Task Scheduling of Automated Guided Vehicle in Flexible Manufacturing System using Ant Colony Optimization

Rashmi
Department of Computer Science and Engineering, Babu Banarsi Das University Lucknow,India

Sunita Bansal
Department of Computer Science and Engineering, Babu Banarsi Das University Lucknow,India

Abstract- **Flexible Manufacturing System (FMS),equipped with several CNC machines and Auto Guided Vehicle (AGV) based material handling systems has been designed and implemented to have the flexibility and efficiency in production process. After the implementation of FMS, various problems came such as the scheduling of the resources, such as frequent variation in the parts, tools, AGV routings, becomes a complex task. Flexible Manufacturing System has been regularly investigated and it continues to attract both academic and industrial sectors. Automated guided vehicle are used due to their flexibility and compatibility. Scheduling, dispatching and routing of Automated Guided Vehicle are an important task .This has been done traditionally using various mathematical programming techniques. Random search algorithms have been attempted for scheduling in these previous years. Most of these researches have been emphasized only on single objective optimization .In scheduling, multi objective function with conflicting objectives are complex and combinatorial in nature and they hardly have a unique solution. This paper contains multi objective task scheduling of AGV in a flexible manufacturing environment using ant colony optimization. In this paper I have made an attempt to find the near optimum schedule for two AGVs based on the balanced workload between them and the minimum traveling time for their maximum utilization.**

Keywords: flexible manufacturing system, ant colony optimization, automated guided vehicle (AGV), Task scheduling, Matlab.

I. INTRODUCTION

A. Flexible Manufacturing System

Flexible Manufacturing System is “An automated manufacturing system consisting of numerically controlled machines capable of performing multiple functions linked together by a computer system.” A Flexible Manufacturing System is totally automated manufacturing system that consists of machining centers, with automated loading and unloading of parts, an Automated Guided Vehicle system for moving parts between machines, and other automated elements to allow unattended production of parts. In the present day automated manufacturing environment, flexible manufacturing systems (FMS) are agile and provide wide flexibility. FMS are well suited for simultaneous production of wide variety of part types in low volumes. FMS is a complex system consisting of elements like workstations, automated storage and retrieval systems, and material handling devices such as robots and AGVs The FMS elements can operate in an asynchronous manner and the scheduling problems are more complex. Moreover, the components are highly interrelated and in addition, contain multiple part types and alternative routings etc.FMS performance can be enhanced by better co-ordination and scheduling of production machines and material handling equipment

B. Automated guided Vehicle

An automated guided vehicle or automatic guided vehicle (AGV) is a mobile robot that follows markers or wires in the floor, or uses vision or lasers. They are most often used in industrial applications to move materials around a manufacturing facility or a warehouse. AGV (Automated Guided Vehicles) is a material handling system which is used for loading/unloading of parts between different workstations. Automated Guided Vehicles are widely used in flexible manufacturing systems due to their flexibility and compatibility. Given below is an AGV for carrying heavy cargo.

Figure:1 AGV for carrying heavy cargo.

C. Task Scheduling

Scheduling algorithm rises most modern system to perform multitasking and multiplexing (transmit multiple flows simultaneously) .Task scheduling is used for multitasking and multiplexing. Scheduling, dispatching and routing of Automated Guided Vehicle are an important task**.**

D. Ant colony optimization

The Ant colony optimization algorithm(ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs.Phermone secrection of ant is very effective way of commumnication between ants than any other swarm the behavior of ant can be shown as

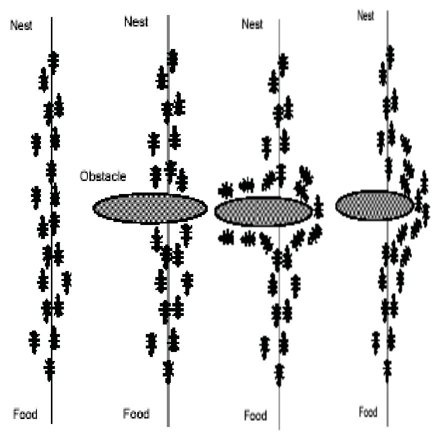

Figure 2: Normal Behaviour of Ants

Ant colony optimization is an nontraditional meta heuristic approach which performs better in dynamic environment

II. LITERATURE SURVEY

Ant Colony Optimization is a prominent non traditional optimization technique that has been used for the optimization of various problems. Various research works has been done from past times on effective and better use of ACO.Some of them can be given as C Gagne, W L Price and M Garvel [1] have compare ACO with other heuristic approaches in which ACO gives certain advantages. R Kumar, Mk Tiwari and R Shankar [2] incorporated stagnation avoidance and prevention from quick convergence to get near optimal solution in scheduling of FMS using ACO..Stefan Babos[3] used parallel implementation of ACO. Zijian Guo, Xiang Quan Song and Penghang [4]used ACO for container transportation network of seaport and compare it with Dijikstra to show ACO gives excellent results. Pan Junjie and Wang Dingwei [5] implemented ACO for multiple travelling salesman problem.Sg Pannamblam, N.Jawahar and B G Girish [6] used ACO for Flexible job scheduling for minimum markspan criterian.Hamesh Babu Navala and Ganjana K.Tiwari [8] provided a review on use of swarm intelligence metaheuristic to scheduling of FMS using ACO and PSO and shows that effectiveness of this hybrid approach is increased.Krishna H.Hingrajya, Ravinrdra Kumar Gupta and Gajendra Singh Chandel [9] gave a improved ACO for TSP which involve combination with candidate list strategy and dynamic updating. Sunita Bansal and manuj Darbari [10] gave application of multi objective optimization in Prioritizing and Machine scheduling . Imran Ali

Siddiqui ,Sunita Bansal, Manuj Darbari [11] gave application of activity theory and particle swarm optimization technique in Cooperative Software Development.Sunita Bansal, Manuj Darbari[12], Multi-Objective Intelligent Manufacturing System for Multi Machine Scheduling Gurinder Singh and Dinesh Gupta [13] gave an integrated approach to Test Suite selection using ACO and genetic algorithm. Przemyslaw Korytkowski, Szymon Rym Aszewski, Tomsaz Wisniewski [14] used an gave that job shop scheduling can be optimized using ACO.ACO has been continuously used for scheduling algorithm

III. PROPOSED WORK

My Proposal is to give an algorithm that will reduce manufacturing time, cost and balancing the task between different AGVs .As the type and the operations of FMS differ with configuration. Because a specific configuration is not possible, most of the research focuses on specific manufacturing systems. The configuration of the system, the assumptions and the objective criteria in this work are presented in the following sections.

1. In a FMS, AGVs are used to perform the tasks for loading / unloading the parts between the workstations.
2. The assumptions made in this work are as follows:

- The number of AGVs is taken as two.
- The travelling times of AGVs to workstations are considered.
- The AGVs performing the tasks in the workstations are restricted to certain number of times.
- An AGV will not take part in the execution of another task, until it finished the present task assigned i.e. Non pre-emptive scheduling.
- If two AGVs want to enter the same workstation, it is called task collision and permits the AGV, which arrives first to the workstation. If two AGVs arrive simultaneously at the same workstation, AGV having the higher priority is permitted (the priority ordering of AGV is AGV0, AGV1).

3. The objective is to find the near-optimum schedule for two AGVs based on the balanced workload and the minimum travelling time for maximum utilization using Ant Colony Optimization (ACO) algorithm. The objective function, which can be defined mathematically for the problem, can be described as follows:

$$\textbf{Min } C = W1\,(\Sigma A1 - \Sigma A2) + W2\,(\Sigma A1 + \Sigma A2) \qquad (1)$$

Where: $\Sigma A1$ – Sum of the travelling times that are assigned to AGV1
$\Sigma A2$ – Sum of the travelling times that are assigned to AGV2
$W1$, $W2$ – Weight age factors

The propose algorithms is done in 5 phase

- The initialization phase
- Probabilistic transition rule
- Local trail updating by each ant
- Performance evaluation of each ant
- Global trail updating by a few best ants

The algorithm can be given as

STEP 1: For all workstation and AGV combination Pheromones trail is initialized .
STEP 2: Generate ants.
STEP 3: Each ants work is to assign a workstation to AGV based on Probabilistic Transition rule

$$= \qquad (2)$$

STEP 4: Local updating is done by all ants

(3)

.**STEP 5**: If all workstation assigned a AGV then Ants forms schedule based on combination objective function

$$\textbf{Min } C = W1\,(\Sigma A1 - \Sigma A2) + W2\,(\Sigma A + \Sigma A2)$$

else goto **STEP 3**

STEP 6: Global updating is done by few selected ants

$$\gamma_{wv}(t+1) = (1-\rho)\gamma. \qquad (4)$$

$,if\,an$

STEP 7: If Termination then Store optimal solution and stop
else goto **STEP 3**
where

=probability that ant k will assign workstation w to AGV

= pheromone trail

w=number of workstation
v=number of AGVs..(here taken as 2)
n=number of ants assigning particular workstation to a particular AGV
φ=pheromone trail for local updating
ρ=pheromone trail for global updating
A1=task time for AGV1
A2=task time for AGV2

In this problem, the initial pheromone trail kept between workstation and AGV combination is 0.1. The trail evaporation parameter *φ* influences the local search of the ants. A higher value of evaporation factor increases the tendency of the ants for higher exploration in its search space. A lower value of the parameter leads to the convergence of ants at local minima. The trail evaporation parameter is taken as 0.3. A higher value of the parameter increases the tendency of the ants to converge at sub-optimal results. Hence the global trail evaporation parameter ρ is taken as 0.3. The number of ants is kept as 20.the termination condition is considerd to be 100 iterations.

IV. MATLAB

Matlab is a High-level language for numerical computation, visualization, and application development .It has Interactive environment for iterative exploration, design, and problem solving Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration, and solving ordinary differential equations Built-in graphics for visualizing data and tools for creating custom plots .Development tools for improving code quality and maintainability and maximizing performance .Tools for building applications with custom graphical interfaces .It has Functions for integrating MATLAB based algorithms with external applications and languages such as C, Java, .NET

V. RESULT

In this paper, two AGVs are taken for transporting the parts among the workstations. Suppose that each AGV is doing certain task and that traveling time of AGV to particular workstation represents the task time, the AGV should be scheduled according to the task times. The objective of the paper is to find optimum schedule in which the balancing of the AGVs should be satisfied , the workload for the AGVs should be equal, based on the traveling times and also the traveling time for the optimal schedule must be minimum for the AGVs accomplishing a certain task .A task is considered for which task time of different AGVs are taken to be

TABLE 1:
Task or Travelling Time for Both AGVs to Workstations

AGV	WORKSTATIONS				
	1	2	3	4	5
1	20	25	40	45	34
2	25	30	45	30	25

The result for this scenario by applying the given algorithm can be given as

Combine objective function =106

Schedule of AGVs to get the minimum objective function for accomplishing the defined task = 12121

VI. CONCLUSION AND FUTURE WORK

This study is focused on the multi-objective task scheduling of AGV in an FMS using ant colony optimization algorithm. In this procedure a scheduling path is developed for the task scheduling of AGV with the objective of balancing the AGVs and minimizing the task times of AGVs in an FMS. The optimum schedules for the combined objective Function is obtained. The result obtained by the ACO algorithm is promising and it performs better in dynamic enviornment.Even a small saving in the combined objective function will cause a efficient improvement in task scheduling. This would results in increased utilization of AGV and hence the overall efficiency of the whole system. This work can be modified to any kind of FMS for its problem environment and can be applied for optimizing different objectives separately or in combination. When there will be a variation in the number of workstations and number of AGV's then this procedure will require to be changed accordingly. Further research can be done by relaxing some of the assumptions made in this work and to apply the method to wide range of problems. The applicability of the proposed work has considerable applications to research with further accuracy such as it could include other hardware elements of the defined system to make the task scheduling simpler and an integrated one

VII. ACKNOWLEDGMENT

This work was supported by Dr.Sunita Bansal, Assistant Professor Babu Banarsi Das University Lucknow, India

REFERENCES

[1] C Gagne, W L Price and M Garvel "Comparing an Ant Colony Optimization algorithm with other heuristics for the single machine problem with sequence dependent set up times" Journel of operational research society(2002) ,S3,895-906.
[2] R Kumar, Mk Tiwari and R Shankar "Scheduling of Flexible manufacturing systems: an ant colony optimization approach" Proc. Instn Mech. Engrs Vol. 217 ,2012,Part B: J. Engineering Manufacture.
[3] Stefan Babos "Parallelization technique for ant colony optimization metaheuristic".Journal of Information, Control and Management Systems, Vol. 2, (2004), No.2
[4] Zijian Guo, Xiang Quan Song and Penghang "An Ant Colony Optimization algorithm for container transportation network of seaport" Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, 2005,pp. 581 – 591.
[5] Pan Junjie and Wang Dingwei"An Ant Colony Optimization Algorithm for Multiple Travelling Salesman Problem."Proceedings of the First International Conference on Innovative Computing, Information and Control (ICICIC'06)0-7695-2616-0/06
[6] S G Pannamblam, N.Jawahar and B G Girish "An Ant Colony Optimization algorithm for Flexible Job shop scheduling problem" (2010)
[7] Jun-qing Li, Member, IEEE, Quan-ke Pan, Sheng-xian Xie, Bao-xian Jia and Yu-ting Wang"A hybrid particle swarm optimization and tabu search algorithm for flexible job-shop scheduling problem "International Journal of Computer Theory and Engineering, Vol. 2, No. 2 April, 2010 1793-8201
[8] Hamesh Babu Navala and Ganjana K.Tiwari"Review on use of Swarm Intelligence Metaheuristics in Scheduling of Flexible Manufacturing System."International Journal of Engineering and Technology Vol.3 (2), 2011, 80-86
[9] Krishna H.Hingrajyaravinrdra Kumar Gupta and Gajendra Singh Chandel "An Ant Colony Optimization Algorithm for Solving Travelling Salesman Problem "International Journal of Scientific and Research Publications, Volume 2, Issue 8, August 2012 1 ISSN 2250-3153
[10] Sunita Bansal, Manuj Darbari"Application of multi objective optimization in Prioritizing and Machine scheduling: a Mobile Scheduler Toolkit" International Journal of Applied Information Systems, Vol. 3, n. 2, 2012.
[11] . Imran Ali Siddiqui ,Sunita Bansal, Manuj Darbari "Application of activity theory and particle swarm optimization technique in Cooperative Software Development".International Review on Computers and Software (I.RE.CO.S.), Vol 7, n. 5.2012
[12] Sunita Bansal, Manuj Darbari, "Multi-Objective Intelligent Manufacturing System for Multi Machine Scheduling".International Journal of Advanced Computer Science and Applications, Vol. 3, No. 3, 2012
[13] Gurinder Singh and Dinesh Gupta"An Integrated Approach to Test Suite Selection Using Ant Colony Optimization and Genetic Algorithm "Volume 3, Issue 6, June 2013 ISSN: 2277 128X
[14] Przemyslaw Korytkowski, Szymon Rym Aszewski, Tomsaz Wisniewski "Ant colony optimization for job shop scheduling using multi-attribute dispatching rules "Int J Adv Manuf Technol (2013) 67:231–241 DOI 10.1007/s00170-013-47692.