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Comparative study for Utilization of machines in the Flow-Shop Scheduling Problems

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Abstract: Scheduling is the procedure of generating the schedule which is a physical document and generally informs the happening of things and demonstrate a plan for the timing of certain activities. The flow shop problem is one of the most widely studied classical scheduling problems and reflects real operation of several industries. The aim of the present work is to evaluate the performance of four methods when it is used to solve flow shop scheduling problems with minimization makespan. The four heuristics methods are Johnson, Palmer, CDS and Gupta methods. In this work, an attempt has been made to solve the flow shop scheduling problem for comparative study for utilization of machines in the flow-shop scheduling problems among pervious methods. A simulation study has been made to evaluate the performance of the four method under consideration based on two performance measures makespan and utilization of machine , the results has been proved that the Palmer and CDS heuristic methods show the minimum value of average of makespan and average utilization of machine when it compared with other heuristic methods.

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1. INTRODUCTION:

Scheduling is the procedure of generating the schedule which is a physical document and generally informs the happening of things and demonstrate a plan for the timing of certain activities. Finding good schedules for given sets of jobs can thus help factory supervisors effectively control job flow and provide solutions for job sequencing. The flow shop problem is one of the most widely studied classical scheduling problems and reflects real operation of several industries. Flow shop Scheduling determines an optimum sequence of n jobs to be processed on m machines in the same order.

"Survey of literature shows that most of the heuristics developed for makespan minimization in flow shop scheduling over the last half century. One of the earliest heuristic known as Johnson 1954 considered for the two-machine flow shop problem with the objective of minimizing makespan. After that the researchers developed different heuristics for makespan minimization in the flow shop scheduling for m machine problems. (Malik et al., 2013)

The concept of a slope index as a measure to sequence jobs was firstly introduced by Page1961. Later on, Palmer1965 adopted this idea and utilized the slope index to solve job sequencing for the m-machine flow shop problem. The idea was to give priority of the jobs so that jobs with processing times that tends to increase from machine to machine will receive higher priority. Gupta 1971 suggested another heuristic which was similar to Palmer's heuristic. Gupta defined the slope index in a different manner by taking into account some attractive facts about optimality of Johnson's rule for the three machine problems. Campbell et al.1970 proposed a simple heuristic extension of Johnson's algorithm to solve an m-machines flow shop problem. The extension is known in literature as the Campbell, Dudek, and Smith (CDS) heuristic."(Semančo et al., 2012; Malik et al., 2013; Umarali et al., 2015)

The scheduling literature provides a rich knowledge of the general flow shop scheduling problem to get permutation schedules with minimal Makespan. It can be stated that this is a very popular topic in scheduling circles.

Khodadadi (2012) considered a new simple heuristic algorithm for a 'three- machine, n-job' flow shop scheduling method to find optimal or near optimal sequence minimizing the total weighted mean production flow-time for the problem has been discussed.

Singhal et al.(2012) presented The Nawaz, Enscore, and Ham (NEH) algorithm is an efficient algorithm that works by minimizing the makespan for Permutation Flow shop Scheduling Problems (PFSP). The proposed algorithm is obtained by modifying the NEH algorithm and produces improved quality solutions with algorithmic complexity same as the original algorithm.

Semančo et al. (2012) proposed a constructive heuristic approach for the solution of the permutation flow shop problem. The proposed heuristic algorithm, named MOD, is tested against four other heuristics that are well-known from the open literature, namely, NEH, Palmer's Slope Index, CDS and Gupta's algorithm. The computational experiment itself contains 120 benchmark problem data sets proposed by Taillard. The results compared and showed that the proposed algorithm is a feasible alternative for practical application when solving n-job and m-machine in flow-shop scheduling problems to give relatively good solutions in a short-time interval.

Singh and Kumar (2012) proposed a novel approach to find an optimal path from source to destination by taking advantage of job sequencing technique. Used n jobs m machine sequencing technique and this is divided into n jobs two machine problems. Using Johnson's sequencing rule, the problem solved and obtained the (n-1) sub sequences of the route. Using the proposed algorithm, the optimal sequence calculated which leads to the shortest path of the network.

Basker and Xavior (2012) Proposed a new heuristic algorithm based on Pascal's Triangle. The effectiveness of the new Heuristic is analyzed using few case studies in comparison with some of the popular Heuristics like RA Heuristics, Palmer Heuristics, Gupta Heuristics, CDS Heuristics and Johnson's algorithm.

Malik et al. (2013) focused on scheduling the jobs in a flow shop environment with makespan minimization. The five heuristics available in the literature known as, Palmer's 1965, RA 1970, CDS 1970, Gupta's1971 and NEH 1983 have been analyzed and tested .From the comparative analysis, it has been found that NEH heuristic up to four machines problem provides better results and as the size of machines increases, RA considers to be the superior for most of the flow shop scheduling problems.

Sheibani (2013) described an adaption of the fuzzy greedy heuristic (FGH) for the permutation flow-shop scheduling problem with the makespan criterion. Computational experiments using standard benchmark problems indicate that the proposed method is very efficient.

Agarwal and Garg (2013) considered the production planning problem of a flexible manufacturing system. The objective is to minimize the Makespan of batch-processing machines in a flow shop. Consequently, comparisons based on Palmer's and Gupta's heuristics are proposed. Gantt chart is generated to verify the effectiveness of the proposed approaches.

Iqbal et al. (2013) proposed heuristic techniques called row sum methods to obtain a sequence of jobs for solving job sequencing problems, in order to minimize the total elapsed time of the sequence.

Kumar et al. (2014) proposed the permutation flow shop sequencing problem with the objective of makespan minimization using the new modified proposed method of Johnson's algorithm as well as the Gupta's heuristic algorithm.

GA can produce near optimal solutions in a short computational time for different size problems.

Caldwell and Gamboa (2014) presented new algorithm can obtain results less effective against Gupta for certain random configurations in approximately 18% of the cases; therefore it is better to analyze the multi-project environment configuration with both algorithms, rather than making them compete knowing that both algorithms have the same degree of simplicity in calculation and application by automatic ways.

Umarali and Chakraborty (2015) considered the permutation flow shop scheduling problem with the objective of minimizing the makespan. The proposed heuristic algorithm, named as NEH-SD uses two parameters, the mean and standard deviation of processing times for sorting the jobs in sequence to have the initial sequence of jobs. The heuristic is tested against two well-known heuristics from the literature, namely, NEH and CDS. The computational experiments show that the proposed algorithm is a feasible alternative for practical application when solving n-job and m-machine flow-shop scheduling problems to give relatively good solutions in a short time interval.

In this paper, four heuristics methods are used to evaluate four Flow shop scheduling problems. The methods under consideration are Johnson, Palmer, CDS and Gupta methods. Experiments comparison between the four methods under consideration of the heuristic methods used 130 benchmark problem data sets proposed by Taillard. The computational experiment shows that CDS and Palmer is a feasible alternative for practical application when solving n-job and m-machine in flow shop scheduling problems to give relatively good solutions in a short-time interval. CDS and Palmer have a superior performance among all the four proposed heuristic methods. The remainder of the paper is organized as follows. Section 2 provided the heuristic methods that under consideration. Section 3 provides the computational experiments and results. Finally, some conclusions on this study are given in Section 4

2. The Heuristic Methods :

Heuristic refers to experience-based techniques for problem solving, learning, and discovery. Heuristic methods are used to speed up the process of finding a good enough solution, where an exhaustive search is impractical (Singhal et al., 2012). The heuristic algorithms are more efficient and economical of getting a practical solution, though it sometimes cannot reach the optimum (Kumar et al., 2014). This section presented Johnson's algorithm and three heuristic scheduling methods are Palmer, CDS (Campbell, Dudek and Smith) and Gupta with more details as follows:

Table 1 (20 Jobs 5 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	1390	0.7414	1384	0.7447	1390	0.7414	1425	0.7232
2	1432	0.7257	1439	0.7222	1424	0.7298	1380	0.7530
3	1270	0.7252	1162	0.7926	1255	0.7339	1247	0.7386
4	1514	0.7445	1490	0.7565	1426	0.7905	1554	0.7254
5	1354	0.7338	1360	0.7306	1323	0.7510	1370	0.7253
6	1312	0.7706	1344	0.7522	1312	0.7706	1333	0.7584
7	1393	0.7104	1400	0.7069	1393	0.7104	1390	0.7119
8	1368	0.7648	1313	0.7968	1345	0.7778	1432	0.7306
9	1427	0.7347	1426	0.7352	1360	0.7709	1444	0.7260
10	1320	0.7238	1229	0.7774	1164	0.8208	1215	0.7863
Average	1378	0.73749	1354.7	0.75151	1339	0.75971	1379	0.73787

Table 2 (20 Jobs 10 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	1814	0.5694	1790	0.577	1757	0.5879	2027	0.5096
2	1854	0.5857	1948	0.5574	1854	0.5857	1960	0.5540
3	1713	0.5765	1729	0.5712	1651	0.5982	1780	0.5548
4	1778	0.5022	1585	0.5634	1547	0.5772	1709	0.5225
5	1670	0.5664	1648	0.5740	1558	0.6071	1914	0.4942
6	1728	0.5289	1527	0.5986	1560	0.5855	1650	0.5539
7	1728	0.5427	1735	0.5405	1630	0.5753	1761	0.5325
8	1911	0.5182	1763	0.5617	1811	0.5468	2097	0.4722
9	1970	0.5093	1836	0.5465	1720	0.5834	1837	0.5462
10	1979	0.532	1898	0.5547	1884	0.5588	2137	0.4927
Average	1814.5	0.54313	1745.9	0.5645	1697.2	0.58059	1887.2	0.52326

Table 3 (20 Jobs 20Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	2559	0.3961	2818	0.3597	2559	0.3961	2833	0.3578
2	2463	0.3811	2331	0.4027	2285	0.4108	2586	0.3630
3	2828	0.3593	2678	0.3753	2600	0.3908	2929	0.3469
4	2630	0.3752	2629	0.3753	2434	0.4054	2660	0.3709
5	2665	0.384	2704	0.3785	2506	0.4084	2868	0.3568
6	2692	0.3659	2572	0.3830	2422	0.4067	2709	0.3636
7	2605	0.3857	2456	0.4091	2489	0.4037	2811	0.3575
8	2544	0.3883	2435	0.4057	2362	0.4182	2612	0.3782
9	2483	0.4068	2754	0.3668	2414	0.4184	2701	0.3740
10	2560	0.3777	2633	0.3672	2469	0.3916	2656	0.3640
Average	2602	0.3961	2601	0.38233	2454	0.40501	2736	0.36327

Table 4 (50 Jobs 5 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	2926	0.8255	2774	0.8707	2877	0.8396	2820	0.8565
2	3032	0.8608	3041	0.8582	3032	0.8608	2975	0.8772
3	2894	0.8286	2777	0.8635	2703	0.8872	3071	0.7809
4	3053	0.84	2860	0.8967	2888	0.888	3132	0.8188
5	3058	0.8323	2963	0.859	3038	0.8378	3114	0.8173
6	3144	0.8272	3090	0.8417	3031	0.8581	3169	0.8207
7	2996	0.8227	2845	0.8664	2964	0.8316	3097	0.7959
8	3131	0.7916	2826	0.8771	2835	0.8743	3091	0.8019
9	3118	0.7455	2733	0.8505	2796	0.8313	3211	0.7239
10	2940	0.872	2915	0.8795	2940	0.872	3092	0.8291
Average	3029.2	0.82462	2882.4	0.86633	2910.4	0.85807	3077.2	0.81222

Table 5 (50 Jobs 10 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	3863	0.6498	3461	0.7252	3381	0.7424	3672	0.6836
2	3424	0.7078	3313	0.7315	3246	0.7466	3587	0.6757
3	3537	0.6787	3321	0.7229	3287	0.7304	3660	0.6559
4	3684	0.6862	3511	0.7201	3404	0.7427	3623	0.6978
5	3630	0.6995	3427	0.7409	3375	0.7523	3521	0.7211
6	3416	0.7345	3323	0.755	3400	0.7379	3547	0.7074
7	3864	0.6518	3457	0.7285	3510	0.7175	3738	0.6737
8	3640	0.674	3382	0.7255	3371	0.7278	3784	0.6484
9	3562	0.6831	3414	0.7127	3251	0.7484	3561	0.6833
10	3723	0.6835	3404	0.7475	3429	0.7421	3755	0.6777
Average	3634.3	0.68489	3401.3	0.73098	3365.4	0.73881	3644.8	0.68246

Table 6 (50 Jobs 20 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	4666	0.5563	4272	0.6076	4360	0.5953	4706	0.5515
2	4531	0.5437	4303	0.5725	4216	0.5843	4440	0.5549
3	4438	0.5457	4210	0.5752	4203	0.5762	4468	0.542
4	4589	0.5372	4233	0.5823	4280	0.5759	4782	0.5155
5	4467	0.55	4376	0.5615	4124	0.5932	4654	0.5279
6	4691	0.5226	4312	0.5685	4226	0.5801	4748	0.5163
7	4481	0.5543	4306	0.5768	4134	0.6008	4622	0.5374
8	4737	0.5198	4310	0.5713	4262	0.5778	4582	0.5374
9	4436	0.5629	4547	0.5492	4219	0.5919	4525	0.5519
10	4475	0.5654	4197	0.6028	4270	0.5925	4523	0.5594
Average	4551.1	0.54579	4306.6	0.57677	4229.4	0.5868	4605	0.53942

Table 7 (100 Jobs 5 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	5749	0.8974	5749	0.8974	5589	0.9231	5765	0.895
2	5665	0.8890	5316	0.9474	5563	0.9053	5718	0.8808
3	5614	0.8812	5325	0.929	5493	0.9006	5525	0.8954
4	5233	0.9183	5049	0.9518	5233	0.9183	5274	0.9112
5	5642	0.8897	5317	0.9441	5484	0.9153	5535	0.9069
6	5383	0.9106	5274	0.9295	5240	0.9355	5274	0.9295
7	5578	0.8874	5378	0.9207	5557	0.8907	5417	0.9138
8	5512	0.8831	5263	0.9249	5387	0.9036	5541	0.8785
9	5824	0.8873	5606	0.9218	5758	0.8975	5901	0.8757
10	5749	0.8974	5749	0.8974	5589	0.9231	5765	0.895
Average	5665	0.8890	5316	0.9474	5563	0.9053	5718	0.8808

Table 8 (100 Jobs 10 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	6753	0.7687	7075	0.698	6210	0.8359	6507	0.7978
2	6381	0.7591	7058	0.7073	5851	0.8278	6302	0.7686
3	7526	0.6591	7181	0.6908	7218	0.6872	7724	0.6422
4	7643	0.6447	7039	0.70	7141	0.69	7707	0.6393
5	6321	0.7863	6070	0.8188	6018	0.8259	6517	0.7627
6	6162	0.7702	5870	0.8085	5751	0.8252	6154	0.7712
7	6612	0.7415	6442	0.7611	6204	0.7903	6489	0.7556
8	6399	0.779	6168	0.8082	6218	0.8017	6363	0.7835
9	6391	0.8042	6081	0.8452	6349	0.8095	6317	0.8136
10	6574	0.7755	6259	0.8145	6387	0.7982	6803	0.7494
Average	6676.2	0.7488	6524.3	0.76524	6334.7	0.78917	6688.3	0.7484

Table 9 (100 Jobs 20Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	7622	0.6479	7075	0.698	6979	0.7076	7737	0.6383
2	7582	0.6585	7058	0.7073	6998	0.7134	7672	0.6507
3	7526	0.6591	7181	0.6908	7218	0.6872	7724	0.6422
4	7643	0.6447	7039	0.7000	7141	0.6900	7707	0.6393
5	7444	0.6666	7259	0.6836	7113	0.6976	7620	0.6512
6	7787	0.6376	7109	0.6984	7283	0.6817	7742	0.6413
7	7666	0.6529	7279	0.6876	7150	0.7000	7975	0.6276
8	7702	0.6611	7567	0.6729	7213	0.7060	7971	0.6388
9	7422	0.6734	7271	0.6874	7171	0.6970	7677	0.6511
10	7681	0.6553	7305	0.689	7151	0.7038	7530	0.6684
Average	7607.5	0.65571	7214.3	0.6915	7141.7	0.6984	7735.5	0.64489

Table 10 (200 Jobs 10 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	11902	0.836	11443	0.8774	11632	0.8632	12191	0.8236
2	11984	0.8282	10986	0.9034	11370	0.8729	12145	0.8172
3	11941	0.8471	11336	0.8924	11761	0.8601	11937	0.8474
4	11674	0.8581	11265	0.8924	11411	0.8778	11683	0.8574
5	11708	0.8534	11125	0.8981	11379	0.8780	11654	0.8573
6	11646	0.836	10865	0.896	11328	0.8595	11588	0.8402
7	12315	0.8286	11303	0.9028	11643	0.8764	12051	0.8467
8	11755	0.8603	11275	0.897	11460	0.8825	12098	0.8359
9	12144	0.8175	11184	0.8877	11259	0.8817	12208	0.8132
10	11950	0.8390	11355	0.8829	11516	0.8706	11832	0.8473
Average	11901.9	0.84042	11213.7	0.89301	11475.9	0.8723	11938.7	0.83862

Table 11 (200 Jobs 20 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	13287	0.7369	13042	0.7508	12442	0.787	13650	0.7173
2	13231	0.7565	12813	0.7812	12591	0.7949	13154	0.7609
3	13279	0.7569	12846	0.7824	12737	0.7891	13661	0.7357
4	13173	0.7598	13061	0.7663	12598	0.7945	13520	0.7403
5	13630	0.7264	12827	0.7719	12547	0.7891	13148	0.7530
6	13404	0.7467	12404	0.8069	12490	0.8014	13294	0.753
7	13301	0.7572	12584	0.8003	12767	0.7889	13297	0.7574
8	13655	0.7312	12824	0.7786	12644	0.7897	13933	0.7166
9	13636	0.7325	12523	0.7976	12675	0.7881	13456	0.7423
10	13500	0.7395	12615	0.7914	12974	0.7695	13589	0.7203
Average	13409.6	0.74436	12753.9	0.78274	12646.5	0.78922	13470.2	0.73968

Table 12 (250 Jobs 20 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	16230	0.7609	15138	0.8158	15362	0.8039	15955	0.7741
2	16457	0.7641	15504	0.8111	15617	0.8052	16024	0.7583
3	16397	0.7622	15553	0.8036	15482	0.8073	16481	0.7583
4	16413	0.7704	15340	0.8248	15701	0.8053	16587	0.7623
5	16084	0.7755	15000	0.8315	15233	0.8188	16002	0.7794
6	16011	0.7839	15670	0.801	15286	0.8211	16490	0.7611
7	16101	0.7788	15120	0.8294	15220	0.8239	16434	0.763
8	16828	0.7486	15553	0.81	15504	0.8125	16309	0.7724
9	15985	0.7753	14907	0.8313	15205	0.815	16153	0.7672
10	16010	0.7781	15466	0.8055	15343	0.812	16153	0.771
Average	16251.6	0.76978	15325.1	0.8164	15395.3	0.8125	16258.8	0.76671

Table 13 (300 Jobs 20 Machine Problems)								
	Johnson		Palmer		CDS		Gupta	
	C_{max}	MU	C_{max}	MU	C_{max}	MU	C_{max}	MU
1	19078	0.7787	17771	0.8360	17777	0.8357	19008	0.7816
2	19708	0.7899	18049	0.8349	18357	0.8208	18785	0.8021
3	19247	0.7761	18121	0.8243	18343	0.8144	19035	0.7848
4	19258	0.7845	17745	0.8514	18454	0.8187	19339	0.7812
5	18759	0.7937	17770	0.8379	17808	0.8361	18594	0.8008
6	18814	0.8005	17192	0.8409	18059	0.834	18789	0.8016
7	18816	0.7984	17864	0.8409	18192	0.8258	19325	0.7774
8	19653	0.7723	18393	0.8245	18457	0.8216	18933	0.8010
9	18663	0.7963	17298	0.8592	17785	0.8357	18986	0.7828
10	18649	0.8008	17917	0.8335	18041	0.8278	18911	0.7897
Average	19064.5	0.78912	17812	0.8384	18127.3	0.82706	18970.5	0.7903

I. Johnson Algorithm:

Johnson 1954 proposed the first research concerned to the flow shop scheduling problem. Johnson described an exact algorithm to minimize makespan for two machine flow shop scheduling problem. The Johnson's algorithm has also been extended to three machine problem with makespan as the objective. Johnson's Algorithm has been the basis of much flow shop scheduling heuristics (Odior et al., 2012) .

II. Palmer's Heuristic Algorithm :

Palmer 1965 proposed a heuristic algorithm which is a slope order index to sequence the jobs on the machines based on the processing time and known as palmer's heuristic. The idea was give priority of the jobs so that jobs with processing times that tends to increase from machine to machine will receive higher priority (Malik et al., 2013).

III. CDS Heuristic Algorithm :

Campbell, Dudek and Smith 1970 proposed a heuristic for Makespan problems called the (CDS) heuristic. Using two main principles, this procedure achieves good results: it uses Johnson's rule in a heuristic way, and it generally creates several schedules, the best one of which should be chosen (Shevasuthisilp et al., 2009)

IV. Gupta Heuristic Algorithm:

Gupta 1971 suggested another heuristic which was similar to Palmer's heuristic. He defined the slope index in a different manner by taking into account some attractive facts about optimality of Johnson's rule for the three machine problems (Malik et al., 2013). Gupta algorithm is applicable for more than two machines .This algorithm state an m machines, a set of n independent jobs with a chain of operations that must be executed in the same sequence on each machine (Kumar et al., 2014).

3. Computational Experiments and results:

This section presented computational experiments which used the four heuristic methods that under consideration. The computational experiments data of flow shop scheduling are all from an extensive set of Taillard's 1993. (http://mistic.heigvd.ch/taillard/problemes.dir/ordonnancement.dir/ordonnancement.html .The steps which applied to evaluate the performance of the four heuristics method as follows:

1- The study applied two performance measures are average of Makespan and utilization of machine where the total amount of time required completing a group of jobs is called makespan. Utilization is the degree to which equipment, space, or the workforce is currently being used, measured as the ratio of the average output rate to maximum capacity.

These performance measures often are interrelated. That mean, minimizing the average flow time tends to increase utilization. Minimizing the makespan for a group of jobs tends to increase utilization.

2- Many researchers presented simulation study with small number of jobs or machines and others applied simulation study with large number of jobs or machines. This study considered with small, medium, and large sizes to evaluate the performance of the four methods under consideration.

3- The study applied two performance measures to evaluate between four methods.

4- Taillard's benchmark problem datasets has 130 instances which are used in many studies.

5- The study used the Taillard's datasets rang and divided the jobs to three category as follows small size when 20 jobs, medium size when 50 jobs and large size when 100, 200, 250 and 300 jobs.
6- The study divided the machines to three category as follows small size when 5 machines, medium size 10 machines and large size 20 machines.
7- The study used the Taillard's datasets rang and additive 250 and 300 jobs with (20) machines.
8- The sampling runs 10 replications for each of one particular size.

9- Computational experiments in this study developed in WinQSB and take the performance indicators of the methods to be the solution quality makespan (Cmax) and utilization of machine (MU) each method and for each problem instance. The average of makespan and utilization of machine is calculated to use as a performance measure between the four methods.

The outputs for Taillard's 130 instances are shown in tables 1 to 13. Each of the summary tables displays the results for Johnson, Palmer, CDS, Gupta's methods.

The following paragraphs introduce the results of the four heuristics methods when different jobs and different number of machines are used. The results of the comparison between four methods as follows:

1- When small size 20 jobs and (5, 10, 20) the three categories for machines are found that the CDS method is better than another three methods.
2- When medium size 50 jobs and small size 5 for machines are found that the palmer method is better than another three methods.
3- When medium size 50 jobs and medium size 10 machines and large size 20 machines are found that the CDS method is better than another three methods.
4- When large size 100 jobs and small size 5 for machines are found that the palmer method is better than another three methods.
5- When large size 100 jobs and medium size 10 machines and large size 20 machines are found that the CDS method is better than another three methods.
6- When large size 200 jobs and medium size 10 machines are found that the palmer method is better than another three methods.
7- When large size 200 jobs and large size 20 machines are found that the CDS method is better than another three methods.
8- When large size 250 and 300 jobs and large size 20 machines are found that the palmer method is better than another three methods. Average of makespan and average of utilization of machine are identical in the previous results.

4. CONCLUSION:

From the previous results when the study used the four heuristics methods Johnson, Palmer, CDS, Gupta and two performance measure are used the advantages as following:

- The four heuristics methods Johnson, Palmer, CDS, Gupta are the most important methods used to calculate the makespan for two or three or more machines.
- The four heuristics methods Johnson, Palmer, CDS, and Gupta are used with different number of jobs and machines and the results are satisfied.
- The average makespan (Cmax) and average of utilization of machine (MU) are calculated for each method and for each problem which are used as a performance measure between the four methods.
- CDS method is better when number of jobs is small and medium and number of machines is small and medium. The results are more realistic when it compared with real number of jobs and of machines.
- Palmer method is better when number of jobs is large and number of machines is large.

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