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Simultaneous Scheduling of Machines and AGVS in FMS by Using Symbiotic Organisms Search (SOS) Algorithm

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Abstract: Scheduling of flexible manufacturing systems is a NP–hard problem which is very complex. Improvement in the performance of a FMS can be expected by efficient utilization of its resources, by proper integration and synchronization of their scheduling. Symbiotic Organisms Search (SOS) algorithm is a potent tool which is a better alternative for solving optimization problems like scheduling and proven itself.
In this paper, authors addressed the problem of simultaneous scheduling of machines and automated guided vehicles in flexible manufacturing system (FMS) so as to minimize the make span. The organisms in 'SOS' represent both operation sequencing and AGVs assigned. The proposed SOS is tested on various problems with make span as an objective and the results are compared with the results of earlier methods.

I. INTRODUCTION

FMS is an integrated manufacturing system which incorporates many modern facilities such as Computer Numerically Controlled (CNC) machines, Automated Guided Vehicles(AGVs), Automated storage/ Retrieval Systems (AS/RS), Central Tool Magazine (CTM),Robots and Automated inspection using machine vision system under the control of a central computer [3,1].Various subsystems flexibilities are integrated together in creating an overall flexibility in FMS. One of the modern techniques in industrial automation is FMS, and many researchers have been attracted towards FMS over the last three decades. FMS has many advantages such as greater productivity, minimum work-in-process inventory, high machine utilization, production with minimum supervision, increased product variety and high quality to satisfy customer needs. The use of fixtures, pallets, tool transporter and CTM practically eliminated the job setting time [4]. Broadly FMS is classified into four different categories; Single Flexible machines (SFM), Flexible Manufacturing Cells (FMCs), Multi machine FMS(MMFMS) and multi cell FMS (MCFMS) [2]. FMS aims at combining the advantages of higher efficiency in high volume mass production and higher flexibility in low volume job shop production. In FMS, in order to achieve the higher efficiency and flexibility various scheduling decisions such as allocation of machines to jobs, allocation of AGVs and selection of tools are made. Proper scheduling plays a critical role in FMS in improving productivity. In scheduling problems, for 'p' jobs and 'q' machines, $(p)^q$ different number of sequences are to be examined with respect to any performance measure, to suggest a best sequence. This implies that the search region is increased exponentially for problem of larger size that makes the scheduling problem as NP-hard problem. In FMS various jobs are to be allocated to machines to optimize the performance of FMS. This is similar to job shop scheduling. The main difference between them is that the job shop considers only jobs and machines, where as FMS considers resources such as AGVs, CTM, AS/RS, Robots, Pallets and Fixtures in addition to Jobs and machines. Hence scheduling problems connected with FMS are also NP-hard. Many researchers have addressed the machine and vehicle scheduling as independent problems. However the importance of simultaneous scheduling of jobs and automated guided vehicles (AGVs) has been emphasized by only few researchers. Raman et al [5] addressed the problem as an integer programming problem and procedure for solution based on the concepts of project scheduling under resource constraints. It was assumed that after transferring the load, the vehicle always returns to the load/unload station, which reduces the AGV flexibility and influences the schedule length. Ulusoy and Bigle [6] attempted to make AGV scheduling an integral part of scheduling activity in an FMS. The problem was decomposed into two sub problems i.e. machine scheduling problem and vehicle scheduling problem. At each iteration , a new schedule for machines, generated by heuristic procedure was examined for its feasibility to the vehicle scheduling sub problem. The combined machine and AGVs scheduling problem was formulated as a non-linear mixed integer programming (MIP) model.. BILGE and ULUSOY [7] proposed an iterative method based on the decomposition of the master problem into two sub-problems i.e., machine scheduling problem and vehicle scheduling problem. They developed a heuristic, named 'sliding time window (STW)', to solve the simultaneous off-line scheduling of machines and material handling in FMS.

They provided a MIP model to formulate the problem. The MIP heuristic was tested on 82 test problems. Ulusoy et al [8] proposed a genetic algorithm for this problem. Suitable coding scheme was provided, in which chromosome represents both the operation number and AGV assignment. Special genetic operators were developed for this purpose. The authors implemented their GA program with this coding and tested it on the 82 test problems that were solved earlier by the STW heuristic. Abdelmaguidet [9] proposed a hybrid genetic algorithm for the problem. The hybrid GA consists of GA and heuristic. The GA addresses the scheduling of jobs and the heuristic called vehicle assignment algorithm handles the vehicle assignment. The hybrid GA is applied on a set of 82 test problems. Murayama and Kawata [10] also addressed simultaneous scheduling of machines and AGVs. However it is assumed that AGVs can carry multiple loads instead of single load at a time. The genetic algorithm was applied to the problem. MURAYAMA and KAWATA [11] proposed a local search method for simultaneous scheduling of machines and multiple-load automated guided vehicles. They introduced a representation of solutions and a neighborhood operation considering operation sequence and AGV assignment. JERALD et al [12] proposed an adaptive GA (AGA) and ants colony optimization (ACO) for a 16-machine and 43-part problem. Their objective function is a combined objective of minimizing penalty cost and minimizing machine idle time. They also examined the speed of the AGV and found that AGA is superior to the ACO algorithm. JERALD et al [13] compared a GA and an adaptive GA (AGA). They showed that AGA performs better than the GA. JERALD et al [14] considered the scheduling of parts and AS/RS in an FMS using genetic algorithm. They used GA to find out the minimum movement of shuttle for the optimum storage allocation of materials in AS/RS. MURAYAMA and KAWATA [15] proposed a simulated annealing method for the simultaneous scheduling problems of machines and multiple-load AGVs to obtain relatively good solutions for a short time. The proposed method is based on a local search method for job shop scheduling problems. They provided a new representation of solutions and neighborhood operation in order to consider the transportation by multiple-load automated guided vehicles . Reddy and Rao[16] addressed simultaneous scheduling of machines and vehicles for multi objective. Hybrid multi objective GA was used to solve the problem and the combined minimization of makespan, mean flow time and mean tardiness considered as an objective. DEROUSSI et al [17] also addressed the problem of simultaneous scheduling of machines and vehicles in FMS. They proposed a new solution representation based on vehicles rather than machines, whereby each solution can thus be evaluated using a discrete event approach. An efficient neighboring system is then implemented into three different meta-heuristics, namely iterated local search, simulated annealing and their hybridization. Their results were compared with previous studies and show the effectiveness of the presented approach. Philippe Lacomma et al [18] propose a new effective framework based on a disjunctive graph to modelize the joint scheduling problem and on a memetic algorithm for jobs sequence generation on machines, AGVs sequence generation and vehicles assignments to transport operations.

II. FMS ENVIRONMENT

The FMS environment considered here consists of four machines, and CTM consisting of four tools, one Automatic tool changer (ATC),the AGVs and tool transporter(TT). On one end there is loading and unloading station. Buffer storage at each machine center is provided to store the jobs before and after processing. There is an automated storage and retrieval system (AS/RS) for storage of raw material and retrieval. The system is shown in figure1 with the elements.

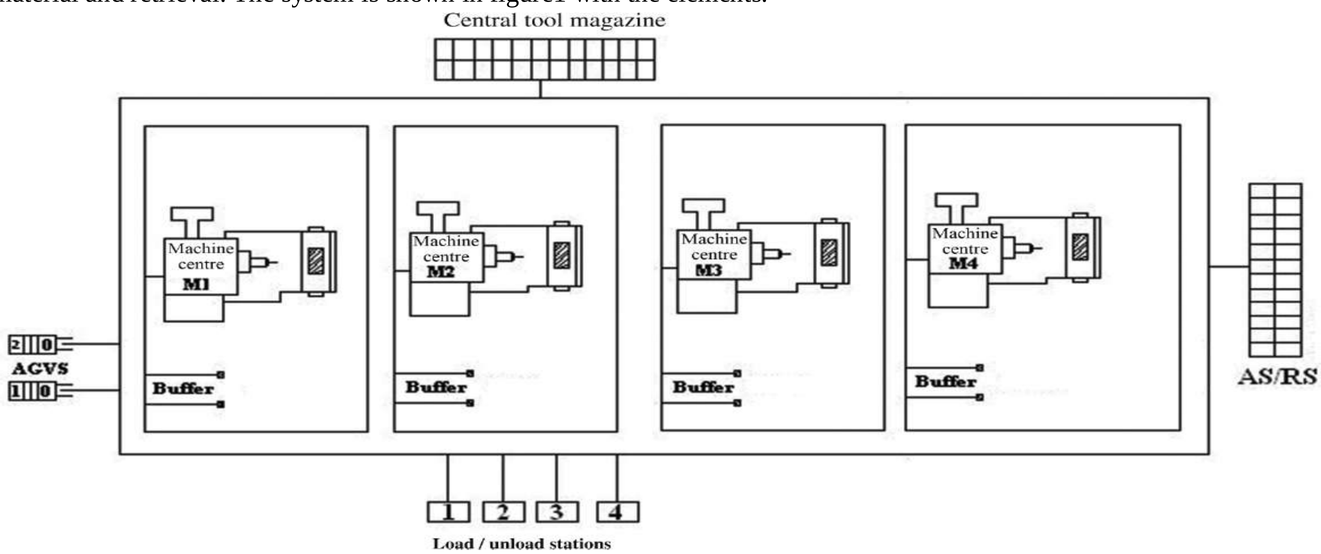

Figure 1. FMS environment

III. PROBLEM AND ASSUMPTIONS

Simultaneous scheduling of the machines and the material handling system in an FMS can be defined as follows: Given the FMS described later, determine the starting and completion times of operations for each job and the trips between workstations together with the vehicle assignment according to the objective of minimising the make span.

It is assumed that all the design and set-up issues for the FMS as suggested by STECKE [19] have already been resolved. Four layout configurations as shown in Fig.2 and ten job sets are used. The number of automated guided vehicles (AGVs) in the system is two. The types and number of machines are known. There is a sufficient input/output buffer space at each machine. Machine loading has been done i.e., allocation of tools to machines and the assignment of operations to machines.Operations are not pre-emptive. Ready times of all jobs are known. The load/unload (L/U) station serves as a distribution centre for parts not yet processed and as a collection centre for parts finished. All vehicles start from the L/U station initially. There is a sufficient input/output buffer space at the L/U station. Trips follow the shortest path between two points and occur either between two machines or between a machine and the L/U station. Pre-emption of the trips is not allowed. The trips are called loaded or deadheading (empty) trips depending on whether or not a part is carried during that trip, respectively. The duration of deadheading trips is sequence-dependent and is not known until the vehicle route is specified. Processing, set-up, loading, unloading and travel times are available and deterministic. Vehicles move along predetermined shortest paths, with the assumption of no delay due to the congestion. As a result of this assumption, it would follow that the guide paths on segments can be uni-directional or bi-directional. However, on busy segments, two uni-directional paths should be used instead of abi-directional guide path so that traffic congestion does not reach a critical level leading to the violation of this assumption. Furthermore, such issues as traffic control, machine failure or downtime, scraps, rework and vehicle dispatches for battery changes are ignored here and leftas issues to be considered during real time control.

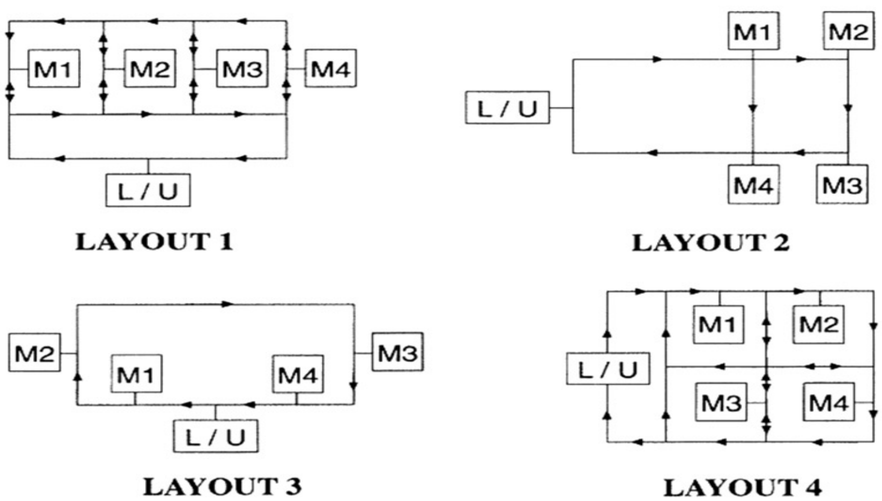

Figure 2.layout configurations used for examples

The following constraints are to be satisfied by the AGV travel when scheduling these FMSs:

A. For each operation *j*, there is a corresponding loaded trip whose destination is the machine where operation *j* is to be performed and its origin is either the machine where the operation preceding *j* is assigned or the L/U station;

B. Operation *j* of job *I* can start only after the trip to load has been completed

C. An AGV trip cannot start before the maximum of the completion time of the previous operation of a job and the deadheading trip of the AGV to the job is obtained. The AGV travel times and the machine allocation and operation times for the jobs are given in Appendix A.

IV. METHODOLOGY

A. Symbiotic Organisms Search Algorithm

The SOS algorithm, proposed by Cheng and Pray go [20], is a simple and powerful meta-heuristic algorithm. The SOS algorithm works on the interdependent behavior seen among organisms in nature. Some organisms do not live alone because they are interdependent on other species for survival and food. The liaison between two different species is known as symbiotic. In this context, 'mutualism', 'commensalism', and 'parasitism' are common symbiotic relations found in nature. Propinquity between two different species that results in mutual benefit is called mutualism. A relationship between two distinct species that offers benefits to

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only one of them (without the affecting other) is called commensalism. Finally, a relationship between two distinct species that offers benefits to one and cause harm to the other is called parasitism. The pseudo code of the above explanation is shown in figure 3.

- Initialization
- REPEAT
  - Mutualism phase
  - Commensalism phase
  - Parasitism phase

UNTIL (termination criterion is met)

Figure 3. Pseudo code for the SOS algorithm:

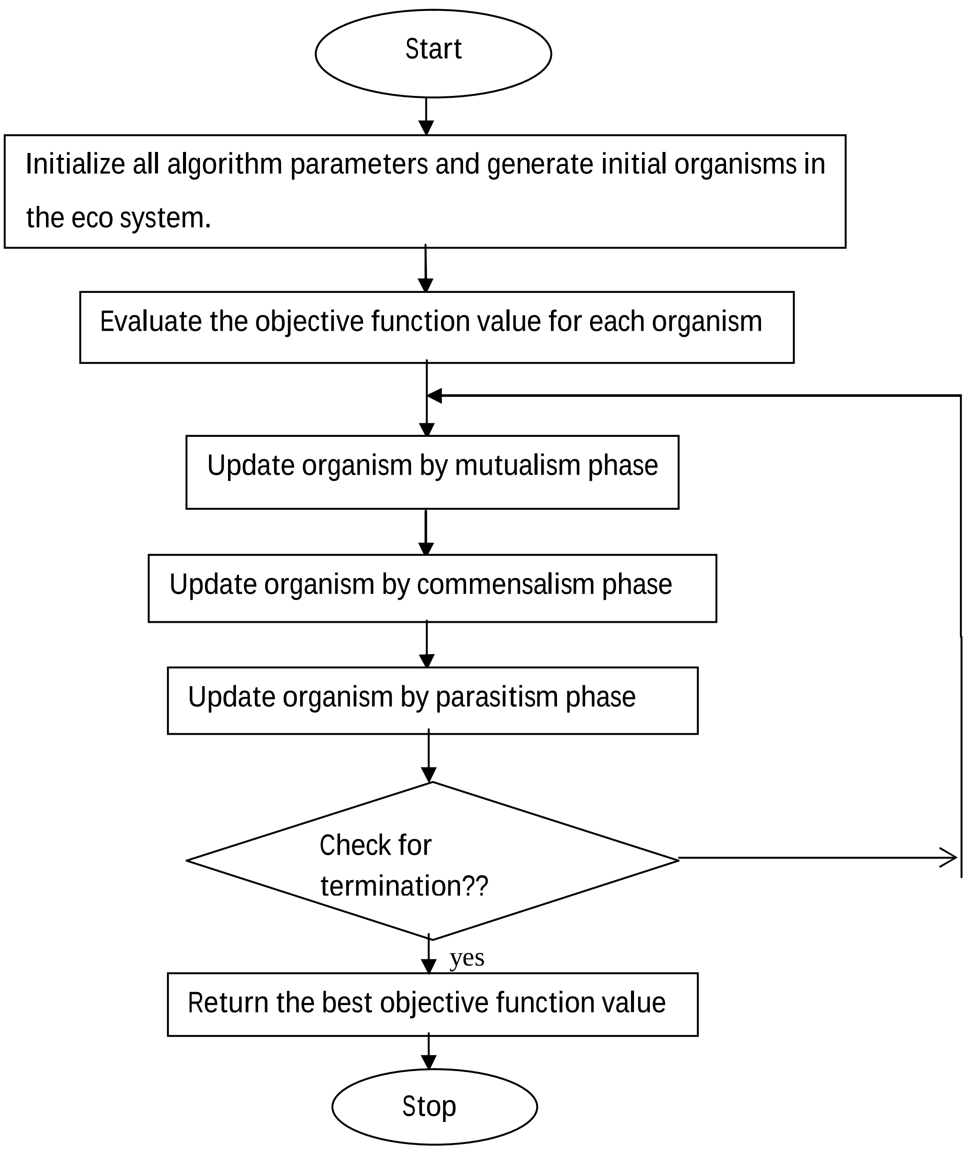


Figure3: Flow chart for the SOS Algorithm

B. Simultaneous scheduling methodology

1) Procedural steps in simultaneous scheduling methodology

a) Step 1: Enter the input data: Job set details, solution vector, AGV travelling time matrix.

b) Step 2: Read parameter of solution vector one after another.

*c) Step 3:*Get job no, operation no, machine no, AGV no.

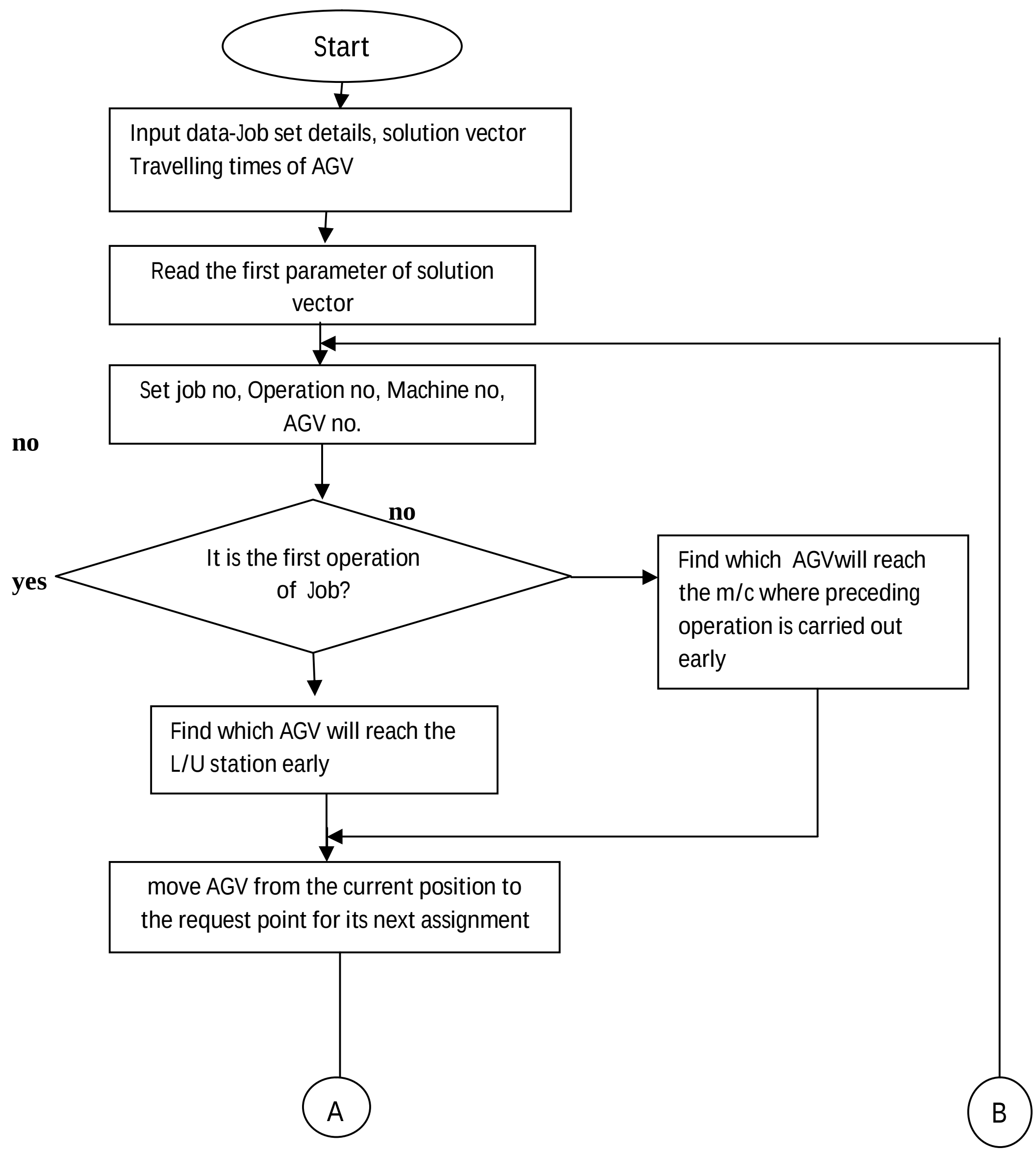
*d) Step 4:*Check whether it is the first operation of a Job or not. If yes find which AGV will reach the L/U station early. If not find which AGV will reach the machine when Preceding operation is carried out early Move the AGV from the current position to the request point for its next assignment

e) : Check whether the Job is ready or not. If yes AGV moves the Job to the next machine at which next operation is scheduled. If not AGV waits till the Job is ready and then AGV moves the Job.

f) Check whether machine is free or not. If it is free load the Job, else the Job waits in the buffer till the machine becomes free

g) Step8: Check whether all the parameters completed. If not read the next parameter of the solution vector and repeat from step 3.

*h) Step9***:** If all parameters are completed out put the make span and stop.



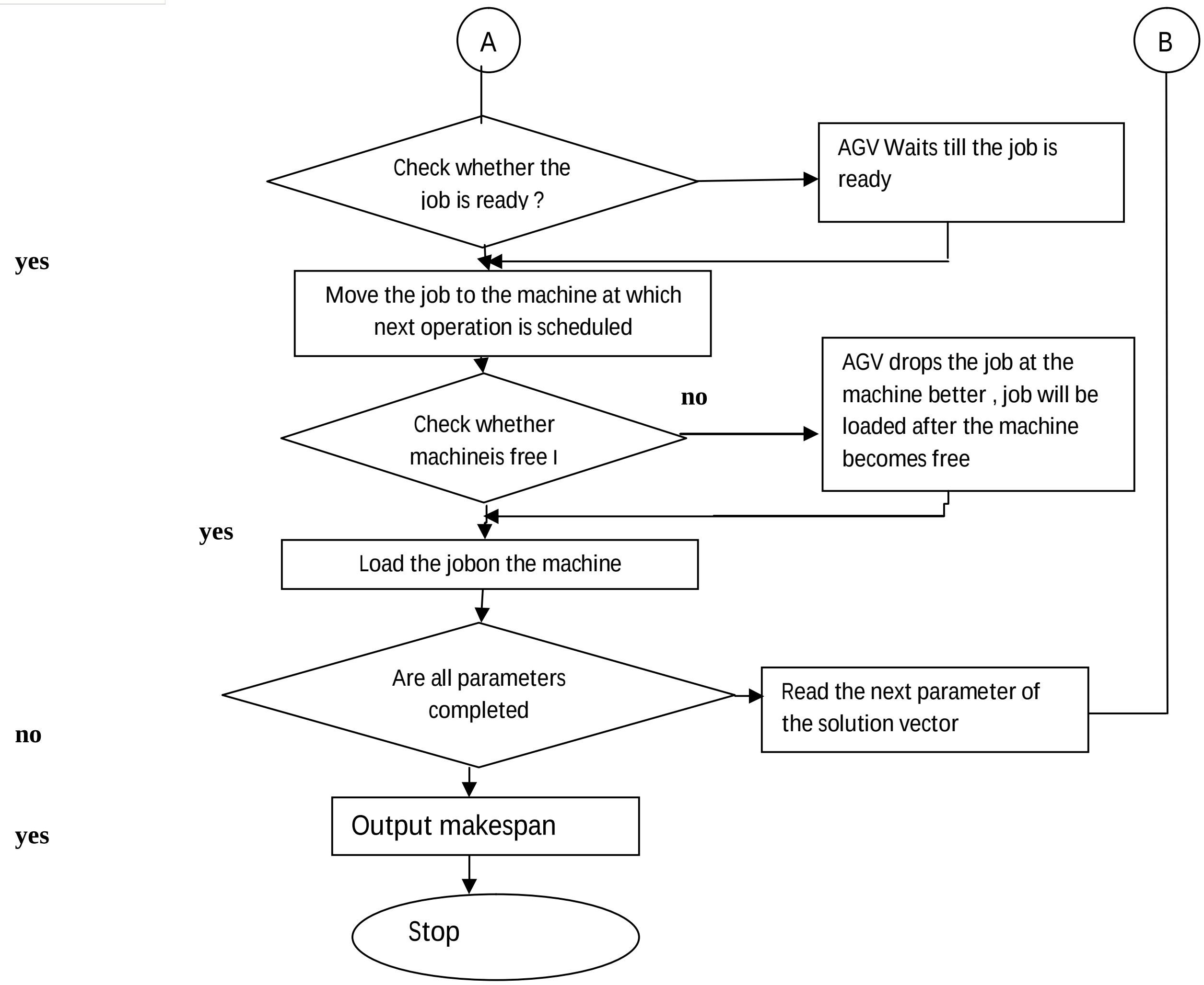


Fig 4: Simultaneous scheduling methodology flow chart

C. Limits Function And Bounds Function

Limits function is used to make sure that the operations in the vector so generated using random numbers follows precedence requirement constraints of the operations. If the precedence is not followed, the limits function correct the vector so that the operations of the vector follows precedence requirement constraints. Bounds function is used to make sure that the AGVs in the vector so generated using random numbers are within bounds. If the AGVs are not within the bounds which will be corrected by bounds function so that the AGVs of the vector are within the bounds.

IV. RESULTS AND DISCUSSION

Make span of simulation in FMS for simultaneous scheduling of Jobs and Machines has been executed by the proposed algorithm on 10 different job sets with different processing sequences and process times are generated and presented in Appendix A. Different combinations of each 10 job sets and 4 layouts are used to generate 82 example problems. In all these problems there are 4 machines and 2 AGVs, Table 1 consist of make span of problems whose t_i/p_i ratios greater than 0.25 while Table 2 consist of make span of problems whose t_i/p_i ratios are less than 0.25. A code is used to designate the problems which are given in the first column. The digits that follow EX indicates the job set in the layout. In table 2, another digits is appended to the code. Here having zero or one as the last digit implies that the process times are doubled or triple respectively, where as travel times are halved in both cases. The minimum make span is represented in bold letters. The results show that solutions obtained by proposed algorithm are better. The Gantt chart for the sequence generated for job set 5layout 2 by SOS is shown fig 5.The operations that are assigned to each machine as well as start and finish times of each operation shown in the Gantt chart. The loaded trip times and empty trip times of AGVs for all the jobs are shown in the Gantt chart. The Gantt chart shows the correctness of solution provided by the proposed SOS method.

Table 1. Comparision of SOS results with other methods for t_i/p_i>0.25

Problem	SOS	STW	UGA	AGA	RGA	PDE1	PDE2
EX 1.1	96	96	96	96	96	96	96
EX 1.2	82	82	82	82	82	82	82
EX 1.3	84	84	84	84	84	84	84
EX 1.4	103	108	103	103	103	103	103
EX 2.1	105	105	104	102	100	100	100
EX 2.2	76	80	76	76	76	76	76
EX 2.3	86	86	86	86	86	86	86
EX 2.4	108	116	113	108	108	108	106
EX 3.1	99	105	105	99	99	99	99
EX 3.2	85	88	85	85	85	85	85
EX 3.3	86	86	86	86	86	86	86
EX 3.4	111	116	113	111	111	111	110
EX 4.1	116	118	116	112	112	112	112
EX 4.2	88	93	88	88	87	85	86
EX 4.3	89	95	91	89	89	89	89
EX 4.4	126	126	126	126	126	126	126
EX 5.1	87	89	87	87	87	87	87
EX 5.2	69	69	69	69	69	69	69
EX 5.3	74	76	75	74	74	74	74
EX 5.4	96	99	97	96	96	96	95
EX 6.1	119	120	121	118	118	115	118
EX 6.2	98	98	98	98	98	98	98
EX 6.3	103	104	104	104	103	103	103
EX 6.4	125	120	123	120	120	120	120
EX 7.1	120	119	118	115	111	112	114
EX 7.2	87	90	85	79	79	79	79
EX 7.3	91	91	88	86	83	83	84
EX 7.4	141	136	128	127	126	126	126
EX 8.1	151	161	152	161	161	161	161
EX 8.2	141	151	142	151	151	153	151
EX 8.3	143	153	143	153	153	152	153
EX 8.4	156	163	163	163	163	163	163
EX 9.1	118	120	117	118	116	114	114
EX 9.2	102	104	102	104	102	104	104
EX 9.3	105	110	105	106	105	103	103
EX 9.4	123	125	123	122	122	123	123
EX 10.1	150	153	150	147	147	147	147

EX 10.2	141	139	137	136	135	135	135
EX 10.3	148	143	143	141	139	139	139
EX 10.4	165	171	164	159	158	158	158

Table 2. Comparision of SOS results with other methods for $t_i/p_i<0.25$

problem	SOS	STW	UGA	AGA	RGA	PDE1	PDE2
EX 1.10	126	126	126	126	126	126	126
EX 1.20	123	123	123	123	123	123	123
EX 1.30	122	122	122	122	122	122	122
EX 1.40	124	124	124	124	124	124	124
EX 2.10	148	148	148	148	148	148	148
EX 2.20	143	143	143	143	143	143	143
EX 2.30	146	146	146	146	146	146	146
EX 2.41	217	217	217	217	217	217	217
EX 3.10	150	148	150	150	150	150	150
EX 3.20	145	148	145	145	145	145	145
EX 3.30	146	149	146	146	146	146	146
EX 3.41	221	221	221	221	221	221	221
EX 4.10	119	121	119	119	119	119	119
EX 4.20	114	116	114	114	114	114	114
EX 4.30	114	116	114	114	114	114	114
EX 4.41	172	179	172	172	172	171	171
EX 5.10	102	102	102	102	102	102	102
EX 5.20	100	100	100	100	100	100	100
EX 5.30	99	99	99	99	99	99	99
EX 5.41	148	154	148	148	148	148	148
EX 6.10	186	186	186	186	186	186	186
EX 6.20	181	181	181	181	181	181	181
EX 6.30	182	184	182	182	182	182	182
EX 6.40	184	185	184	184	184	184	184
EX 7.10	137	137	137	137	137	137	137
EX 7.20	136	136	136	136	136	136	136
EX 7.30	137	137	137	137	137	137	137
EX 7.41	203	203	203	203	203	203	203
EX 8.10	272	292	271	292	292	292	292
EX 8.20	267	287	268	287	287	287	287
EX 8.30	268	288	270	288	288	288	288
EX 8.40	273	293	273	293	293	293	293
EX 9.10	176	176	176	176	176	176	176
EX 9.20	173	174	173	173	173	173	173
EX 9.30	174	176	174	174	174	174	174

EX 9.40	175	177	175	175	175	175	175
EX 10.10	238	238	236	238	238	238	238
EX 10.20	236	236	238	236	236	236	236
EX 10.30	237	237	241	237	237	237	237
EX 10.40	243	240	244	240	240	240	240

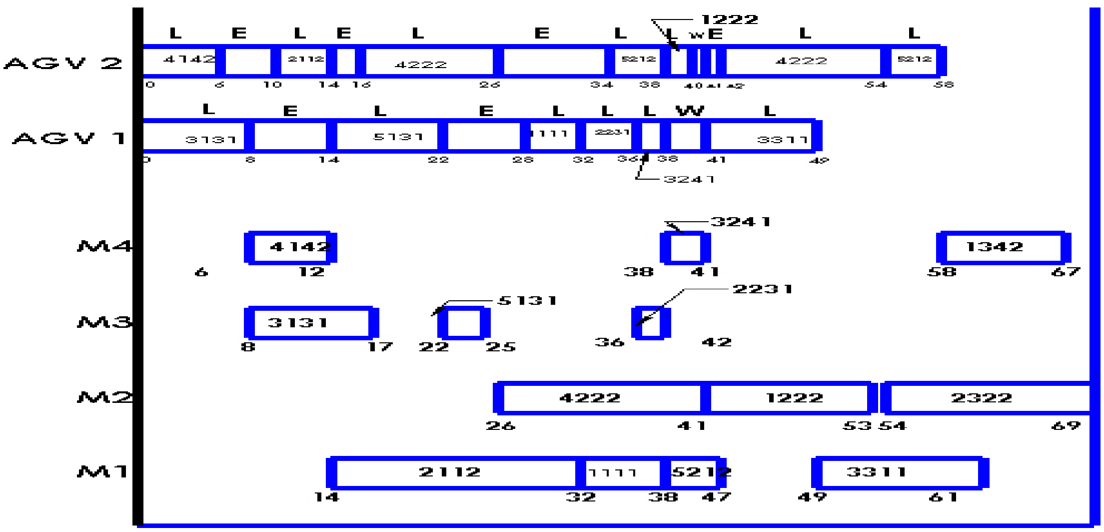


Figure 5.Gantt chart for job set 5 layout 2

V. CONCLUSION

Scheduling of Jobs and machines is performed by the proposed SOS algorithm. It is noticed that results obtained by SOS algorithm is better. The work can be extended by considering down time and AGVs dispatch time for battery change.

BIBLIOGRAPHY

[1] BAKER,K.R Introduction to Sequencing and Scheduling. New York, Wiley (1974).
[2] LEE,D., ANDF.DICESARE. Integrated Scheduling of FMSs Employing Automated Guided Vehicles "IEEE Transactions on Industrial Electronics,41(6), pp.602–610 ,(1994).
[3] AGNETIS,A.A.ALFIERI,P.BRANDIMARTE,ANDP.PRINSECCHI.JointJob/ToolSchedulinginaFlexibleManufacturingCell with No On-Board Tool Magazine" Computer Integrated Manufacturing System10(1),pp.61–68(1997).
[4] JERALD,J., And P.ASOKAN. Simultaneous Scheduling of Parts and Automated Guided Vehicles in an FMS Environment using Adaptive Genetic Algorithm. International Journal of Advanced Manufacturing Technology, 29(5),pp.584–589 (2006).
[5] RAMAN N, TALBOT F B, RACHAMADGU R V. Simultaneous scheduling of machines and material handling devices in automated manufacturing [C]// STECKE K E, SURI R. Proceedings of the Second ORSA/TIMS Conference on Flexible Manufacturing Systems. University of Michigan, Ann Arbor, MI,USA, 1986: 455−466.
[6] ULUSOY G, BILGE U. Simultaneous scheduling of machines and automated guided vehicles [J]. International Journal of Production Research, 1993, 31(12): 2857−2873.
[7] BILGE U, ULUSOY G. A time window approach to simultaneous scheduling of machines and material handling system in FMS [J]. Operations Research, 1995, 43: 1058−1070.
[8] ULUSOY G, SIVRIKAYA-SERIFOGLU F, BILGE U. A genetic algorithm approach to the simultaneous scheduling of machines and automated guided vehicles [J]. Computers & Industrial Engineering, 1997, 24(4): 335−351.
[9] ABDELMAGUID T F, NASSEF O N, KAMAL B A, HASSAN M F. A hybrid GA/heuristic approach to the simultaneous scheduling of machines and automated guided vehicles [J]. International Journal of Production Research, 2004, 42: 267−281.
[10] MURAYAMA N, KAWATA S. A genetic algorithm approach to simultaneous scheduling of processing machines and multiple-load automated guided vehicles [J]. Transactions of the Japan Society of Mechanical Engineers C, 2005, 71(712): 3638−3643. (in Japanese)
[11] MURAYAMA N, KAWATA S. Job-shop scheduling considering material handling by multiple-load AGVs [R]. The Institute of Electronics, Information and Communication Engineers, IEICE Tech. Report, 2005,105(159): 17−21. (in Japanese)
[12] JERALD J, ASOKAN P, SARAVANAN R, RANI A D C. Simultaneous scheduling of parts and AGVs in an FMS using non-traditional optimization algorithms [J]. International Journal of Applied Management and Technology, 2005, 3(1): 305−315.

[13] JERALD J, ASOKAN P, SARAVANAN R, RANI A D C. Simultaneous scheduling of parts and automated guided vehicles in an FMS environment using adaptive genetic algorithms [J]. International Journal of Advanced Manufacturing Technology, 2006, 59: 584−589.

[14] JERALD J, ASOKAN P, PRABHAHARAN G, SARAVANAN R. Scheduling of parts and AS/RS in FMS using genetic algorithm [J]. International Journal of Applied Management and Technology, 2006, 4(1): 25−34.

[15] MURAYAMA N, KAWATA S. Simulated annealing method for simultaneous scheduling of machines and multiple-load AGVs [C]// IJCC Workshop on Digital Engineering. Pyeongchang-gun, Gangwon-do, SouthKorea, 2006: 55−62. (in Japanese)

[16] REDDY B S P, RAO C S P. A hybrid multi-objective GA for simultaneous scheduling of machines and AGVs in FMS [J]. International Journal of Advanced Manufacturing Technology, 2006, 31(5/6): 602−613.

[17] DEROUSSI L, GOURGAND M, TCHERNEV N. A simple met heuristic approach to the simultaneous scheduling of machines and automated guided vehicles [J]. International Journal of Production Research, 2008, 46(8): 2143−2164.

[18] PHILIPPE LACOMME ,MOHAND LARABI , NIKOLAY TCHERNEV Job-shop based framework for simultaneous scheduling of machines and automated guided vehicles Int. J. Production Economics 143 (2013) 24–34

[19] STECKE K E. Design, planning, scheduling, and control problems of flexible manufacturing systems [J]. Annals of Operations Research, 1985, 3(1): 3−12.

[20] MIN-YUAN CHENG, DODDY PRAYOGO. Symbiotic organisms search: a new metaheurstic optimization algorithm. Computers& structures, 2014, Vol 139, 98-112.

APENDIX A

A. *Travel time matrix for the example problem*

	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	1	0	2
M4	4	8	10	12	0

B. *Data for the job sets used:*

Job Set 1		Job Set 2		Job Set 3	
Job1	M1- (8); M2- (16); M4-(12)	Job1	M1-(10); M4-(18)	Job1	M1-(16); M3-(15)
Job2	M1- (20); M3-(10); M2- (18)	Job2	M2-(10); M4- (18)	Job2	M2- (18); M4- (15)
Job3	M3-(12); M4-(8); M1- (15)	Job3	M1- (10); M3- (20)	Job3	M1- (10); M2- (10)
Job4	M4- (14); M2-(18)	Job4	M2- (10); M3-(15); M4-(12)	Job4	M3- (15); M4- (10)
Job5	M3-(10); M1-(15)	Job5	M1- (10); M2- (15); M4- (12)	Job5	M1-(8); M2- (10); M3-(15); M4-(17)
Job Set 4		Job6	M1-(10); M2-(15); M3- (12)	Job6	M2-(10); M3- (15); M4- (8); M1-(15)
Job1	M4- (11); M1-(10); M2- (7)	Job Set 5		Job Set 6	
Job2	M3- (12); M2-(10); M4-(8)	Job1	M1-(6); M2-(12); M4- (9)	Job1	M1- (9); M2-(11); M4-(7)
Job3	M2- (7); M3-(10); M1- (9); M3- (8)	Job2	M1- (18); M3-(6); M2-(15)	Job2	M1-(19); M2-(20); M4-(13)
Job4	M2-(7); M4- (8); M1- (12);	Job3	M3- (9); M4-(3); M1- (12)	Job3	M2- (14); M3-(20); M4- (9)

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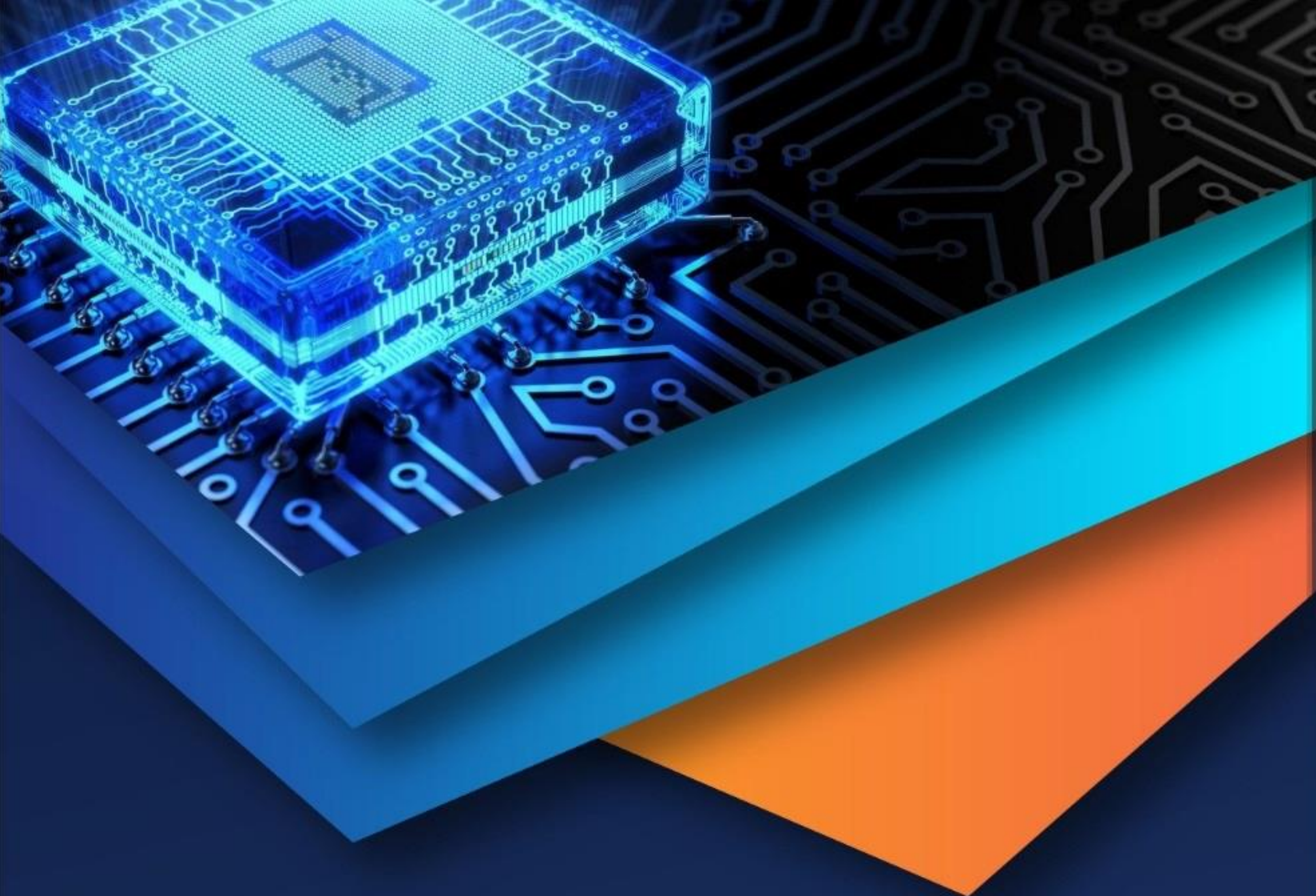
	M2- (6)				
Job5	M1- (9); M2-(7); M4- (8); M2- (10); M3- (8)	Job4	M4-(6); M2-(15)	Job4	M2-(14); M3- (20); M4-(9)
Job Set 7		Job5	M3-(3); M1- (9)	Job5	M1-(11); M3- (16); M4-(8)
Job1	M1-(6); M4- (6)	Job Set 8		Job6	M1-(10); M3-(12); M4-(10)
Job2	M2-(11); M4-(9)	Job1	M2-(12); M3- (21); M4- (11)	Job Set 9	
Job3	M2-(9); M4-(7)	Job2	M2-(12); M3-(21); M4-(11)	Job1	M3- (9); M1-(12); M2-(9); M4-(6)
Job4	M3- (16); M4-(7)	Job3	M2-(12); M3-(21); M4-(11)	Job2	M3-(16); M2- (11); M4-(9)
Job5	M1-(9); M3-(18)	Job4	M2-(12); M3-(21); M4-(11)	Job3	M1-(21); M2-(18); M4-(7)
Job6	M2-(13); M3-(19); M4-(6)	Job5	M1-(10); M2-(14); M3-(18); M4-(9)	Job4	M2- (20); M3- (10); M4-(11)
Job7	M1-(10); M2-(9); M3-(13)	Job6	M1-(10); M2-(14); M3-(18); M4-(9)	Job5	M3-(14); M1- (16); M2-(13); M4-(9)
Job8	M1-(11); M2-(9); M4-(8)				
Job Set 10					
Job1	M1-(11); M3-(19); M2-(16); M4-(13)	Job3	M3-(8); M2-(10); M1-(14); M4-(9)	Job5	M1-(9); M3-(16); M4-(18)
Job2	M2-(21); M3-(16); M4-(14)	Job4	M2-(13); M3-(20); M4-(10)	Job6	M2-(19); M1-(21); M3-(11); M4-(15)



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