Minimizing Production Operation Cycle Time Using Exponential Distribution Heuristic

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MINIMIZING PRODUCTION OPERATION CYCLE TIME USING EXPONENTIAL DISTRIBUTION HEURISTIC

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ABSTRACT

In any production flowshop, the total completion time should be optimal as possible. Many algorithms had done on this work. For identifying an optimum sequence for 'n' jobs in 'm' machines, n! Sequences to be worked. Since limitation in computing capabilities, the heuristics are required to evaluate an optimal sequence in an easy way. The classical algorithm like RA, Palmer, CDS methods gives the near to optimal makespan time. But the optimum results couldn't be obtained so far. This paper deals with the heuristic to get an optimal sequence in a flowshop. An algorithm is newly proposed based on exponential function from mathematical and computational aspects to identify the optimal sequence. Using the taillard flowshop problem, the proposed heuristic was compared with an existing heuristic. As an outcome, well-bound results are obtained which are better as compared. The degree of elapse time to lower bound are evaluated and graphically presented.

Keywords: Flow shop, Makespan, Exponential distribution, MATLAB, Optimization.

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1. INTRODUCTION

Many algorithms and heuristics had been developed so for. All these methodologies are directly to identify an optimum makespan. Since the makespan is reduced; idle time of the machines, the waiting time of the jobs and other parameters also controlled indirectly. A scheduling problem is to find a minimum total completion time giving a sequence of 'n' jobs on given 'm' machines, to address different kinds of production oriented problems in manufacturing and genetic industries. In 1954, a simple algorithm was given by Johnson [1], for flowshop scheduling problems for 'n' jobs in 2 machines. This work was further developed by Ignall and Scharge [2], Bagga. (1969), Szwarch (1977), Anup (2002), Singh (2005), Gupta (2006).

2. LITERATURE REVIEW

The production of finished products from raw materials needs several operations to be performed in a given sequence. Frequently, similar operations required for several products are performed at the same workstation, particularly when the products are produced on a mass scale; it is required to select a preferred order for products passing through a work center. The problem becomes complex when there are several workstations serving many products. In all such problems, the criterion of selection is minimum total processing time. Sharma et al [3] studied for 'n' jobs in 2 machines in flowshop problem to minimize rental cost under the predefined rental policy in which probabilities have been associated with processing time including breakdown interval and job – block criteria. The study made by Gupta et al [4] by introducing the concept of set up time separated from processing time, each associated with probabilities including job block criteria and breakdown interval.

The flowshop scheduling problem has been a keen area for the researchers over five decades. It is generally not practicable to solve such problems by enumeration. Unfortunately, generalized sequencing models are also not available to deal with all cases. The solution method in such cases was first developed by Johnson. The NP-completeness of the flowshop-scheduling problem was discussed widely by Quan-Ke Pan and Ling Wang [5]. In the 1965's Palmer [6] have been the first to propose heuristic procedures. The first significant work in the development of an efficient heuristic is due to Campell, Dudek, and Smith [7]. Their algorithm consists essentially in splitting the given m-machine problem into a series of an equivalent two-machine flow shop problem and solving by Johnson's rule.In 1977, Dannenbring [8] has developed a procedure called 'rapid access', which attempts to combine the advantages of Palmer's slope index and CDS procedures. Though the procedure by Dannenbring has found to yield better quality solution than those by Palmer's and CDS methods; it requires much more computational effort.

During the 1980s, King and Spachis [9] treated the makespan problem as equivalent to that of minimizing total delay and run-out delay. They have proposed heuristics that aim at matching the two consecutive job time-block profiles by considering these delays. One of the heuristics turns out to be better than the CDS heuristic.In 1982, Stinson et al [10] have proposed a radically different approach. They treated the makespan oriented problem as a traveling salesman problem and developed a procedure in two steps. The heuristic solution is found to yield better quality solution than those by Palmer [11] and CDS methods at the cost of increased computational effort. In 1983, Nawaz et al [12] presented a heuristic based on the premise that a job with higher total processing time should be given higher priority than a job with less total processing time. A schedule is developed by the job-insertion technique. The number of enumeration's in the heuristic method is ½ n (n+1) – 1.

A simple modification and extension of Palmer's heuristic were carried out by Hundal and Rajagopal [13]. Two sets of indices have been proposed and three sequences were obtained. In 1989, Widner and Hertz [14] proposed a new heuristic called Sequencing Problem involving a Resolution by Integrated Taboo search technique (SPIRIT). Osman and Potts [15] and Ogbu and

Smith [16] made use of simulated annealing; a heuristic technique adapted to a number of combinatorial optimization problems. Simulated annealing follows the same basic steps which are used in the conventional descent method. In 2013, Pugazhenthi and Anthony Xavior [16] reported a dummy machine concept with the advancement of Pascal's triangle method (PTM), followed by Johnson' algorithm. The advance of this work had been proposed by Pugazhenthi and Anthony Xavior [17] as a current view. This new work is a methodology using an exponential function from mathematical and computational aspects to overcome the results of the above-mentioned algorithms and the results are represented graphically. For the general comparison, the Taillard [18] had proposed a set of flowshop problems for 20, 50 and 100 jobs on 5, 10 and 20 machines are considered.

3. METHODOLOGY

3.1. EXPONENTIAL EVALUATION

This algorithm distributes a factor to the processing time of the jobs in each machine from the advancement of the classical algorithm. This factor added to the job is evaluated through the exponential equation, which gives a value of the index to the respective job. By sorting the index valve, the optimal order of sequence can be obtained. From the illustration of Palmer, the Palmer sequence can provide an optimum elapsed time. The advancement of his methodology is proposed as a new heuristic to evaluate the optimal elapsed time. This heuristic provides 'n' values which are to be descended and respective jobs to be sequenced. Using the Taillard benchmark flowshop problem, the newly proposed heuristic is compared with the proposed algorithm. The processing times vary from 1 to 99-time units and they are generated using a random number generator for different seeds.

3.2. PROCEDURE FOR NEWLY PROPOSED HEURISTIC

Step 1: Let 'n' number of jobs to be machined on 'm' machines. It is assumed that all jobs are present for processing at time zero. And one job can run in one machine at a time without changing the machine order.

Step 2: The exponential index to be calculated using the exponential equation for n jobs.

$$y_j = \sum_{i=0}^{i=m-1} (2.61 * m - \exp(i)) * T_{m-i}$$

Where, Y_j= exponential index valve for j^{th} job,

m= number of machines

$T_{(m-i)}$= process time of job under (m-i)th machine

Step 3: sort the exponential index in descending order.

Step 4: based on the sorted value, the jobs to be sequenced.

4. ANALYSIS OF NEW HEURISTIC OVER A PROPOSED HEURISTIC

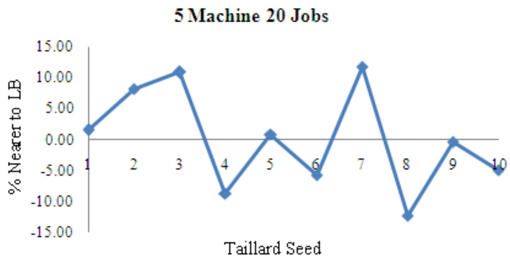
Using the above-mentioned algorithm, the set of results are obtained in MATLAB programming environment. From the table 1, the results are compared and examined to the lower bound values of Taillard flowshop problem. From these results, the graphical representations (Figure 1(a) - 1(i)) are done.

The degree of optimal for newly proposed heuristic over a proposed heuristic is obtained from each set of seed; which is shown in table 2 and it has been graphically denoted in figure 2.

Table 1 Statistic of new heuristic over a proposed heuristic

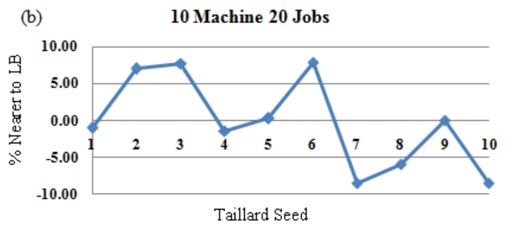
5 m 20 jobs

Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
873654221	1232	1377	1398	1.50
379008056	1290	1360	1481	8.17
1866992158	1073	1236	1387	10.89
216771124	1268	1564	1438	-8.76
495070989	1198	1342	1354	0.89
402959317	1180	1385	1310	-5.73
1369363414	1226	1268	1438	11.82
2021925980	1170	1504	1339	-12.32
573109518	1206	1434	1428	-0.42
88325120	1082	1298	1237	-4.93



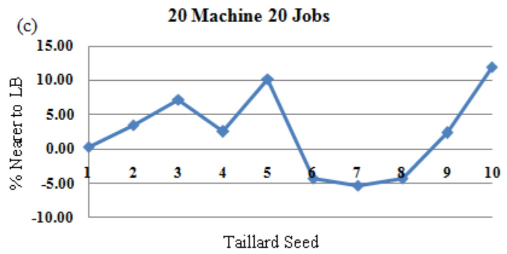
10 m 20 jobs

Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
587595453	1448	1915	1896	-1.00
1401007982	1479	1928	2073	6.99
873136276	1407	1737	1883	7.75
268827376	1308	1727	1703	-1.41
1634173168	1325	1713	1718	0.29
691823909	1290	1618	1757	7.91
73807235	1388	1870	1725	-8.41
1273398721	1363	1928	1821	-5.88
2065119309	1472	1832	1832	0.00
1672900551	1356	2035	1876	-8.48



20 m 20 jobs

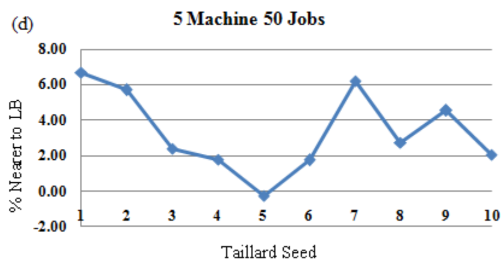
Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
479340445	1911	2606	2614	0.31
268827376	1711	2516	2608	3.53
1958948863	1844	2575	2776	7.24



918272953	1810	2561	2628	2.55
555010963	1899	2513	2799	10.22
2010851491	1875	2697	2588	-4.21
1519833303	1875	2687	2551	-5.33
1748670931	1880	2676	2568	-4.21
1923497586	1840	2553	2615	2.37
1829909967	1900	2372	2695	11.99

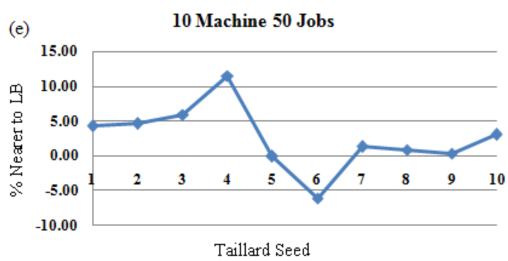
5M 50J

Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
1328042058	2712	2906	3114	6.68
200382020	2808	3055	3240	5.71
496319842	2596	2902	2974	2.42
1203030903	2740	3052	3108	1.80
1730708564	2837	3125	3117	-0.26
450926852	2793	3067	3122	1.76
1301135678	2689	2858	3048	6.23
1273398721	2667	2984	3068	2.74
587288402	2527	2830	2965	4.55
248421594	2776	2970	3033	2.08



10M 50J

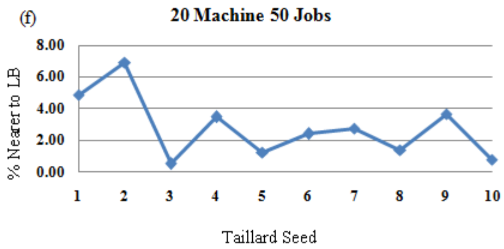
Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
1958948863	2907	3717	3883	4.28
575633267	2821	3429	3594	4.59
655816003	2801	3402	3614	5.87
1977864101	2968	3325	3755	11.45
93805469	2908	3726	3723	-0.08
1803345551	2941	3846	3625	-6.10
49612559	3062	3624	3672	1.31
1899802599	2959	3640	3674	0.93



2013025619	2795	3662	3675	0.35
578962478	3046	3655	3770	3.05

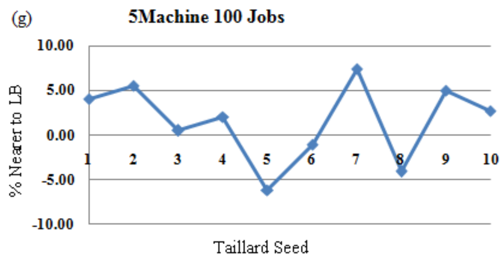
20M 50J

Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
1539989115	3480	4610	4846	4.87
691823909	3424	4338	4661	6.93
655816003	3351	4513	4537	0.53
1315102446	3336	4557	4721	3.47
1949668355	3313	4603	4661	1.24
1923497586	3460	4478	4589	2.42
1805594913	3427	4642	4773	2.74
1861070898	3383	4534	4597	1.37
715643788	3457	4417	4584	3.64
464843328	3438	4646	4682	0.77



5 m 100 jobs

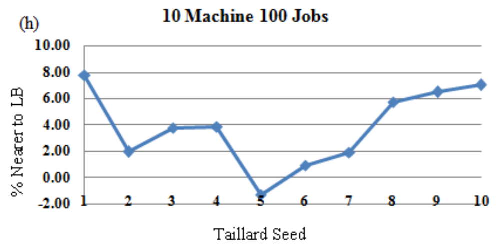
Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
896678084	5437	5838	6086	4.07
1179439976	5208	5536	5861	5.55
1122278347	5130	5674	5702	0.49
416756875	4963	5425	5540	2.08
267829958	5195	6165	5810	-6.11
1835213917	5063	5520	5463	-1.04
1328833962	5198	5497	5938	7.43
1418570761	5038	5754	5529	-4.07
161033112	5385	5738	6040	5.00
304212574	5272	5587	5745	2.75



10 m 100 jobs

Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %

1539989115	5759	6339	6870	7.73
655816003	5345	6298	6422	1.93
960914243	5623	6497	6752	3.78
1915696806	5732	6742	7010	3.82
2013025619	5431	6617	6531	-1.32
1168140026	5246	6279	6336	0.90
1923497586	5523	6476	6599	1.86
167698528	5556	6279	6658	5.69
1528387973	5779	6524	6976	6.48
993794175	5830	6468	6954	6.99



20M 100J

Taillard Seeds	Lower Bound	Proposed Heuristic	PTM	Near to LB %
450926852	5851	7240	7840	7.65
1462772409	6099	7584	7613	0.38
1021685265	6099	7668	7830	2.07
83696007	6072	7616	7694	1.01
508154254	6009	7590	7767	2.28
1861070898	6144	7430	7888	5.81
26482542	5991	7730	7827	1.24
444956424	6084	7589	7919	4.17
2115448041	5979	7433	7864	5.48
118254244	6298	7769	7891	1.55

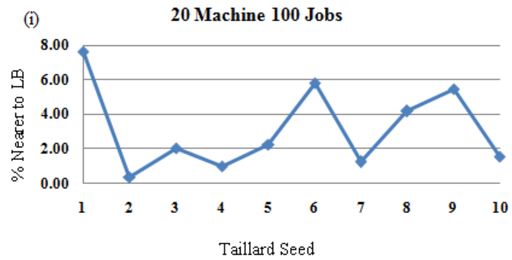


Table 2 Degree of Accuracy

Machine	Job	Degree of accuracy
5	20	1.11
10	20	-2.22
20	20	24.45
5	50	33.72
10	50	25.64
20	50	27.99
5	100	16.14
10	100	37.87
20	100	31.64

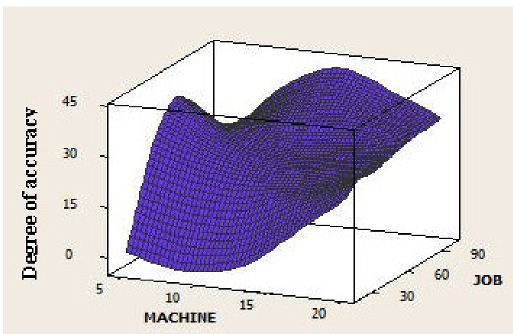


Fig. 2 Degree of Accuracy

The degree of accuracy nearer to lower bound is represented in figure 2. From this figure 2, it concludes that for jobs and machines more, the results are good enough than other proposed heuristic.

5. CONCLUSION

In this research article, a new heuristic is proposed based on exponential distribution function from mathematical and computational criteria to identify the optimal makespan giving sequence in a flow shop. The attempt made was good for a high number of jobs or machine; it was proved by the degree of accuracy chart. The processing times of jobs on machines are taken from Taillard flowshop problem. It noticed that obtained minimum elapsed time for an optimal sequence from the proposed heuristic and it is compared to PTM. The MATLAB program was generated for computational results. These results give a better optimal sequence and which is represented graphically.

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