

Particle Swarm Optimization for Scheduling of Machines and AGVs in FMS

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ABSTRACT: The proposed project work leads to minimize the make span of machines and automated guided vehicles, in a flexible manufacturing system environment where the simultaneous scheduling is permitted. This has been done by an algorithm called as particle swarm optimization. In this project study, chromosome means the operation sequencing and assignment of AGV dimensions, that is the machine scheduling and the AGVs scheduling.

The flow of materials between machines are made by various number of similar type of AGVs, so that after every trip to the load/unload station the materials should not be allowed to be return. This scenario leads to complex the existing problem which results in optimizing deadheading trips travel time among the continuous loaded trips of the AGVs. In order to increase the performance of the FMS the proposed algorithm results in making the scheduling of machines and AGVs as an amalgamated activity of scheduling.

KEYWORDS: FMS Scheduling, Algorithm, Particle Swarm Optimization, AGVs, Machines.

I. INTRODUCTION

The manufacturing sector in these days witnessed changed paradigm from manufacturing of batch production to mass production, as a result there is a huge pressure on the manufacturer to manufacture goods for increased demand time to time. This scenario leads to motivate the manufacturing sectors to find the alternative ways to handle such situation in order to maximize the productivity by minimum utilization of resources. This in turn tells the essential of having a flexible manufacturing system to the manufacturer in their manufacturing environment. FMS scenario has lot of benefits over the conventional manufacturing scenario in terms of design, scheduling, planning and control. Still some problems are need to be addressed in the FMS life cycle such as scheduling requires more attentions because of its dynamic nature like allocation of parts, routing related to AGVs, automated storage and retrieval system, assignment of the storages, allocation of tools etc. The components of FMS are automated machine tools, automatically handling of material, and automated storage and retrieval system. Effective performance of these components tends to improve the productivity of the total FMS.

This proposed project work is addresses the uses related to scheduling problems of FMS, so that efficiency of the total FMS can be handled properly and effectively.

FMS has vast applications in the manufacturing sectors. It can be used as a effective tools for metal cutting process, metal forming applications, assembly line handling, welding.

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II. LITERATURE REVIEW

Raman et al.(1986), have proposed a off-line scheduling model which is deterministic in nature. The authors were formulated the problem in the form of integer programming and developed the procedure for solution according to the concepts of scheduling the project activities as per the scenario of constrained resources in nature.

Blazewicz et al.(1991) were recommended that, one can consider the FMS as a type of identical parallel machines, which are arranged in the form of a loop. They proposed the issues of scheduling problems which are simultaneous in nature by the help of a dynamic programming concept.

Sabuncuoglu and Hommertzhaim(1992) were conducted a experiment to examine the various machines and AGVs according to scheduling rules for the FMS scenario over the parameter mean flow time.

Ulusoy et al.(1997) were also addressed the similar problem proposed by Bilge and Ulusoy et al.(1991), with the help of application of genetic algorithms. They represented operation number and assignment of AGV as a chromosomes input to develop the special genetic operators.

Lacomme et al.(2005) were addressed the continuous job input and dispatching the vehicles for a single system of the AGVs. The authors solved the problem with the help of branch and bound technique which are coupled with a model called discrete event simulation.

Soloman and Desrosier (1998) discussed the various algorithms for design and analysis of routings of vehicle and problems of scheduling as per the restrictions of time window.

Akturk and Yilmaz (1996) were developed the algorithm as per the mixed integer programming problem for scheduling the vehicles and jobs in a hierarchy of decision making. The limitation of this algorithm is that it can be applicable to only small number of jobs and vehicles.

Bilge and Ulusoy (1995) suggested a approach of time window to machines and machine handling systems simultaneous scheduling to FMS environment.

Ulusoy et al.(1997) presented a paper on genetic algorithm for the purpose of solving the scheduling the simultaneous machines and devices of material handling in FMS.

El –Maraghy and Ravi (1992) were contributed to FMS by developing the latest tools for design, in order to model and evaluate the FMS.

Orhan and Doyen (2004) were invented and discussed a new idea to solve the scheduling problems arised in hybrid flow shop. This has been done by developing an artificial immune system.

III. PARTICLE SWARM OPTIMIZATION ALGORITHM

This section of thesis lists the various steps of PSO algorithm in order to solve the problem for the objective of minimized make span.

1. Randomly initialize the population of 'n' size
2. Determine the value for its fitness for every particle. Suppose value of fitness is more than the value of (pbest), then set current value as new 'pbest'.
3. Select the particle with best fitness value for all particles of 'gbest'.
4. Determine the particle velocity for every particle from this following equation.

$$v[] = c1*rand()*(pbest[] - present[]) + c2* rand()* (gbest[] - present[])$$

Where present [] = present [] + v []

v [] is the particle velocity, present [] is the current particle (solution),

rand () is a random functions in the range [0, 1].

c1, c2 are learning factors = 0.5.

5. Let 'Vmax' be the maximum velocity, which can be clamped by every dimensions of particle velocity. If sum of acceleration of velocity exceeds to Vmax , then set the dimension of velocity is limited to Vmax.

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6. Algorithm terminates, suppose the maximum number of iterations were reached, otherwise go to step no 2.

In the beginning initial population is generated randomly followed by this, the value of objective function is calculated. In order to generate the new value from the available population, the following formula can be used.

New sequence = present sequence + velocity

Where, Velocity = $C1 * rand * (pbest - present) + C2 * rand * (gbest - present)$

rand = Random Number

This below table describes job set and layout, it also shows that job1 requires machines M1,M2,M4. job 2 requires machines M1,M3,M2. job 3 requires machines M3,M4,M1 .job 4 requires machines M4,M2. job 5 requires machines M3,M1

Job Set 5 layout1													
JOB1			JOB2			JOB3			JOB4		JOB5		
M1	M2	M4	M1	M3	M2	M3	M4	M1	M4	M2	M3	M1	

Suppose, the sequence of particle at iteration 'n' be

Present[n] : 1 4 2 10 7 11 12 5 13 3 8 9 6

Therefore 'pbest' values for the particle sequence are:

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

Also, the 'gbest' values of the sequence are:

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

Velocity by the iteration are as follows ,

Velocity = $C1 * rand1 * (pbest - present) + C2 * rand2 * (gbest - present)$

The value of C1 and C2 are equal to 0.5

Randomly generated rand1=0.532

Randomly generated rand2=0.265

Therefore pbest - present =

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

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

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

The obtained differences derived from the sequence are considered to be the velocity. Such difference in the sequence may be determined as,

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

In present sequence 7 and 4 are swapped and rewritten as,

[1 7 2 10 4 11 12 13 5 3 8 9 6] after we get

[1 7 2 10 4 11 12 13 5 3 8 9 6] therefore pbest - present is termed as (7,4) (13,5) also, gbest - present

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

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

The value of pbest-present are (3,5) (5,13) (6,9)

Hence velocity = $0.5 * 0.532 * [(7, 4) (13, 5)] + 0.5 * 0.265 [(3, 5) (5, 13) (6, 9)]$

Taking 0.2660 [(7, 4) (13, 5)] is impossible, first change (7, 4) is taken, as it is minimum part of difference.

Taking 0.1325 of [(3,5) (5,13) (6,9)] which is 13.25% as only 3 changes is possible to be made, so this sequence is not at all possible to use. Therefore (3, 5) is taken (13 % change).

Velocity becomes (7, 4) (3, 5)

New sequence [n+1] = present[n] + velocity

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=1 4 2 10 7 11 12 5 13 3 8 9 6 + [(7, 4) (3, 5)]
(ie) Obtained sequence = 1 7 2 10 4 11 12 3 13 5 8 9 6

The below Table no.1 describes job completion time calculation for the obtained sequence. It contains job sequence, job operation number, machine AGV number, travel time, job reach, job ready, processing time, job completion for obtained sequence.

Table 1: Job completion time calculation for the obtained sequence.

Job sequence	Job . Operation Number	Machine. AGV Number	Travel Time (min)	Job Reach (min)	Job Ready (min)	Processing Time (min)	Job Completion (min)
1	1,1	1,1	0	6	6	6	12
7	3,1	3,2	0	10	10	9	19
2	1,2	2,1	6	18	18	12	30
10	4,1	4,2	18	30	30	6	36
4	2,1	1,1	28	34	34	18	52
11	4,2	2,2	36	44	44	15	59
12	5,1	3,1	46	56	56	3	59
3	1,3	4,2	44	52	52	9	61
13	5,2	1,1	59	67	67	9	76
5	2,2	3,2	62	70	70	6	76
8	3,2	4,1	75	81	81	3	84
9	3,3	1,1	84	94	94	12	106
6	2,3	1,2	76	82	82	15	97

Hence the new sequence is [1 7 2 10 4 11 12 3 13 5 8 9 6]

Similarly for machines and AGVs schedule PSO is implemented and new sequence is obtained the same is repeated for 100 iterations.

For example: Best sequence for layout 1 and job set 1(EX11)

4 1 5 2 12 7 10 8 6 11 9 13 3 = make span 93

The below table no.2 describes job sequence, job operation number, machine AGV number, travel time, job reach, job ready, processing time, job completion time for problem no.EX11(i.e EX11 is best sequence for layout 1 and job set 1)

Table 2: Job completion time calculation for problem No.EX11

Job sequence	Job . Operation Number	Machine. AGV Number	Travel Time (min)	Job Reach (min)	Job Ready (min)	Processing Time (min)	Job Completion (min)
4	2,1	1,1	0	6	6	20	26
1	1,1	1,2	0	6	26	8	34
5	2,2	3,2	6	8	14	10	24
2	1,2	2,1	6	6	12	16	28
12	5,1	3,1	22	10	32	10	42
7	3,1	3,2	22	10	42	12	54
10	4,1	4,2	40	12	52	14	66
8	3,2	4,1	32	6	66	8	74
6	2,3	2,1	44	6	50	18	68
11	4,2	2,1	58	8	68	18	86
9	3,3	1,2	52	10	62	15	77
13	5,2	1,2	70	8	78	15	93
3	1,3	4,1	66	8	74	12	86

Best sequence in the example problem:

Lay out 1& job set 2(EX21): 10 3 1 5 2 4 6 13 11 7 14 8 12 15 9=101(makes pan)

Lay out 1& job set 3(EX31): 9 10 1 3 7 11 8 4 12 13 14 15 5 2 6=106

Lay out 1& job set 4(EX41): 4 1 11 15 12 16 17 7 5 2 6 8 13 18 9 3 10 14 19=122

Lay out 1& job set 5(EX51): 4 1 5 2 12 7 10 8 6 11 9 13 3=87

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IV. EXPERIMENTAL RESULTS

In this research literature, like loop or ladder or combination of both here four such layouts are generated each assigned with four machines also in this project work, 10 different set of jobs with their different sequences of processing and times of processes are generated and same were documented and presented systematically also, here 82 example problems were established based on the inputs of combination of 10set of jobs and proposed four layouts. Only two AGVs are used in all these established problems. The table 3 shows the various examples of problem whose ratio of travel time to processing times are greater than 0.25, whereas table 4 documents the ratio of travel time to processing times whose ratios are lesser than 0.25. The digit EX means the set of job and layout. The another code of table 3 that is either 0 or 1 as the last digit. It means that the processing times are doubled, tripled respectively, where as in both the cases the travel time is halved. Table 3 also resembles that there is a high improvements are achieved on layouts layouts 2 and 3, where as improvements over the layouts 1 and 4 are less. After having the results of PSO Algorithm, they identified that, out of 40 problems which were considered for the case of ratio of travelling time to processing time are greater than 0.25, the PSO Algorithm gives better results for 31, whereas out of 42 problems whose ratio of travelling time to processing time are less than 0.25, PSO Algorithm gives better results for 37 problems. Similarly PSO Algorithm they were compared with results of Ulsoy Genetic Algorithm, out of 40 problem for their ratios of travelling time to processing time are greater than 0.25, the PSO Algorithm better results for 26 problems and equal results for 4 problems. Also for the ratios of travelling time to processing time are less than 0.25, out 42 problems. PSO Algorithm gives better results for 36 problems and equal results for 5 problems. Continued the comparing the results of PSO Algorithm with Adaptive Genetic Algorithm, ratios of travelling time to processing time which are greater than 0.25, out of 40 problems, PSO Algorithm gives better results for 23 problems. If the ratios of travelling time to processing time are less than the 0.25, out of 42 problems, PSO Algorithm 36 problems gives better results and equal results for 4 problem accordingly, comparing the results of PSO Algorithm with proposed genetic Algorithm, for the cases where the ratios of travelling time to processing time are greater than 0.25, the PSO Algorithm gives better results for 22 problems and equal results for 2 problems out of the 40 problems.

This below Table no.3 shows the various examples of problem whose ratio of travel time to processing time greater than 0.25. this table shows that processing time are doubled, tripled respectively, where as travel time is halved. also it shows that out of 40 problems whose ratio of travelling time to processing time are greater than 0.25, PSO algorithm gives better results for 31 problems.

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Table 3: Results comparison for t/p ratio >0.25

PROB.No	STW [4]	UGA [28]	AGA [1]	PGA [21]	PSO [Proposed]
EX11	96	96	96	96	93
EX21	105	104	102	100	101
EX31	105	105	99	99	106
EX41	118	116	112	112	122
EX51	89	87	87	87	87
EX61	120	121	118	118	112
EX71	119	118	115	111	125
EX81	161	152	161	161	134
EX91	120	117	118	116	112
EX101	153	150	147	147	149
EX12	82	82	82	82	74
EX22	80	76	76	76	76
EX32	88	85	85	85	77
EX42	93	88	88	87	92
EX52	69	69	69	69	67
EX62	100	98	98	98	90
EX72	90	85	79	79	85
EX82	151	142	151	151	128
EX92	104	102	104	102	95
EX102	139	137	136	135	128
EX13	84	84	84	84	76
EX23	86	86	86	86	79
EX33	86	86	86	86	80
EX43	95	91	89	89	97
EX53	76	75	74	74	68
EX63	104	104	104	103	89
EX73	91	88	86	83	94
EX83	153	143	153	153	130
EX93	110	105	106	105	97
EX103	143	143	141	139	130
EX14	108	103	103	103	102
EX24	116	113	108	108	111
EX34	116	113	111	111	123
EX44	126	126	126	126	139
EX54	99	97	96	96	95
EX64	120	123	120	120	122
EX74	136	128	127	126	141
EX84	163	163	163	163	150
EX94	125	123	122	122	123
EX104	171	164	159	158	168

STW: Sliding Time Window, UGA: Ulusoy Genetic Algorithm, AGA: Adaptive Genetic Algorithm, PGA: Proposed Genetic Algorithm, AIS: Artificial Immune System.

The below table no.4 documents the ratio of travel time to processing times whose ratios are lesser than 0.25.this also shows that out of 40 problems whose ratio of travelling time to processing time less than 0.25, PSO algorithm gives better results for 26 problems and equal results for 4problem ,compared with Ulsoy genetic algorithm.

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Table 4: Results comparison for t/p ratio <0.25

PROB.No.	STW [4]	UGA [28]	AGA [1]	PGA [21]	PSO [Proposed]
EX110	126	126	126	126	119
EX210	148	148	148	148	128
EX310	150	148	150	150	125
EX410	121	119	119	119	112
EX510	102	102	102	102	93
EX610	186	186	186	186	143
EX710	137	137	137	137	137
EX810	292	271	292	292	247
EX910	176	176	176	176	146
EX1010	238	236	238	238	185
EX120	123	123	123	123	118
EX220	143	143	143	143	123
EX320	148	145	145	145	148
EX420	116	114	114	114	111
EX520	100	100	100	100	92
EX620	183	181	181	181	140
EX720	136	136	136	136	136
EX820	287	268	287	287	244
EX920	174	173	173	173	145
EX1020	236	238	236	236	210
EX130	122	122	122	122	117
EX230	146	146	146	146	126
EX330	149	146	146	146	125
EX430	116	114	114	114	110
EX530	99	99	99	99	91
EX630	184	182	182	182	141
EX730	137	137	137	137	137
EX830	288	270	288	288	245
EX930	176	174	174	174	144
EX1030	237	241	237	237	185
EX140	124	124	124	124	118
EX241	217	217	217	217	187
EX340	151	151	151	151	125
EX341	222	221	221	221	185
EX441	179	172	172	172	166
EX541	154	148	148	148	137
EX640	185	181	181	181	141
EX740	138	137	137	137	137
EX741	203	203	203	203	203
EX840	293	273	293	293	248
EX940	177	175	175	175	146
EX1040	240	244	240	240	185

V. CONCLUSION

In the project work, using PSO Algorithm, the effective optimal sequence of machines and AGVS were determined, these by optimized scheduling of FMS has been done. The so developed iterative algorithm can reflect the total set of requirement of flow for the given schedule of machine and in the same way the assignment of the vehicle were done, real time dispatching scheme is opposed to that which uses no information other than the queue request. The main object of this project work is to make scheduling, so that one can participate actively in the off-line schedule of specification also it is concluded that, the PSO algorithm is very suitable for this kind of problems of schedule among the nontraditional technique considered in this work. The table 3 and 4 which document the computational result have indicate the PSO algorithm is very effective in developing the optimal solution for FMS. This iterative algorithm can promise the scheduling improvement in scheduling especially in environment where the time of cycle is very low and also have the comparable time. Also the route of process and layout were not suit with each other. This approach can also be used for various objectives and various configurations of FMS.

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