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A Comparision of Hybrid Metaheuristics Performances in Simultaneous Scheduling of Machines and AGVs in FMS

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ABSTRACT
Flexible manufacturing system (FMS) is a production method that is designed to easily adapt to changes in the type and quantity of the product being manufactured. Machines and computerized systems can be configured to manufacture a variety of parts and handle changing levels of production. In FMS machines alone are not only important resources, even the material handling systems like AGVs are also important resources. Hence, a carefully designed and managed material handling system is important in achieving the required integration in flexible manufacturing environment. It is necessary that their operations should be optimized and above all synchronized with machine operations. This is referred to as simultaneous scheduling of both machines and AGVs. But this simultaneous scheduling process is a complex problem. It is observed from the literature that for solving the simultaneous scheduling problems in FMS most of the researchers implemented several metaheuristics and hybrid metaheuristics. In the present work comparision of performances of the three hybrid metaheuristics from the literature, namely Hybrid Jaya (Prakash Babu kanakavalli et al,2019), Hybrid Teaching Learning Based Optimization (Prakash Babu kanakavalli et al, 2019) and Hybrid Differential Evolution (HDE) (Prakash Babu kanakavalli et al, 2020), in solving the 82 bench mark problems considered from the literature is done.

Keywords - ***AGVs, FMS, Hybrid Metaheuristics, Makespan, Simultaneous scheduling***

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I. INTRODUCTION

A flexible manufacturing system is a automated machine cell, consisting of a group of processing workstations, interconnected with automated material handling and storage system. The FMS is most suited for the mid-variety, mid-volume production range. External changes such as change in product design and production system, Optimizing the manufacturing cycle time, reduced production costs, overcoming internal changes like breakdowns etc. are the benefits related to FMS. It includes the capabilities like ability to identify and distinguish among the different part styles processed by the system, quick changeover of operating instructions, and quick changeover of physical setup. However- there are a number of problems faced during the life cycle of an FMS and these functions are classified into: design- planning- scheduling- and controlling. In particular- the scheduling task and control problem during the manufacturing operation are of importance owing to the dynamic nature of the FMS in respect of flexible parts- tools- assignments. In FMS scheduling- decisions that need to be made include not only sequencing of jobs on machines but also the routing of the jobs through the system. Apart from the machines- other resources in the system like Automated Guided Vehicle (AGV) and Automated Storage/Retrieval System (AS/RS) must be considered.

II. LITERATURE REVIEW

In simultaneous scheduling- the real time as well as the off-line scheduling is taken into account. Bilge and Ulusoy [1] exploited the interactions between the machine and AGVs scheduling simultaneously. The material transfer between machines is done by a number of identical AGVs which are not allowed to return to the load/unload station after each delivery. Abdelmaguid et al.[2] suggested a hybrid GA for the problem of simultaneous scheduling of machines and AGVs in FMS with minimizing the makespan. The algorithm is applied to a set of 82 test problems- which was constructed by other researchers- and the comparison of the results indicates the superior performance with the developed coding. Reddy and Rao [3] studied the simultaneous scheduling problem with makespan- mean flow time and mean tardiness as an criterion. The proposed hybrid GA for FMS scheduling problems yielded better results when compared to other algorithms. Gnanavelbabu et al. [4] examined the scheduling of machines and AGVs simultaneously in FMS using differential evolution with makespan minimization. The algorithm is tested by using test problems proposed by various researchers and the makespan obtained by the algorithm is compared with that obtained by other researchers are analyzed. Anandaraman et al. [5] presented a solution for the simultaneous scheduling problem by evolutionary approach in FMS with vehicles and robots with the objectives to minimize the makespan- mean flow time and mean tardiness. The scheduling optimization is carried out using metaheuristic algorithm. The algorithms are applied for test problems taken from the literature and the results obtained using the two algorithms are compared. Nouri et al. [6] introduced the clustered holonic multiagent model using metaheuristic for simultaneous scheduling of machines and transport robot in FMS. Computational results are presented using three sets of benchmark instances in the literature. New upper bounds are found- showing the effectiveness of the presented approach. Md Kamal et al. [7] Flexible Job Shop Scheduling Problem (FJSSP) is an extension of the classical Job Shop Scheduling Problem (JSSP). Keeping in view this aspect- this article presents a comprehensive literature review of the FJSSPs solved using the GA. The survey is further extended by the inclusion of the hybrid GA (HGA). Lundy et al [8] discussed about the convergence of an annealing algorithm. Storn R et al. [9] proposed a simple and efficient adaptives scheme for global optimization over Continuous Spaces. Hyunchul et al. [10] proposed a new evolutionary algorithm based on sheep flocks heredity model. Prakash Babu kanakavalli et al. [11] proposed a Hybrid JAYA(HJAYA) algorithm for solving simultaneous scheduling problems. Prakash Babu kanakavalli et al.[12] proposed a hybrid Teaching Learning Based optimization (HTLBO) algorithm for solving simultaneous scheduling problems. Prakash Babu kanakavalli et al.[13] proposed a hybrid Differential Evolution (HDE) for solving simultaneous scheduling problems.

III. HYBRID METAHEURISTIC ALGORITHMS

For several problems a simple Evolutionary algorithm might be good enough to find the desired solution. As reported in the literature, there are several types of problems where a direct evolutionary algorithm could not to obtain a convenient (optimal) solution. This clearly paves way to the need for hybridization of evolutionary algorithms with other optimization algorithms, machine learning techniques, heuristics etc. Some of the possible reasons for hybridization are as follows:

1. To improve the performance of the evolutionary algorithm (example: speed of convergence)
2. To improve the quality of the solutions obtained by the evolutionary algorithm
3. To incorporate the evolutionary algorithm as part of a larger system

In this paper comparision of performances of the three hybrid metaheuristic algorithms namely Hybrid Jaya (Prakash Babu kanakavalli et al,2019), Hybrid Teaching Learning Based Optimization (Prakash Babu kanakavalli et al, 2019) and Hybrid Differential Evolution (HDE) (Prakash Babu kanakavalli et al, 2020), in solving the 82 bench mark problems considered from the literature is done.

IV. RESULTS AND DISCUSSSION

Makespans obtained by Hybrid Jaya (Prakash Babu kanakavalli et al,2019), Hybrid Teaching Learning Based Optimization (Prakash Babu kanakavalli et al, 2019) and Hybrid Differential Evolution (HDE) (Prakash Babu kanakavalli et al, 2020) algorithms, for different combinations of job sets and layouts with t/p > 0.25 are presented in the below Table.

Table .1: Comparison of makespan values (for t/p > 0.25)

Job. No	t/p	HJAYA	HTLBO	HDE
1.1	0.59	96	96	96
2.1	0.61	113	113	98
3.1	0.59	120	120	109
4.1	0.91	116	116	116
5.1	0.85	89	89	89
6.1	0.78	132	132	113
7.1	0.78	132	132	121
8.1	0.58	175	185	150
9.1	0.61	117	116	116
10.1	0.55	167	167	167
1.2	0.47	82	82	82
2.2	0.49	86	86	76
3.2	0.47	96	96	83
4.2	0.73	90	90	90
5.2	0.68	73	73	73
6.2	0.54	108	108	90
7.2	0.62	92	91	85
8.2	0.46	159	159	131
9.2	0.49	104	104	104
10.2	0.44	150	148	149
1.3	0.52	84	84	84
2.3	0.54	100	100	82
3.3	0.51	102	102	86
4.3	0.8	96	96	96
5.3	0.74	76	76	76
6.3	0.54	116	116	92
7.3	0.68	104	104	90
8.3	0.5	169	169	133
9.3	0.53	108	106	105
10.3	0.49	154	154	129
1.4	0.74	104	104	104
2.4	0.77	124	124	112
3.4	0.74	130	130	113
4.4	1.14	128	128	128
5.4	1.06	97	97	97
6.4	0.78	140	140	119
7.4	0.97	154	154	135
8.4	0.72	195	195	152
9.4	0.76	123	123	125
10.4	0.69	178	178	161

From Table 1, out of 40 problems 38 problems gives better results using HDE when compared with others, 17 problems gives better results using HTLBO when compared with others, 15 problems gives better results using HJAYA when compared with others. Makespans obtained by the three hybrid metaheuristic algorithms for different combinations of job sets and layouts with t/p < 0.25 are presented in Table 2.

Table 2. Comparison of makespan values (for t/p < 0.25)

Job.No	t/p	HJAYA	HTLBO	HDE
1.10	0.15	126	126	126
2.10	0.15	148	148	131
3.10	0.15	162	162	143
4.10	0.15	123	123	123
5.10	0.21	102	102	102
6.10	0.16	192	192	146
7.10	0.19	137	137	137
8.10	0.14	292	292	247
9.10	0.15	182	182	182
10.10	0.14	262	262	218
1.20	0.12	123	123	123
2.20	0.12	143	143	128
3.20	0.12	159	159	139
4.20	0.12	116	116	116
5.20	0.17	100	100	100
6.20	0.12	187	187	141
7.20	0.15	136	136	136
8.20	0.11	287	287	244
9.20	0.12	179	179	179
10.20	0.11	259	259	212
1.30	0.13	122	122	122
2.30	0.13	146	146	129
3.30	0.13	160	160	138
4.30	0.13	117	117	117
5.30	0.18	99	99	99
6.30	0.24	188	188	141
7.30	0.17	137	137	137
8.30	0.13	288	288	245
9.30	0.13	180	180	180
10.30	0.12	260	260	191
1.40	0.18	124	124	124
2.41	0.13	217	217	191
3.40	0.18	162	162	143
3.41	0.12	239	239	209
4.41	0.19	177	177	177
5.41	0.18	148	148	148
6.40	0.19	189	189	151
7.40	0.24	138	138	137
7.41	0.16	203	203	203
8.40	0.18	293	293	248
9.40	0.19	182	182	182
10.40	0.17	266	265	214

From Table 2, out of 42 problems 42 problems gives better results using HDE when compared with others, 20 problems gives better results using HTLBO when compared with others, 20 problems gives better results using HJAYA when compared with others.

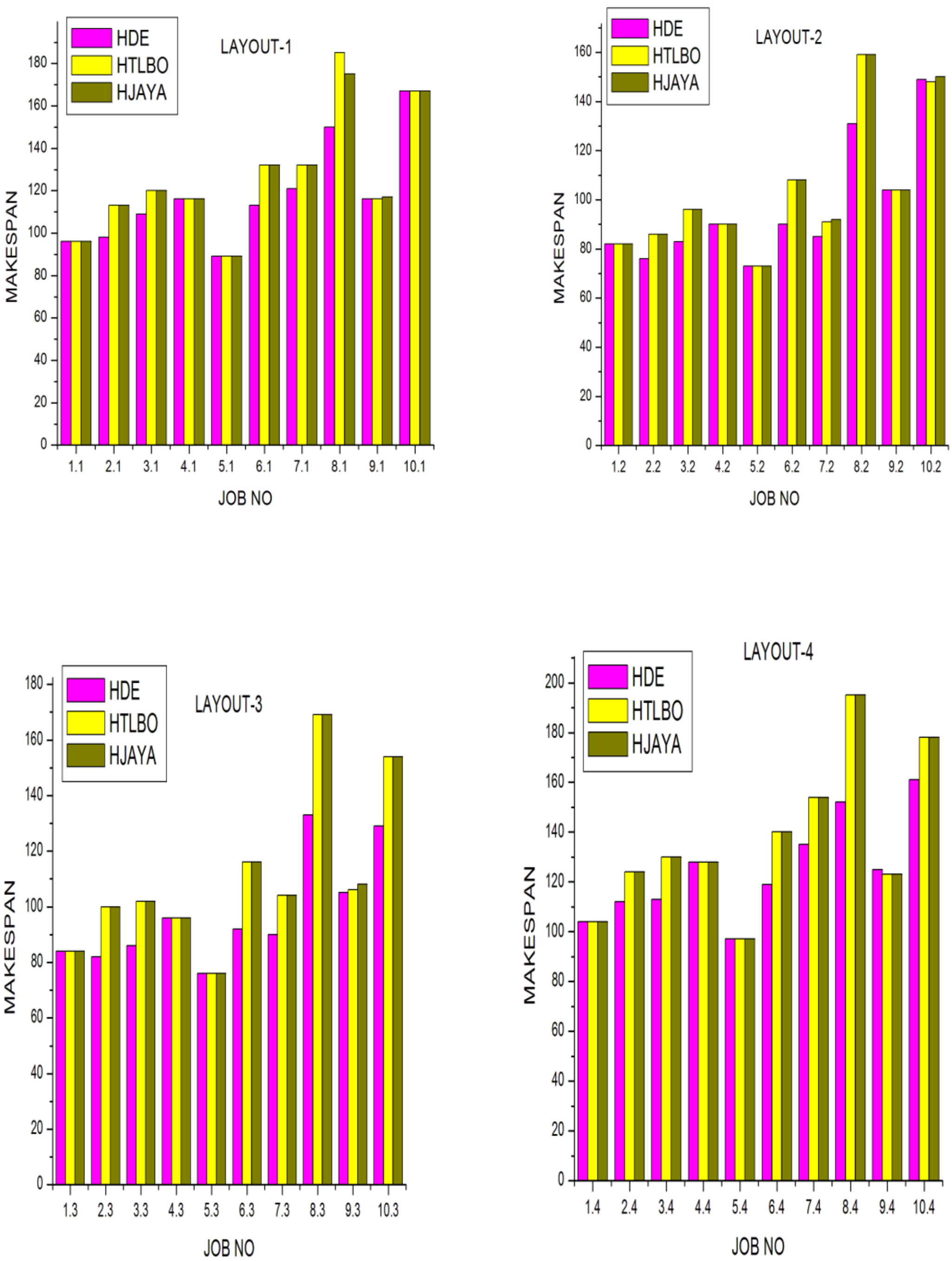

Fig. 1: Comparisions of Performances related to hybrid metaheuristic Algorithms for t/p > 0.25.

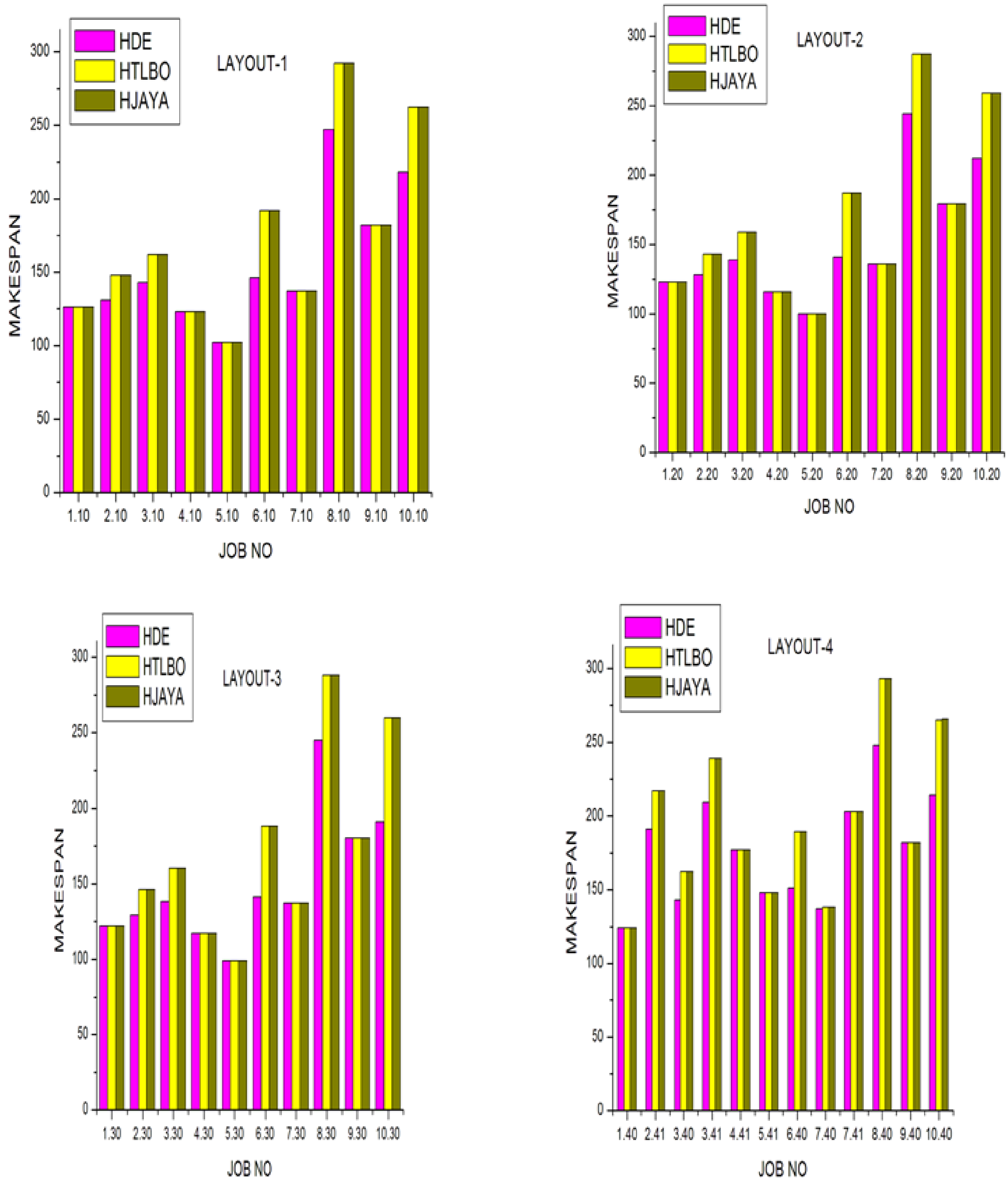

Fig. 2: Comparisions of Performances related to hybrid metaheuristic Algorithms for t/p < 0.25.

It is observed from the above graphs that majority of the problems the HDE performed better than others, except in 5.41 problems where HJAYA is reported to be better.

V. CONCLUSION

In the present work comparision of performances of the three hybrid metaheuristics from the literature namely Hybrid Jaya (Prakash Babu kanakavalli et al,2019), Hybrid Teaching Learning Based Optimization (Prakash Babu kanakavalli et al, 2019) and Hybrid Differential Evolution (HDE) (Prakash Babu kanakavalli et al, 2020), in solving the 82 bench mark problems considered from the literature is done. From the comparision it is observed that out of 82 problems HDE yielded improved results in 80 problems when compared to HJAYA and HTLBO algorithms. Hence it is concluded that HDE is best algorithm in solving simultaneous scheduling problems.

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