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Performance Study of Flexible Manufacturing System using Simulation Techniques and Scheduling using Dispatching

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Abstract—*Flexible manufacturing system (FMS) is a highly integrated and dynamic manufacturing system. The relation between its components is very complex. The mathematical programming approaches are very difficult to solve for very complex system so the simulation of FMS is widely used to analyze its performance measures. Optimum Automated Guided Vehicles (AGVs) operation also plays a crucial role in improving the performance of Flexible Manufacturing System (FMS). One of the main elements in the implementation of AGV is task scheduling. This will enhance the productivity, Minimize delivery cost and optimally utilize the entire fleet. Since fms is a highly dynamic system with considerable product mix and manufacturing environment is also dynamic in nature.*

1. INTRODUCTION

In the present market scenario, the customer demand and specification of any product changes very rapidly so it is very important for a manufacturing system to accommodate these changes as quickly as possible to be able to compete in the market. This evolution induces often a conflict for a manufacturing system because as the variety is increased the productivity decreases. So the flexible manufacturing system (FMS) is a good combination between variety and productivity. In this system, the main focus is on flexibility rather than the system efficiencies. A competitive FMS is expected to be flexible enough to respond to small batches of customer demand and due to the fact that the construction of any new production line is a large investment so the current production line is reconfigured to keep up with the increased frequency of new product design.

Since an FMS can be viewed as a discrete event system, the methods for modeling and control of such a system have been developed by using Petri nets (Ezpeleta et al., 1995 and Viswanadham et al., 1990) max-plus algebra (Cuninghame, 1979) or, by using a matrix description approach (Lewis et al., 1998 and Gurel et al., 2000). There are research activities that follow the trend of graphically oriented design of FMS controllers. Good examples are the programs like Onika (Gertz and Khosla, 1994), Robotica (Nethery and Spong, 1994), OpenRob (Ge et al., 2000), and the Robotics Toolbox for MATLAB, which are intended for the graphical design of systems for the control of robotized plants and which integrate already existing software modules for control of robot manipulators.

Static Scheduling in FMS has been extensively studied over the last two decades and influence of real time events in the static scheduling now a days dynamic scheduling attracts the interest of research both in academia and industry.The purpose of scheduling is to minimize the make span and production cost by suggesting a production facility what to make,when with which staff, and on which equipment.It also aims to maximize the utilization of resources too.

There are many elements of FMS scheduling.However, the important factor that should be considered is scheduling of multiple AGVs. This is due to fact that in a typical shop floor environment, AGVs is shared by several machines.

Nomenclature

AGV AUTOMATED GUIDED VECHILE

M MACHINE

SPT SHORTEST PROCESSING TIME

RIT/TPT RATIO OF IDLE TIME TO TOTAL PROCESSING TIME

1.1 Static and dynamic scheduling

Scheduling is a process of selection among alternative plans and assigning resources and times to the set of activities in the selected plan .In the manufacturing system resources represents machines,operators ,tools and buffers and activites are processing of product on machines or the transport of product between machines.Since manufacturing environment is dynamic in nature and are subject to varios disruptions called as real time events, which can change system status and affect its performance.Dynamic scheduling has considered a significant number of real time events and theirs effects of considering various manufacturing systems such as flow shops ,job shops ,FMS etc. The real time events have been cl;assified as resource related like nachine breakdown ,operator illness, unavailability or tool failures ,loading limits ,delay in the arrival or shortage of the material, defective material etc. Job related like rush-jobs,job cancellation ,due date changes, early or late arrival of jobs, change in job priority,change in processing time etc

1.2 Dispatching rules

Dispatching rules have played a significant role within dynamic contexts. A variety of simple and complex dispatching rules have been proposed ,no rule performs well for all criteria . Hence ,many investigations were carried out toward recognizing a combination of several dispatching rules to find a range of system states in which the relative performance of various dispatching rules dynamically under different dynamic and stochastic conditions of the shop floor, simulation was used

2. LITERATUR SURVEY

Browne et al.,1984 defines FMS as an integrated computer-controlled system with automated material handling devices and CNC machine-tools and which can be used to simultaneously process a medium-sized volume of a variety of parts.

Chan et al.(2007) presented a simulation study using Taguchi's method analysis of physical and operating parameters of the flexible manufacturing system along with flexibility. An approach is developed to study the impact of variations in the physical and operating parameters of an FMS and to identify the level of these variations. The physical and operating parameters of alternative resources may influence the system's performance with the changing levels of flexibility and operational control parameters such as scheduling rules. The results of simulation study shows that expected benefits may not be present when routing flexibility (RF) levels are increased with presence of the variations in physical and operating parameters. The increase in RF level becomes counterproductive under such environment when variations are above certain limits. It may be useful for decision maker to distinguish the level of flexibility up to which it can be gainfully increased under the presence of variations. decision maker to distinguish the level of flexibility up to which it can be gainfully increased under the presence of variations.

Viswanadham et al.(1990) investigated the use of Petri net (PN) models in the prevention and avoidance of deadlocks in flexible manufacturing systems. For deadlock prevention, a reachability graph of a Petri net model of the given FMS is used, whereas for deadlock avoidance, Petri net-based on-line controller is proposed. Deadlock handling can take two forms: deadlock prevention in which deadlocks are eliminated by static resource allocation policies and deadlock avoidance in which dynamic policies are employed to avert deadlocks just in time.

Nandkeolyar and Christy(1989) interfaced a computer simulation model of an FMS with the Hooke–Jeeves algorithm to search an optimum design without full factorial experimentation. Some modifications of the HJ algorithm are carried out to accommodate the stochastic nature of computer simulation. The inter-relationships between FMS components are not well understood. Consequently, it has not been possible to develop closed form analytic models of FMSs. So, computer simulation has been extensively applied to study their performance.

After reviewing the above set of research papers it can be said that the design and modeling of the complex FMS is a difficult task using mathematical techniques, so the computer simulation seems to be a better option. Therefore, to check the accuracy of the results obtained from simulation techniques this research work has been carried out.The number of dispatching rules ,heuristic and meta heuristic has been used for static scheduling of jobs in FMS and its optimazation. Some of the papers emphasis the rescheduling of jobs ,but there is scope of further study of dynamic scheduling of FMS with suitable dispatching rules.

3. SCHEDULING OF MACHINES AND AGVS IN FMS

Fms is highly automated machine cell, consisting of a group of processing work stations, interconnected by an automated material handling, automated storage system and controlled by distributed computer system. This is based on the minimization of single objective functions .Total operation completion time, $O_{ij}=T_{ij} + P_{ij}$

Where i=job, j=operation, Tij=travel time, Pij=operation processing time

Job completion time, $C_i = \sum O_{ij}$, i=1 to n.

Makespan= $\max(C_1,C_2 \ldots\ldots\ldots\ldots\ldots C_n)$

Rebustfactor=1/makespan

Mean tardiness: $1/n \sum T_i$

4. CASE STUDIES

The system shown in the Fig. 4 consists of three robots, two machines, i.e. a drilling machine and a milling machine and an inspection center. The system also consists of two conveyors, conveyor in and conveyor out. The system has operational flexibility in the sense that two types of products are produced in the system using two different process operations. Type A product undergoes milling operation only whereas Type B product undergoes drilling and then milling. Both the parts are inspected before moving to conveyor out. Robot 2 loads the milling and drilling machine from conveyor in, and Robot 1 loads the part B onto the milling machine after it completes the drilling operation. It also unloads the milling machine. Robot 3 loads the inspection center.

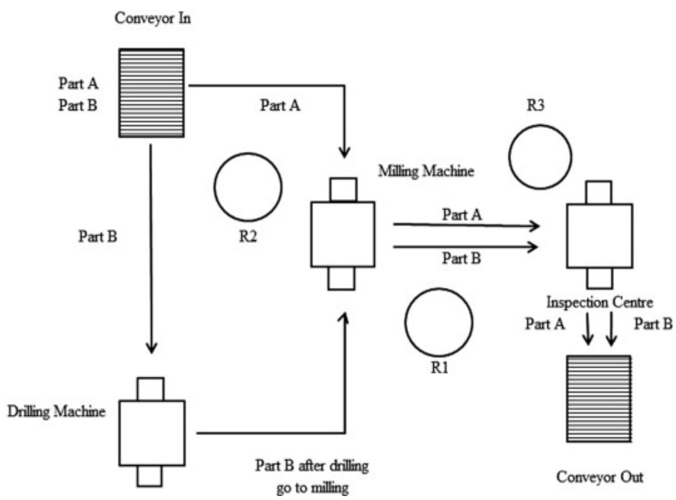

Fig. 1: block diagram of considered FMS

5. RESULTS AND DISCUSSIONS

By the three different techniques the obtained results for case study are as follows:

Solution Techniques	**Utilization**		
operations	**VisualSlamAweSim**	**Bottleneck**	**Petrinet**
Drilling	0.5343	0.428	0.4237
Milling	0.9903	0.9987	0.9884
Inspection	0.811	0.7704	0.7493

Overall productivity (parts per minute)			
Visual Slam AweSim	Bottle-neck	Petri net model	
0.118	0.107	0.121	

Then the Utilization and overall productivity is compared as and shown in

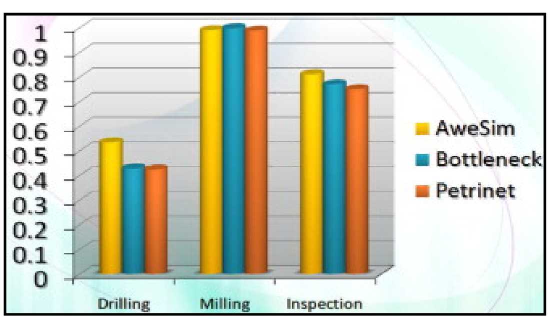

Fig. 2: Comparison of utlization of various techniques

The results are used to study the performance of fms scheduling with or without breakdown of machines by considering the priority dispatching rules. Number of parts produced is better in RIT/TPT while breakdown introduced and SPT and FIFO is better when machine is available.

6. CONCLUSION

This paper focussed on fms scheduling with dispatching rules under dynamic environment. Traditionally SPT, FIFO, LIFO, EDD etc are used in scheduling the proposed dispatched rules are SPT, FIFO and RIT/TPT performs better in traditional and with real real time event and also for the better performance of fms simulation methods are better.

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