INTEGRATED SCHEDULING OF MACHINES AND AGVS IN FMS BY USING DISPATCHING RULES

Received: 17 April 2017 / Accepted: 20 May 2017

Abstract: Recent advancement in meta-heuristics for simultaneous scheduling of machines and AGV studies have applied various techniques such as Differential evaluation (DE), Simulated Annealing (SA) and Ant Colony Optimization (ACO) to solve the simultaneous scheduling problem. All of these technique requires an initial scheduler in order to initiate the scheduling process and the priority rule algorithms will typically be used. However, from the literature, none of these studies elaborate and justify their selection of a particular priority rule algorithms over another. Since the initial scheduler can significantly affect the entire scheduling process, it is important that the correct initial scheduler be selected. In this paper we quantitatively compared three initial scheduler algorithms to determine the best algorithm performance. We believe the performance comparison would enable users to utilize the best initial scheduler to fit their meta-heuristics simultaneous scheduling studies.

Key words: simultaneous scheduling, priority rules, performance

Integrisano raspoređivanje mašina i AGVs u FMS korištenjem dispečerska pravila. Nedavni napredak u meta-heuristici za istovremeno raspoređivanje mašina i AGV studije su primenjeni u raznim tehnikama, kao što je diferencijalno vrednovanje (DE), Simulano žarenje (SA) i Optimizacija uz pomoć kolonije mrava (ACO) da reši istovremeno raspoređivanje problem. Sve ove tehnike zahtevaju inicijalni planer kako bi se započeo proces za raspoređivanje i algoritmi prioriteta pravila koja će se obično koristiti. Međutim, iz literature, nijedna od ovih studija ne elaborira i opravdava izbor određenog prioriteta pravila algoritama nad drugim. Pošto početni raspored može značajno uticati na čitav proces za raspoređivanje, važno je da se izabere ispravn početni planer. U ovom radu su kvantitativno upoređena tri početna planer algoritma da bi se odredile najbolje performanse algoritma. Veruje se da će poređenje performansi omogućiti korisnicima da postave najbolji početni planer da bi odgovarao njihovoj meta heuristikoj simultanoj studiji raspoređivanja.

Ključne reči: simultano raspoređivanje, prioriteta pravila, performanse

1. INTRODUCTION

FMS is a highly automated and sophisticated system in the field of manufacturing to achieve high flexibility and productivity in mid-variety and mid-range of products [1, 2]. The great demand for goods needs new way to enhance productivity with existing manufacturing system and available resources. FMS has emerged as a viable alternative to the conventional manufacturing system and showed benefits in cost reduction, enhanced utilizations, reduced work-in-process levels, etc. The problems encountered in the life cycle of a FMS are classified in to design, planning, scheduling and control [3]. The task of scheduling and controlling problems plays an important role during operation owing to the dynamic nature of the FMS such as flexible parts, tools, AGV routings [4] and AS/RS storage assignments[5].scheduling of machines in FMS is made through sequencing of jobs on machines, and routing of jobs through the system [6,7]. Other resources in the system,(e.g. material-handling devices like AGVs and AS/RS) need to be considered. To have flexible and efficient production, automated guided vehicle systems (AGVS) and the material-handling system (MHS) are being employed [8,9]. The AGVs effectiveness depends on several factors. Function of a well-designed vehicle management are: Dispatching

the process of selecting and assigning tasks to AGV; Routing the process of selecting specific paths by AGVs; and Scheduling – the process of determining the arrival and departure dates. The demand for goods enhances pressure on manufacturing systems seeking ways to increase productivity with available resources. Scheduling is a critical function for the control and operation of any FMS [10].

1.1 Dispatching rules

Over the last four decades, the sequencing and scheduling problem has been solved using dispatching rules (also called scheduling rules, sequencing rules, decision rules, or priority rules). These dispatching rules are used to determine the priority of each job. The priority of a job is determined as a function of job parameters, machine parameters, or shop characteristics. When the priority of each job is determined, jobs are sorted and then the job with the highest priority is selected to be processed first. Baker [11] and Morton and Pentico [12] classified dispatching rules as follows:

Local rules

Local rules are concerned with the local available information.

Global rules

Global rules are used to dispatch jobs using all

information available on the shop floor.

Static rules

Static rules do not change over time, and ignore the status of the job shop floor.

Dynamic rules

Dynamic rules are time dependent, and change according to the status of the job shop floor.

Forecast rules

Forecast rules are used to give priority to jobs according to what the job is going to come across in the future, and according to the situation at the local machine. Several dispatching rules have been reported by many researchers. The following are some of the dispatching rules that have been developed, investigated, and implemented by several researchers and practitioners:

- 1. SPT or SEPT:** Shortest Processing Time or Shortest Expected Processing Time. The job with the smallest operation processing time is processed first.
- 2. LPT or LEPT:** Longest Processing Time or Longest Expected Processing Time. The job with the largest operation processing time is processed first.
- 3. EDD:** Earliest Due Date. The job with the smallest due date is processed first.
- 4. JST:** Job Slack Time. The job with minimum slack is processed first. The job slack time is computed as the difference between the job due date, the work remaining, and the current time.
- 5. CR:** Critical Ratio. The job with the smallest ratio is processed first. The CR is determined by dividing job's allowance by the remaining work time.
- 6. RANDOM:** Service in Random Order. A job is randomly selected from the set of jobs which are queued at the machine.
- 7. FCFS or SORT:** First Come, First Served or Smallest Ready Time. The job which arrives first at the machine will be served first.
- 8. LCFS:** Last Come, First Served. The job which arrives last will be served first.
- 9. LFJ:** Least Flexible Job. The job with the least flexibility is processed first.
- 10. FOFO:** First Off, First On. The job with the operation that could be completed earliest will be processed first even if this operation is not yet in the queue. In this case, the machine will be idle until the operation arrives.
- 11. LAWING:** Least Anticipated Work in Next Queue. From the set of jobs waiting for a specific machine, a job will be selected that will encounter the smallest queue at the next machine in its route.
- 12. COVERT:** Cost OVER Time. COVERT is a composite rule that puts the job with the largest COVERT ratio in first position. The COVERT ratio is computed by dividing an anticipated tardiness for the associated job and its operation processing time.
- 13. Most Operation Remaining Rule (MOPNR):** Every job has a number of operations and according to this rule the operation which has more number of succeeding operations will be given the first priority.
- 14. Preferred Customer Order (PCO):** Sometimes jobs belonging to a particular customer may be given priority for different reasons like the business

offered by them is more than that offered by others or because of their regular business orders etc.

15. Least Slack (LS): Generally there is always a difference between actual finishing time of the job and the due date by which it is supposed to be finished, which is known as "slack". According to this rule the job with the least slack is given first priority as mentioned earlier.

2. SCHEDULING WITH DISPATCHING RULES

Scheduling provides a basis for assigning jobs, whereas sequencing (also referred as dispatching) specifies the priority for completion of jobs in a systematic way at WorkCentre. Hansmann and Hess [13] have adopted the Linear Programming (LP) in a model to achieve maximum profit or lowest cost. Held and Karp [14] have applied the dynamic programming (DP) while solving a large problem. Ignall and Schrage [15] have developed branch and bound algorithms for the permutation flow shop problem with makespan minimization. Bomberger [16] has followed the DP approach considering the production scheduling of different items over the same facility in the system on a repetitive basis. The facility in the system is: only one item can be produced at a time associating with setup cost and setup time under constant demand rate. Campbell *et al.* [17] have applied heuristic algorithm in stages. Lockett and Muhlemann [18] have used the branch and bound algorithm for scheduling jobs with sequencing suitable for small size problems. Crowin and Esogbue [19] have considered two different flow shop scheduling problems for minimizing makespan. After establishing the optimum permutation schedules, an efficient DP formulation has been developed. Holland [20] has invented the algorithms based on Darwin's theory of natural selection and survival. These were invented by. Rinnooy Kan [21] has formulated mathematical programming models and obtained unsatisfactory results. Majority of these techniques are unable to provide feasible solutions and have limited practical use. Panwalkar and Iskander [22] have utilized have classified 100 scheduling rules into static and dynamic rules. Tripathy [23] and, Arani *et al.* [24] have shown better results applying the integer programming on vehicle scheduling problem. Holthaus and Rajendran [25] have utilized the dispatching rules to optimize the job-shop scheduling problems in the manufacturing world. Pan and Fan [26] have used branch and bound algorithm for the problem and reduced the size of the problem including dominance properties. However, the algorithm is limited to 18 jobs. Chen *et al.* [27] have applied DP approach to Lagrangean relaxation for complex scheduling problems and found optimal solution for single and parallel machine problem. Papakostas and Chrysosouris [28] have proposed a dispatching rule (*viz.*, RTSLACK) by maximizing the slack time of the remaining tasks in the manufacturing resources in a series of single machines and hybrid flow shop scheduling instances. Barman and Lisboa [29] have utilized a combination of dispatching rules for cost performance and minimized both mean and variable

waiting cost. Ko et al. [30] have proposed a dispatching rule for non-identical parallel machines with sequence dependent setups and quality restrictions. Kayvanfar et al. [31] have examined a single machine scheduling problem with controllable processing times. Ying et al. [32] have studied the single-machine scheduling problem with a Common Due Window (CDW) having constant size and position to minimize the total weighted earliness and tardiness penalties in jobs completion. Ling et al. [33] minimizing total deviation of job completion time on a single machine scheduling. Dispatching rules have a significant role due to ease of implementation and compatibility with the dynamic

nature of manufacturing systems.

3. FMS DESCRIPTION

The FMS considered in this work has the configurations as shown in Fig 1. There are four Machines having Computer Numerical Controlled Machines (CNCs) each equipped with an independent and self sufficient tool magazine, one Automatic Tool Changer (ATC) and one Automatic Pallet Changer (APC).

LAYOUT 1

LAYOUT 2

LAYOUT 3

LAYOUT 4

Fig. 1. the layout configurations adopted in example problems

3.1 FMS Environment

The environment within which the FMS under consideration operates can be described as follows:

1. The types and number of machines are known. Operations are non-preemptive. There is sufficient input/output buffer space at each machine.
2. Processing, set-up, loading and unloading times are available and are deterministic.
3. Number of AGVs is given and the AGVs are all identical in the sense that they have the same speed and load carrying characteristics.
4. Flow path layout is given and travel times on each segment of the path are known.
5. A load/unload (L/U) station serves as a distribution center for parts not yet processed and as a collection center for parts finished. All vehicles start from the L/U station initially and return to it after accomplishing all their assignments. There is sufficient input/output buffer space at the (L/U) station.
6. AGVs carry a single unit-load at a time. They move along predetermined shortest paths, with the assumption of no delay due to congestion. Preemption of trips is not allowed. The trips are called loaded or deadheading (empty) trips depending on whether a part is carried or no part is carried during that trip, respectively. The durations

for the deadheading trips are sequence dependent and are not known until the vehicle route is specified.

7. It is assumed that all the design and set-up issues within the hierarchy of OR/MS problems in an FMS as suggested by Stecke [34] have already been resolved. Machine loading, i.e., the allocation of tools to machines and the assignment of operations to machines, is made. Pallets and other necessary equipment are allocated to parts. The set of part types to be produced during the planning period and the routing of each part type are available before making scheduling decisions. In other words, routing flexibility is not considered. The routing for a part type can be selected based on considerations of technological feasibility and processing efficiency, or by formulating the set-up phase problems in a manner that can also handle the routing decisions.
8. Ready-times of all jobs are known. Initially, partially processed parts might be available at machines waiting for further processing, and they can be treated as jobs having zero ready times and their routing consists of the remaining operations.
9. Such issues as traffic control, congestion, machine failure or downtime, scraps, rework, and vehicle dispatches for battery change are ignored here and

left as issues to be considered during real-time control.

3.2 Assumptions

- The types and no. of machines are known
- There is sufficient input/output buffer space for each machine
 - Machine loading
 - Allocation of tools to machine has been done
 - Assignment of operation to machine are made
- Pallet and other necessary equipment are allocated
- The speed of AGV kept at 40 m/min
- The distance between the two machines and distance between loading/ unloading machines are known

3.3 Input data

The input data i.e. travelling time matrix from table 1.1 and Job sets for the problem is taken from a paper

by Bilge U and Ulusoy G [35]. Data given in Table 1. gives the distances from load/unload stations to machines and distances between machines in metres for all the four layouts .The Ten job sets are given in Table 2. given below each containing four to eight different job sets, machines in each job set to be used and numbers with in the parenthesis is the processing time of particular job on specified machine. The load/unload (L/U) station serves as a distribution center for parts not yet processed and as a collection center for parts finished. All vehicles start from the L/U station initially. Trips follow the shortest path between two points either between two machines or between a machine and the L/U station. Preemption of trips is not allowed the trips are called loaded or deadheading (empty) trips. The durations for the deadheading trips are sequence dependent and are not known until the vehicle route is specified.

Layout-1	L/U	M1	M2	M3	M4
L/U	0	6	8	10	12
M1	12	0	6	8	10
M2	10	6	0	6	8
M3	8	8	6	0	6
M4	6	10	8	6	0
Layout-2	L/U	M1	M2	M3	M4
L/U	0	4	6	8	6
M1	6	0	2	4	2
M2	8	12	0	2	4
M3	6	10	12	0	2
M4	4	8	10	12	0
Layout-3	L/U	M1	M2	M3	M4
L/U	0	2	4	10	12
M1	12	0	2	8	10
M2	10	12	0	6	8
M3	4	6	8	0	2
M4	2	4	6	12	0
Layout-4	L/U	M1	M2	M3	M4
L/U	0	4	8	10	14
M1	18	0	4	6	10
M2	20	14	0	8	6
M3	12	8	6	0	6
M4	14	14	12	6	0

Table 1. Travel time matrix for this particular problem

JobSet-1 Job 1: M1(8); M2(16); M4(12) Job 2: M1(20); M3(10); M2(18) Job 3: M3(12); M4(8); M1(15) Job 4: M4(14); M2(18) Job 5: M3(10); M1(15)	JobSet-2 Job 1: M1(10); M4(18) Job 2: M2(10); M4(18) Job 3: M1(10); M3(20); Job 4: M2(10); M3(15); M4(12) Job 5: M1(10); M2(15); M4(12) Job 6: M1(10); M2(15); M3(12)
JobSet-3 Job 1:M1(16); M3(15) Job 2:M2(18); M4(15) Job 3:M1(20); M2(10) Job 4:M3(15); M4(10) Job 5:M1(8);M2(10);M3(15);M4(17) Job 6: M2(10);M3(15);M4(8);M1(15)	JobSet-4 Job1: M4(11); M1(10); M2(7) Job2: M3(12); M2(10); M4(8) Job3: M2(7); M3(10); M1(9); M3(8) Job4: M2(7); M4(8); M1(12);M2(6) Job5:M1(9);M2(7);M4(8);M2(10);M3(8)

JobSet-5 Job 1: M1(6);M2(12);M4(9) Job 2: M1(18);M3(6); M2(15) Job 3: M3(9);M4(3);M1(12) Job 4: M4(6);M2(15) Job 5: M3(3);M1(9)	JobSet-6 Job 1: M1(9); M2(11); M4(7) Job 2: M1(19); M2(20); M4(13) Job 3: M2(14); M3(20); M4(9) Job 4: M2(14); M3(20); M4(9) Job 5: M1(11); M3(16); M4(8) Job 6: M1(10); M3(12); M4(10)
JobSet-7 Job 1: M1(6); M4(6) Job 2: M2(11); M4(9) Job 3: M2(9); M4(7) Job 4: M3(16); M4(7) Job 5: M1(9); M3(18) Job 6: M2(13); M3(19); M4(6) Job 7: M1(10); M2(9); M3(13) Job 8: M1(11); M2(9); M4(8)	JobSet-8 Job 1: M2(12); M3(21);M4(11) Job 2: M2(12); M3(21);M4(11) Job 3: M2(12); M3(21);M4(11) Job 4: M2(12); M3(21);M4(11) Job 5: M1(10); M2(14);M3(18);M4(9) Job 6: M1(10);M2(14); M3(18);M4(9)
JobSet-9 Job 1: M3(9);M1(12);M2(9);M4(6) Job 2: M3(16);M2(11); M4(9) Job 3: M1(21); M2(18); M4(7) Job 4: M2(20); M3(22); M4(11) Job 5:M3(14);M1(16);M2(13); M4(9)	JobSet-10 Job1:M1(11);M3(19);M2(16);M4(13) Job2: M2(21);M3(16); M4(14) Job3:M3(8); M2(10); M1(14); M4(9) Job4: M2(13); M3(20); M4(10) Job5: M1(9); M3(16); M4(18) ; Job6:M2(19);M1(21); M3(11);M4(15)

Table 2. Data for the Job Sets Used in Example Problems

3.4 Objective function

Operation completion time= $O_{ij}=T_{ij}+P_{ij}$
 T_{ij} =Traveling time for j^{th} operation and i^{th} job
 P_{ij} =operation processing time

$$\text{Mean Tardiness} = \frac{1}{n} \sum_{i=1}^n T_i \quad n = \text{number of jobs};$$

T_i = Tardiness

Optimization parameters considered

Population Size = Double the no of operations

Iterations completed = 1000

3.5 Vehicle scheduling methodology

Jobs are scheduled based on the operation sequence derived by the Sheep Flock Heredity algorithm. Initially AGVs carry jobs from the load/unload station to the respective workstations where the first operations are scheduled. AGVs make two types of trips, a loaded trip where it carries a load and a deadheading trip where the vehicle moves to pick up a load. Deadheading trip can start immediately after the delivery and vehicle demand at different workstations are considered and the subsequent assignments are made. If both AGVs are available task is assigned to the earliest available vehicle. If no vehicle is available, the earliest available times of the AGVs are computed and the assignment is made. If the vehicle is idle and no job is ready, assign the operation that is going to be completed early and is identified the vehicle is moved to pick up that job. This type of vehicle scheduling methodology helps in reducing the waiting times and thus helps in improving the resource utilization and the throughput. The flow chart of the vehicle assignment methodology is given in Fig. 2.

4. IMPLEMENTATION OF SEQUENCING RULES

Scheduling provides a basis for assigning jobs to a work center. Sequencing (also referred to as dispatching) specifies the order in which jobs should be completed at each centre. The sequencing methods are referred to as priority rules for sequencing or dispatching jobs to a work center. In the manufacturing world, scheduling problems are extensively adopting the dispatching rules to provide good solutions to complex problems in a real-time production environment.

4.1 First cum First Serve(FCFS)

For implementation of First cum first serve rule, Job set 5 and Layout1 is considered.

Job Set 5												
Job1	Job2		Job3				Job4		Job5			
M ₁	M ₂	M ₄	M ₁	M ₃	M ₂	M ₃	M ₄	M ₁	M ₄	M ₂	M ₃	M ₁
1	2	3	4	5	6	7	8	9	10	11	12	13

In FCFS continuous numbers are marked initially for the operations in a job set by following precedence relation, i.e., operation of the same job set must be in increasing order but anywhere in the sequence. According to this rule the sequence is.

1 2 3 4 5 6 7 8 9 10 11 12 13

4.2 Shortest processing time (SPT)

For implementation of shortest processing time rule, Job set 3 and Layout 2 are considered.

In SPT continuous numbers are marked initially for the operations in a job set by following precedence relation. And the total process time for each and every job is found out. For example in the above Job set total

processing times are job1-31, job2-33, job3-30, job4-25, job5-50, and job6-44. According to this rule the

priority of job is 4, 3, 1, 2, 6, 5 and the sequence is:
8 5 6 12 3 4 14 15 16 9 10 11 12

Job set 3

Job 1		Job 2		Job 3		Job 4		Job 5				Job 6			
M1	M3	M2	M4	M1	M2	M3	M4	M1	M2	M3	M4	M2	M3	M4	M1
16	15	18	15	20	10	15	10	8	10	15	17	10	15	8	15
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

4.3 Longest processing time (LPT)

For implementation of longest processing time rule, Job set 9 and Layout 3 are considered.

In LPT continuous numbers are marked initially for the operations in a job set by precedence relation. The total process time for each and every job is found. For example in job set No 9 total processing times are job1-

36, job2-36, job3-46, job4-53, and for job5-52, since both the process times are same first one is selected as priority. According to this rule the priority of job is 4, 5, 3, 1, 2 and the sequence is:

11 12 13 14 15 16 17 8 9 10 1 2 3 4 5 6 7

And the test results obtained by simulating FCFS, SPT and LPT for simultaneous scheduling problems are given below in Table 3. and Table 4.

Job set 9

Job 1				Job 2			Job 3			Job 4			Job 5			
M3	M1	M2	M4	M3	M2	M4	M1	M2	M4	M2	M3	M4	M3	M1	M2	M4
9	12	9	6	16	11	9	21	18	7	20	22	11	14	16	13	19
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Fig. 2. flow chart for Simultaneous scheduling machines and AGVs

3. RESULT AND DISCUSSION

Ten different job sets with different processing sequences, and process times are generated and presented. Different combinations of these ten job sets and four layouts are used to generate 82 example problems. In all these problems there are two vehicles. Table 3. consists of problems whose t_i/p_i ratios are greater than 0.25, and whose t_i/p_i ratios are lesser than

0.25 ratios are represented in Table 4. A code is used to designate the example problems which are given in the first column. The digits that follow 1.1 indicate the job set and the layout. In Table 2 another digit is appended to the code. Here, having a 0 or 1 as the last digit implies that the process times are doubled or tripled, respectively, where in both cases travel times are halved.

Job. No	t/p	FCFS	SPT	LPT
1.1	0.59	173	193	177
2.1	0.61	158	158	177
3.1	0.59	202	224	198
4.1	0.91	263	267	264
5.1	0.85	148	164	148
6.1	0.78	231	240	227
7.1	0.78	195	210	201
8.1	0.58	261	261	266
9.1	0.61	270	277	268
10.1	0.55	308	308	310
1.2	0.47	143	173	165
2.2	0.49	124	124	130
3.2	0.47	162	188	160
4.2	0.73	217	223	224
5.2	0.68	118	144	131
6.2	0.54	180	169	165
7.2	0.62	149	160	149
8.2	0.46	181	181	198
9.2	0.49	250	249	244
10.2	0.44	290	288	287
1.3	0.52	145	175	167
2.3	0.54	130	130	136
3.3	0.51	160	190	162
4.3	0.8	233	237	230
5.3	0.74	120	146	133
6.3	0.54	182	171	167
7.3	0.68	155	166	151
8.3	0.5	183	183	200
9.3	0.53	252	251	246
10.3	0.49	293	294	293
1.4	0.74	189	207	189
2.4	0.77	174	174	174
3.4	0.74	220	250	212
4.4	1.14	301	301	298
5.4	1.06	171	189	171
6.4	0.78	249	252	237
7.4	0.97	217	242	151
8.4	0.72	285	285	200
9.4	0.76	292	311	290
10.4	0.69	350	350	345

Table 3. Performance evaluation for $t/p > 0.25$ considering FCFS, SPT and LPT procedures

Job.No	t/p	FCFS	SPT	LPT
1.10	0.15	207	248	252
2.10	0.15	217	217	225
3.10	0.15	257	327	282
4.10	0.15	303	328	317
5.10	0.21	152	190	187
6.10	0.16	304	281	297
7.10	0.19	231	240	264
8.10	0.14	338	338	347
9.10	0.15	390	367	359
10.10	0.14	452	429	444
1.20	0.12	194	238	246
2.20	0.12	194	194	206
3.20	0.12	241	311	270
4.20	0.12	285	312	298
5.20	0.17	142	180	184
6.20	0.12	292	260	284
7.20	0.15	212	218	249
8.20	0.11	306	319	334
9.20	0.12	380	355	347
10.20	0.11	445	423	439
1.30	0.13	195	239	247
2.30	0.13	197	197	209
3.30	0.13	240	312	271
4.30	0.13	292	317	301
5.30	0.18	141	181	183
6.30	0.24	296	261	285
7.30	0.17	215	221	250
8.30	0.13	307	320	335
9.30	0.13	381	356	348
10.30	0.12	448	426	442
1.40	0.18	213	255	254
2.41	0.13	307	307	319
3.40	0.18	261	330	282
3.41	0.12	370	476	411
4.41	0.19	434	471	451
5.41	0.18	218	269	270
6.40	0.19	310	288	299
7.40	0.24	239	251	270
7.41	0.16	329	344	385
8.40	0.18	343	343	349
9.40	0.19	396	379	370
10.40	0.17	466	445	455

Table 4. Performance evaluation for $t/p < 0.25$ considering FCFS, SPT and LPT procedures

5. CONCLUSIONS

In this paper the optimal sequence of machines and AGVs are determined by using FCFS, SPT and LPT from Table no 3. and table 4. it is observed that from table 3. out of 40 problems 22 problems gives better results using FCFS when compared with SPT and LPT,

8 problems gives better results using SPT when compared with FCFS and LPT and 24 problems gives better results using LPT when compared with SPT and FCFS and also it can be observed that from table 4. out of 42 problem 30 problems gives better results using FCFS when compared with SPT and LPT, 14 problems gives better results using SPT when compared with

FCFS and LPT and 4 problems gives better results using LPT when compared with SPT and FCFS.

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Acknowledgments

The authors acknowledge with thanks the financial assistance offered by DST-SERB, Govt.of India wide file. No: SB/EMEQ-501/2014 for carry out this work.

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