Scheduling of Flexible Manufacturing System using Genetic Algorithm

Saumya Agrawal, Ayushi Sharma, Satyam Rai, Vijay Singh

Abstract— **The Flexible Manufacturing Systems (FMS) belong to class of productive systems in which the main characteristic is the simultaneous execution of several processes and sharing a finite set of resource. The main focus is on minimizing the idle time of the machine and minimizing the total penalty cost for not meeting the deadline concurrently. This paper focuses on the problems of determination of a schedule with the objective of minimizing the total make span time. An attempt has been made to generate a schedule using Genetic Algorithm. Genetic algorithm (GA) approach is one of the most efficient algorithms that aim to converge and give optimal solution in a shorter time. Therefore in this work a suitable scheduling mechanism is designed to generate a finest schedule using Genetic Algorithm (GA) approach. The results obtained are thus compared with those obtained by other scheduling rules and conclusions are presented.**

Index Terms—**Genetic Algorithm, flexible manufacturing system.**

I. Introduction

FLEXIBLE MANUFACTURING SYSTEM

In today's competitive global market, manufacturers have to modify their operations to ensure a better and faster response to needs of customers. The primary goal of any manufacturing industry is to achieve a high level of productivity and flexibility which can only be done in a fully integrated manufacturing environment. A flexible manufacturing system (FMS) is an integrated computer-controlled configuration in which there is some amount of flexibility that allows the system to react in the case of changes, whether predicted or unpredicted. FMS consists of three main systems. The work machines which are often automated CNC machines are connected by a material handling system(MHS) to optimize parts flow and the central control computer which controls material movements and machine flow. An FMS is modeled as a collection of workstations and automated guided vehicles (AGV). It is designed to simultaneously manufacture a low to medium volumes of a wide variety of high quality products at low cost. The flexibility is generally considered to fall into two categories, which both contain numerous sub-categories. The first category, machine flexibility, covers the system's ability to be changed to produce new product types, and ability to change the order of operations executed on a part. The second category is called routing flexibility, which consists of the ability to use multiple machines to perform the same operation on a part, as well as the system's ability to absorb large-scale changes, such as in volume, capacity, or capability.

The arrangement of machines in an FMS is connected by a transport system. The components are automatically governed using local area network.

Basic components of FMS

FMS is basically composed of the following three parts:

1. ***Workstations*****:** A machine tool which is computer controlled. Machine centers, load/unload stations, assembly workstations, inspection stations, forging stations, sheet metal processing etc. are a few examples of workstations.

2**.** ***Automated Storage stations and Material handling stations:*** The movement of work parts and sub assembly parts between different workstations is done mechanically which is referred to as automated material handling and storage system. The functions performed are:
(*i*) Random movement of work parts between stations independently
(*ii*) Handling various work part configurations
(*iii*) Temporary storage
(*iv*) Loading and unloading of work parts for easy access
(*v*) Computer control compatibility

3. ***Computer controlled systems:*** The functioning of the stated components is co-ordinated by a controlling Computer System. Its functions are:
(i) Controlling work stations
(ii) Control instruction distribution to the work stations
(iii)Controlling production
(iv) Controlling traffic

II. Literature Review

Many heuristic algorithms have been developed to generate optimum schedule and part-releasing policies. Most of these algorithms include enumerative procedures, mathematical programming and approximation techniques, i.e., linear programming, integer programming, goal programming, dynamic programming, transportation and network analysis, branch and bound, Lagrangian relaxation, priority-rule-based heuristics, local search algorithms (ITS, TA, TS, SA), evolution-ary algorithm (GA), etc. Of these techniques, few are specific to particular objectives, and few are specific to particular problem instances with respect to computational time needed.

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N. Jawahar (1997) discussed about Genetic Algorithm based scheduler for setup constrained FMC in which make-span time criterion has been considered as a measure of performance. [5] Machine loading problem for a random FMS with multiple machines and fixed number of tool slots was carried out by A. Kumar (2005). They proposed a constraint based GA which avoided getting trapped at local minima. S.G. Ponnambalam (2008) addressed the problem of solving machine loading in FMS using Particle Swarm Algorithm; the objective function of the scholarly work was to minimize system unbalance. Scheduling of AGVs and machines in FMS using SFHA-Sheep Flock Heredity Algorithm was addressed by K.V. Subbaiah (2009). They were able to minimize the Makespan and mean tardiness of the FMS system. Multiobjective task scheduling of AGV in an FMS was taken up by P. Udhayakumar (2010). They implemented GA and Ant Colony Optimization technique to minimize travelling time of the AGV. N.M. Nidhiry and Dr. R. Saravanan (2012) carried out research on scheduling optimization of FMS, 43 varieties of products were considered software in .net language was developed for getting the optimum solution. A research on Evolutionary Apporaches for scheduling a FMS system with AGV and robot was done by C. Anandaraman (2012).

Sridhar and Rajendran addressed a GA for part family grouping and scheduling parts within part families in a flow-line-based manufacturing cell. Shnits and Sinreich present the development of a multi-criteria control methodology for FMSs. The control methodology is based on a two-tier decision making mechanism. The first tier is designed to select a dominant decision criterion and a relevant scheduling rule set using a rule-based algorithm. In the second tier, using a look-ahead multi-pass simulation, a scheduling rule that best advances the selected criterion is determined. Yu and Greene use a simulation study to examine the effects of machine selection rules and scheduling rules for a flexible multi-stage pull system. J. Jerald and P. Asokan developed a combined objective based scheduling solution for FMS, but the work was for only 43 parts. Many authors have been trying to emphasize the utility and advantages of GA, SA and other heuristics.

Graves addressed an n-job, a single machine problem with an objective to minimize the flow time variance. They proposed heuristic procedure based on genetic algorithm. With the potential to address a more generalized objective function such as weighted flow time variants[9]. Jain described the development of a scheduling system which communicates on-linewith the factory control system and generates schedules in real-time. Chandra et al explained an enterprise-level flexible manufacturing approach for amulti-product manufacturer like an automotive company requires a cost-effective mix ofmany key enablers, including flexible assembly plants, part commonality between products,and supply base flexibility[6]. Das and Canel consider a particular configuration of FMS where it consists of cells of similar machines, and the setup of machines is sequence dependent. Their objective is to minimise the makespan[10].

Kopfer and Mattfield proposed a hybrid GA for the job shop problem and showed that the results are encouraging. Schultz and Mertens compared the GA with an expert system approach and priority rules. They indicated that the GA generally produces satisfactory schedules, and its performance depends on run time (i.e. population size and number of generations). Billo et al.illustrated the use of GA to solve problems associated with the formation of machine cells[1]. Lauff and Warner addressed the problem of alternative process plans and developed a new two chromosomes representation where each chromosome represents a complete schedule[9].

.Prof. Subhash Wadhwa, Anuj Prakash, Prof. S.G. Deshmukh extend the simple genetic algorithm and proposes a new methodology to handle a complex variety of variables in a typical FMS problem.The methodology helps to improve the performance of classical GA by obtaining the results in fewer generations[8]. Chan, Chung, and Chan proposed a genetic algorithm to minimise the makespan of a FMS schedule encompassing multiple factories and alternate routings[10].

III. GENETIC ALGORITHM

GA is adaptive heuristic search algorithms based on the evolutionary ideas of natural selection and genetic. As such they represent an intelligent exploitation of a random search used to solve optimisation problems.

A genetic algorithm (GA) is a procedure used to find approximate solutions to search problems through application of the principles of evolutionary biology. Genetic algorithms use biologically inspired techniques such as genetic inheritance, natural selection, mutation, and sexual reproduction (recombination, or crossover).

Principle: The principle of GA is simple, it imitates genetics and natural selection by a computer approach. The parameters of the problem are coded most naturally as DNA. A set called population of these problems, dependent parameter value vector is processed by GA.

A GA typically consists of the following steps:---

Step 1: Generate the initial population. Obtain the population size and the maximum number of iterations.

Step 2: Compute the fitness function for every member of the initial population.

Step 3: Compute the selection probability for every member of the initial population by calculating the ratio of fitness value of that initial population to the sum of the fitness values of all the individuals.

Step 4: Select two members (parents) to be used for reproduction based on selection probability.

Step 5: Apply crossover, mutation, and inversion to the parents to obtain the offspring. Generated offspring form the new generation.If the size of the new population is equal to the initial population size, go to step 6, else go to step 4.

Step 6: If the current generation is equal to the maximum number of the generation then stop, else move to step 2.

SELECTION

The selection process randomly chooses chromosomes out of population based on the evaluation of their fitness function value. The higher fitness function value, more are the chances for the individual of being selected.

CROSSOVER

The process of taking two parent solutions and generating a child is called crossover.

MUTATION

Each chromosome undergoes mutation with a fixed probability km that is called as mutation probability.

TERMINATION CRITERIA

The processes of fitness computation, selection, crossover, and mutation are executed for a maximum number of iterations.

IV RESULT AND CONCLUSION

Review Paper Name	Objective	Selection	Crossover	Mutation	Future Work
FMS Scheduling using Roulette wheel selection	Minimising the total makespan time	Roulette wheel selection	Single point crossover with fixed crossover probability in range[1,L-1]	Flipping	1.assumed no breakdown 2.transportation and setup time are constant
Scheduling optimisation in FMS using GA with makespan criterion	Minimising the makespan time	Random	Probability	Flipping	Availability and handling times of loading/unloading station
Evaluation of GA approach for scheduling optimisation of Flexible Manufacturing Systems	Minimising the idle time and total penalty cost	Random	Flipping	Mutation probability	Availability and handling times of loading/unloading station
Scheduling of FMS using Genetic Algorithm	Scheduling of variety of incoming jobs into the system	Rank Selection	Probability Pc = 0.6	Probabilty pm=0.005	No breakdown
Scheduling of Flexible Manufacturing System using Genetic Algorithm (Multiobjective)	Approaches applied to the scheduling problem	Roulette wheel selection	Single point crossover with fixed crossover probability in range[1,L-1]	Flipping	transportation and setup time are constant
Scheduling FMS using petri nets and GA	To increase the utilization of resources and to reduce the idle time	Random	Crossover probability	Mutation probability	No breakdown
A combined objective of GA for scheduling of Machines in FMS	Minimizing the total penalty cost and minimizing the idle time	Random	Flipping with a crossover probability	Mutation probability=0.01	Availability and handling times of loading/unloading station
A knowledge based GA for approach for FMS scheduling	To improve the performance of classical GA	Random	Crossover probability	Mutation probability	No breakdown

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