Scheduling of AGV in Flexible Manufacturing System using Metaheuristics Techniques

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ABSTRACT:

AGV-based automated guided vehicles (AGVs) are used in the Flexible Manufacturing System (FMS), which was developed and put into use to increase production flexibility and efficiency. The scheduling of resources, such as the frequently changing parts, tools, and AGV routings, after the introduction of FMS, in practice, becomes a challenging problem. Traditional methods for doing this include a variety of mathematical programming techniques. Random search methods have been tested for scheduling in recent years. Single goal optimization has been the focus of the majority of studies. Conflicting objectives in multi-objective scheduling problems are more difficult and combinatorial in nature, and they rarely have a single solution. This study looks at AGV multi-objective work scheduling in a flexible production environment. The goal of this study was to identify the most ideal schedule for two AGVs based on a balanced workload and the shortest trip distance for maximum utilization.

AGV's, Benchmark problem, Combinatorial optimization problem, Differential Evolution, Flexible manufacturing system, Job shop scheduling.

INTRODUCTION

The flexible manufacturing systems (FMS) used in today's automated manufacturing environment are quick and offer a lot of flexibility. FMS are particularly suited for the concurrent manufacturing of numerous different part types in small volumes. Workstations, automated storage and retrieval systems, and material handling equipment like robots and AGVs are all components of the complex FMS [1]. The scheduling issues are more challenging since the FMS components can work in an asynchronous fashion. The components also feature different part kinds, alternative routings, and a high degree of interdependence. Better scheduling and coordination of manufacturing machinery and material handling equipment can improve FMS performance [2]. Scheduling is the process of allocating scarce resources to jobs throughout time.

It is a procedure for making decisions that connect the company's operations, timeline, budget, and ultimate goals.

For the purposes of the actual evaluation of cycle times, the scheduling of the material handling system in the FMS is just as important as the scheduling of the machines. Due of their adaptability and interoperability, automated guided vehicles (AGVs) are frequently utilized in flexible manufacturing systems [3]. AGVs can be integrated with the shop floor's computerized production and storage equipment, and the entire operation of the shop floor can be managed by a computer system. The majority of scheduling issues in the real world involve the simultaneous optimization of several goals. While dealing with numerous objectives has garnered a lot of attention in recent years, scheduling is still mostly driven by the unworkable single-objective strategy. Obtaining a set of Pareto optimum solutions that satisfy the constraints is the basic objective of a multi-objective optimization problem [4]. The last 20 years have seen a significant increase in the usage of genetic algorithms (GA) to solve issues involving several criteria. In order to solve a problem in a challenging solution space, genetic algorithms, which are non-deterministic stochastic search techniques, apply the theories of evolution and natural selection [5]. Dorigo et al. [6] presented ant algorithms as a multi-agent solution to many combinatorial optimization issues.

In this study, the authors used genetic algorithms and ant colony optimization to try to establish the most ideal schedule for two AGVs based on a balanced workload and the shortest trip distance for maximum utilization.

LITERATURE REVIEW:

Sl no.	Authors	Technique used	Remarks
1.	C.S.P Rao, M.V.Satish kumar, G.Rangajanardhan	Hybrid Differential Evolution	In this by the application of differential evolution, the simultaneous scheduling of machines and AGV‟s has been done. In this, operation-based coding system is employed to represent the solution vector, which is further modified to suit the DE application
02.	B.S.P.Reddy, C.S.P. Rao	Hybrid Multi-Objective Genetic Algorithm	In this the authors have made an attempt to consider simultaneously the machine and the vehicle scheduling aspects in an FMS and addressed the combined problem for the minimization of make span, mean flow time and mean tardiness objectives.
03.	S. V. Kamble & K. S. Kadam	Particle Swarm Optimization	Minimizing the idle time of the m/c and minimizing the total penalty cost for not meeting the dedline concurrently. To achieve this it is necessary to determine the routing for jobs processing sequence of operation on m/c and the starting time for operation on m/c and starting time for operation in order to balance the workload of machine.

04.	Ghada El Khayat, Andre Langevin, Diane Riopel	Mathematical Programming andConstraint Programming	Machines and MHE are considered as the constraining resources. A methmetical programming model and a constraint programming model presented for the problem and solved optimally on test problems used for modeling, testing and integrating both models in a decision support system. The performance of two methods is comparable when using the data from the literature.
05.	Muhammad Hafidz Fazli binMd Fauadi and Tomohiro Murata	Binary Particle Swarm Optimization	It exploits a population of particles to search for promising regions of the search space (swarm). While each particle randomly moves within the search space with a specified velocity. It stores data of the best position it ever encountered. This is known as personal best (pbest) position. Upon finishing each iteration, the pbest position obtained by all individuals of the swarm is communicated to all of the particles in the population. The best value of pbest will be selected as the global best position (Gbest) to represent the best position within the population.
06.	K.V.Subbaiah, M.Nageswara Rao and K. Narayana Rao	Sheep Flock Heredity Algorithm	For this particular problem, coding has been developed, which gives optimum sequence with makespan value and AGV"S schedule for ten job sets andfour layouts. Most of the time, the results of sheep flock algorithm are better than other algorithms and traditional methods.

07.	Paul Pandian,P, S. Saravana Sankar,S.G.Ponnambalam and M. Victor Raj	Jumping Genes Genetic Algorithm	The one of best evolutionary approach i.e., genetic algorithm with jumping genes operation is applied in thisstudy, to optimize AGV flow time and the performance measures of Flexible Job shop manufacturing system. The non dominated sorting approach is used.Genetic algorithm with jumping genes operator is used to evaluate the method.
08.	J.Jerald,P.Asokan,R. Saravanan ,A. Delphin Carolina Rani	Adaptive Genetic Algorithm	Two contradictory objectives are to be achieved simultaneously by scheduling parts and AGVs using the adaptive genetic algorithm. The results are compared to those obtained by conventional genetic algorithm.
09.	M.K.A.Ariffin, M.Badakhshian, S.B.Sulaiman, A.A.Faeiza	Fuzzy Genetic Algorithm	Fuzzy logic controller (FLC) is proposed to control the behaviour of genetic algorithm (GA) to solve the scheduling problem of AGVs. This paper presents an FLC to control the crossover and mutation rate for controlling the GA

PROBLEM DESCRIPTIONS:

FMS operations and types vary depending on the configuration. Due to the impossibility of the generic setup, the majority of research focuses on particular manufacturing systems. The following sections outline the system configuration, underlying presumptions, and objective criteria used in this work.

1. AGVs are utilized in an FMS to handle the responsibilities of loading and unloading parts between workstations.

2. The following are the presumptions made in this work:

• Two AGVs are assumed to exist.

• AGV travel times to workstations are taken into account.

• The number of times the AGVs can complete the duties in the workstations is limited.

• The AGVs performing the tasks in the workstations are restricted to a certain number of times

Non pre-emptive scheduling means that an AGV won't begin working on another task until it has completed the one it is currently working on.

• Task collision, which allows the AGV that arrives first to the workstation, occurs when two AGVs want to enter the same workstation. When two AGVs arrive at a workstation simultaneously, the AGV with the greater priority is allowed (the priority ordering of AGV is AGV0, AGV1).

3. The goal is to use the Genetic Algorithm (GA) and Ant Colony Optimization (ACO) algorithm to create the most ideal schedule for two AGVs based on the balanced workload and the shortest travel time for maximum utilization. The following is a mathematical definition of the objective function for the problem:

$$\text{Min } Z = W1\,(\sum A - \sum B) + W2\,(\sum A + \sum B) \qquad (1)$$

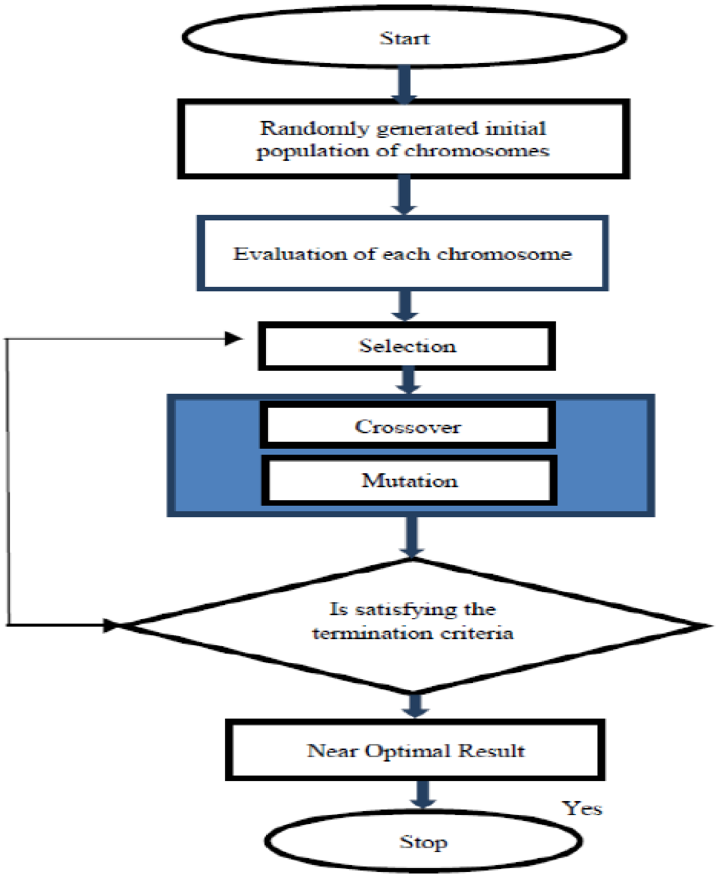
where: $\sum A$ – Sum of the traveling times that are assigned to AGV1
$\sum B$ – Sum of the traveling times that are assigned to AGV2
$W1$, $W2$ – Weightage factors.

Genetic algorithm:

A Genetic Algorithm is an `intelligent‟ probabilistic search algorithm that simulates the process of evolution by taking a population of solutions and applying genetic operators in each reproduction. Each solutionin the population is evaluated according to some fitness measure. Fitter solutions in the population are used for reproduction. New `offspring‟ solutions are generated and unfit solutions in the population are replaced.

GA coding scheme:
As GA works on the coding of parameters, the feasible job sequences (the parameter of the considered problems)are coded in two different ways.
(i) Pheno-style coding
(ii) Binary coding

Algorithm:
Step 1: Generate a random population of n chromosomes (suitable solution for the problem)
Step 2: Evaluate the fitness f(x) of each chromosome x in the population.
Step 3: Create a new population by repeating the following steps until the new population iscomplete
Step 4: Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)
Step 5: With a crossover probability crossover the parents to form new offspring(children).If no crossover was performed, the offspring is an exact copy of the parents.
Step 6: with a mutation probability mutate new offspring at each locus(position in chromosome)
Step 7: Place new offspring in a new population
Step 8: Use the newly generated population for a further run of the algorithm.
Step 9: if the end condition is satisfied, stop, and return the best solution in the current population and Go to step 2.



Differential Evolution:

Evolutionary Algorithms (EA) which simulates the evolution process in computer have created a lot of interest among researchers, which led to their application in a variety of fields. Genetic Algorithms, GA (Holland, J.H., 1975) are popular among EAs and they were used to address scheduling problems by many researchers. Even though GA can be considered a better searching algorithm and many versions of GA were developed by several researchers, still developed a hybrid GA procedure, which uses operation-based coding for scheduling machines. They have also developed a heuristic to solve the vehicle scheduling, because of which they have reduced the length of the chromosome to half that created by Ulusoy. Lacomme et al., (2005) addressed the job input sequencing and vehicle dispatching in a single vehicle automated guided vehicle system. They have coupled the heuristic branch and bound approach with a discrete event simulation model. Siva P.Reddy et al., (2006) have attempted the same problem set as that of Ulusoy and Tamer with a modified GA approach. Jerald et al.,(2006) have used an adaptive genetic algorithm for solving the simultaneous scheduling of parts andAGVs problem.

Mutation

Unlike GA, where mutation follows crossover, in DE mutation will be performed first. Three vectors xr1, xr2, xr3 which are different from the current vector will be randomly selectedand the weighted difference of two vectors in the population is added to a third vector to get the resultant vector known as the mutant vector (v i, g+1), as given below

$$V_{i,g+1} = x_{r1,g} + F(x_{r2,g} - x_{r3,g})$$

Where F > 0 is scaling factor, which controls the magnitude of the differentialvariation of (xr2,g - x r3,g).

CASE STUDY

Two AGVs are tasked with moving the parts between the workstations in this paper. The AGV should be scheduled in accordance with the task times, assuming that each AGV is doing a task and that the traveling time represents the task time. The goal of the study is to identify a schedule that is close to ideal, with the balancing of the AGVs satisfied, i.e., the burden for the AGVs should be equally based on travel times, and the journey times for the ideal schedule should be as short as possible for the AGVs to complete a given task. Any task must be completed five times by both AGVs 1 and 2. The goal of balancing the AGVs is assigned a weight of 0.6, and in order to determine the schedule of AGVs must travel for at least 0.4 seconds.

Table I: Problem No. 1.

AGV	Workstation		
	1	2	3
1	20	25	40
2	25	30	45

Table II: Problem No. 2.

AGV	Workstation			
	1	2	3	4
1	18	21	43	48
2	15	16	42	50

Table III: Problem No. 3.

AGV	Workstation				
	1	2	3	4	5
1	20	25	35	42	54
2	25	40	45	50	55

RESULTS AND DISCUSSIONS

Different optimal plans are created with a combined objective function for the task scheduling of an AGV in an FMS utilizing a variety of non-traditional optimization techniques. These methods simultaneously optimize two opposing goals. The primary goal of the research is to create a timetable that is close to being optimal for the combined objective function. The nearly ideal solution found in each iteration is saved, and the best solution found overall is taken into account when determining the best timetable for the two AGVs. The VC++ language is used to program the GA and ACO algorithm. The case study problem results are displayed as follows using a Pentium IV computer system with a 2.66 GHz processor and 512 MB RAM.

Table IV: Combined objective function comparisons of proposed heuristics.

Problem No.	Combined Objective function	
	Genetic Algorithm (GA)	DIFFERENTIAL EVOLUTION
1	180	176
2	121	120
3	110	102

From the results, it is found that the DA performs better because this algorithm gives a minimum combined objective function when compared with GA.

Conclusion

Today's manufacturing industry cannot escape being flexible, which can be accomplished by using an FMS (Flexible Manufacturing System) (FMS). Few researchers focused on the scheduling issues with AGVs and other machines, whereas many researchers concentrated on the scheduling of FMS alone. The most significant non-traditional optimization algorithms are presented in this study in order to simultaneously schedule machines and AGVs. Even though they are challenging to resolve, parallel scheduling issues are among the most significant because they affect firms' capacity to satisfy consumer needs while turning a profit. They also affect the deployment of intelligent systems, the improvement of communication networks, and the capacity of autonomous systems to optimize their operations. Because of this, operations research analysts and engineers will continue to pursue this goal well into the future

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