that Jayakumar Vasudevan algorithm is the best heuristic approach into solving FSSP with minimizing TCT objective for n-job is less than or equal to m-machine ($n \leq m$). So far, only makespan objective has been analyzed in the literature and we are the first to analyze TCT.

Annexure

1

J/M	M1	M2	M3
J1	4	6	3
J2	5	4	6
J3	3	3	5

2

J/M	M1	M2	M3	M4
J1	2	4	3	7
J2	5	6	1	4
J3	7	8	1	3

3

J/M	M1	M2	M3	M4	M5	M6	M7
J1	5	2	1	7	6	3	7
J2	2	6	2	5	6	7	2
J3	3	4	2	6	1	5	4

4

J/M	M1	M2	M3	M4
J1	3	4	5	6
J2	1	2	3	5
J3	2	3	4	4
J4	2	3	5	3

5.

J/M	M1	M2	M3	M4	M5
J1	5	6	2	3	4
J2	4	2	7	6	3
J3	5	1	1	2	4
J4	3	6	3	4	5

6.

J/M	M1	M2	M3	M4	M5
J1	2	4	3	2	1
J2	5	6	3	2	4
J3	6	7	2	3	4
J4	5	2	3	6	1

7.

J/M	M1	M2	M3	M4	M5	M6
J1	6	5	4	3	2	1
J2	5	4	3	2	1	6
J3	4	3	5	6	5	4
J4	3	6	5	6	6	4

8.

J/M	M1	M2	M3	M4	M5	M6
J1	3	5	2	4	8	1
J2	9	7	6	4	5	3
J3	1	3	5	2	6	4
J4	2	4	8	3	5	7

9.

J/M	M1	M2	M3	M4	M5
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

10.

J/M	M1	M2	M3	M4	M5
J1	7	6	5	4	3
J2	3	6	4	5	7
J3	6	5	4	3	7
J4	6	4	7	6	5
J5	4	3	6	7	5

11.

J/M	M1	M2	M3	M4	M5	M6
J1	4	6	5	7	8	9
J2	9	4	6	7	5	8
J3	8	6	7	5	4	3
J4	7	5	6	4	3	9
J5	5	6	4	3	9	7

12.

J/M	M1	M2	M3	M4	M5	M6
J1	9	1	8	2	7	3
J2	6	4	5	5	4	6
J3	3	7	2	8	1	9
J4	8	9	6	7	5	6
J5	4	5	3	1	2	4

References

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

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

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

[4] Jayakumar S, Meganathan R and Sathiya Shanthi R, "An Heuristic Approach for Solving two machine n-job flow shop scheduling problem with makespan objective", *IOSR Journal of Mathematics,* 12(3), 23-26, (2016).

[5] Jayakumar Sundaramoorthy, Meganathan Rangaraji, Sathiya Santhi, "An Heuristic Approach for Solving permutation flow shop scheduling problem", *International Journal of Emerging Technology and advanced Engineering*, 6(4) , 144-146, (2019).

[6] Jayakumar S and Vasudevan G, "Heuristic algorithm for permutation flow shop scheduling", *International Journal of Technology,* 9(1), 5-7, (2019).

[7] Jayasankari S, Jayakumar S and Vijayaragavan R, "An efficient Flow shop Scheduling Problem with Makespan Objective", *Turkish Journal of Computer and Mathematics Education*, 12(4), 461-466, (2021).

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

[9] Vasudevan G, Jayakumar S and Sathya Shanthi R , "A better heuristic approach for n-job m- machine flow shop scheduling problem", *Journal of Computational Mathematica*, 4(1), 118-124, (2020) .

[10] Vasudevan G and Jayakumar S, "The heuristic algorithm for flow shop scheduling problem with TET objective", *Malaya Journal of Matematik,* 8(4), 2071-2073, (2020).

[11] Vasudevan G and Jayakumar S, "An algorithm for solving n-job m-machine flow shop scheduling problem with objective of minimizing makespan", *International Journal of Advanced Research in Engineering and Technology* (IJARET), 11(11), 1203-1207, (2020).

[12] Chang-Mingji, Hao Wu and Chuan-Gang Li, "Optimal scheduling system for reservoir electric power generation based on functional dynamic programming algorithm", *Journal of Interdisciplinary Mathematics,* 21(5), 1267-1272, (2018).

[13] Xin-jun Li and Jian-jun Wang,"Parallel machines scheduling based on the impact of deteriorating maintenance", *Journal of Interdisciplinary Mathematics,* 21(3), 729-741, (2018).

[14] Yahui Wang, Liuqiang Fu, Yongqiang Su, Qian Yang and Linfeng Wu, "Genetic algorithm in flexible workshop scheduling based on multi-objective optimization", *Journal of Interdisciplinary Mathematics,* 21(5), 1249-1254, (2018).