A Review of Simulation Modeling, Performance Evaluation and Optimization Analysis of Flexible Manufacturing Systems

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Abstract- *In recent time of global competition, Flexible Manufacturing System (FMS) is an important tool to meet customers' continuously varying demands effectively. Its successful implementation results in improvement of flexibility, utilization, throughput along with integrity and automation. However, the adoption of a FMS involves a substantial investment and a high degree of uncertainty for the organization. Therefore it is necessary to evaluate and optimize the FMS performance prior to making costly investment of the system which can be done effectively using simulation and optimization analysis. This paper reviews various literatures based on simulation modeling, performance evaluation and optimization analysis of FMS.*

Keywords- FMS, Simulation, Performance Evaluation, Optimization, Literature review

I. INTRODUCTION

A flexible manufacturing system (FMS) is a highly automated group technology machine cell consisting of a group of processing workstations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by a distributed computer system.

Flexibility signifies a manufacturing system's ability to adjust to customers' preferences.

FMS must possess three capabilities in order to be flexible: [1]

i. The ability to identify and distinguish among different incoming parts or product styles processed by the system
ii. Quick changeover of operating instructions
iii. Quick changeover of physical setup

The basic components of FMS are:

Workstations,
Automated material handling and storage system,
Computer control system.
Operators

Simulation is the imitation of the operation of a real-world process or system over time. For a system that yet not exists, simulation is better than experiment. It can be used to predict performance of the system. While experimenting with actual system is too expensive, simulation emerges as economic and feasible tool as well to analyze the system.

Optimization is the process of maximizing or minimizing desirable requirements or undesirable effects respectively.

The optimization of simulation model deals with the study in which the analyst would like to find possible sets of model specifications which are input parameters which lead to optimal performance. This paper reviews various literatures based on use of simulation and optimization tools for analyzing complex system FMS.

II. FMS PERFORMANCE EVALUATION

Simulation modeling is the process of creating virtual model of physical system to predict its performance in real world. Simulation model of FMS gives values of performance measures of the system. FMS performance can be evaluated by using various measures such as makespan (total time required for processing a product), throughput (production quantities), system utilization, availability etc. Simulation model can be prepared using mathematical approaches and by using computer simulation softwares. Optimization analysis is carried out to improve the performance of FMS using different optimization tools.

III. LITERATURE REVIEW

Smith [2] showed an evidence of references for using simulation in FMS design. He mentioned use of various

simulators such as FLEXSIM, SIMAN, SLAM etc. for design and analysis of FMS.

A GPSS/H model is presented by Schriber [3] for analyzing hypothetical flexible manufacturing system. FMS consisted workstations and automated guided vehicles. (AGVs). The System has been built with facilities, storages, logic switches etc. The model was developed such that it can be applied to other FMS also. Sophisticated FMS can be easily modelled using GPSS/H approach. However, due to space limitations, additional output from the model cannot be obtained.

In Jovanovic's [4] work, bottleneck model and extended bottleneck model are used for quantitative analysis of flexible manufacturing system. Criteria such as maximum production rate and overall system utilization are used as performance measures. The conclusion included that bottleneck model can be used to estimate the number of servers at each station (number of machines of each type) to obtain a specific production rate of the system. Practical guidelines for designing FMS was also provided by this work.

Byoung and others [5] presented a modeling procedure for building a complex P-ACD (Parameterized Activity Cycle Diagram) model for a real-life highly sophisticated FMS capable of processing jobs of any type. P-ACD model for sequencing of job was also developed. A practical limitation of this model is that it does not model the physical behaviors of the material handling system and is difficult to prepare.

In Joseph and Sridharan's work [6], FMS is simulated using C programming language and various sequencing rules such as First in first out (FIFO), Shortest imminent operation (SIO), Earliest due date (EDD), Earliest operation due date (EODD) are used. It was concluded that due date-based part sequencing rules such as EDD and EODD provide better performance for all the measures. EDD being a simpler scheduling rule can be used for part sequencing decision.

Insup Um and others [7] prepared simulation design and analyzed the FMS consisting AGVs. They used robust method that combines Multi Objective NonlinearProgram (MONLP) and Evolution Strategy (ES) for analysis. ES was also used for optimizing the performance of the system. Parameters such as minimizing congestion, maximizing throughput and vehicle utilization are considered for performance analysis of FMS. This approach supported correct experimental results and robust technique was proved to be efficient.

Yusuf Tansel and others [8] presented a simulation model based case study of a FMS considering a multi-response simulation optimization using TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) based Taguchi approach. Factors such as number of operators, velocity of transporters, number of pallets, pallets selection strategy and number of tool are selected along with their levels. Performance measures such as cycle time, throughput and waiting times in queue were considered. The performance of the current FMS design and the proposed FMS design obtained by the TOPSIS based are compared. It was shown that the proposed system, designed by simulation optimization using the TOPSIS-based Taguchi method reveals better outputs.

AinazEbrahimi and others [9] determined optimal performance of FMS using network analysis and simulation process. Taking into account the existing system and changes in sources and distances, simulation optimization model was developed. ARENA simulation software was used for modeling FMS. Cost benefit analysis was carried out to reduce costs and increase the profit. This study improved the performance of FMS.

Mohamed Boualem and others [10] created mathematical queuing based model of FMS. Performance analysis was done using Monte Carlo simulation approach. Simulation modeling helped to understand the behavior of the system. It was also helpful in suggesting and verifying the impact of changes on the performance of the system.

Mehmet and others [11] prepared FMS using integrated definition for function methodology. The proposed approach is carried out with a case study from an aircraft industry to convert an existing system to FMS. FMS was designed using IDEF framework. Cycle time and machine utilization were considered for performance evaluation. Taguchi method was used for optimization. This study enhanced, not only performance of the system, but quality of FMS also.

B Santosh Kumar and others [12] modeled and analyzed FMS using FlexSim software. Results obtained from FlexSim was compared with mathematical bottleneck model. It was shown that FlexSim model was easy to analyze complex FMS.

Reddy and Rao [13] developed simulation model of FMS using Automod. They considered machine and vehicle scheduling and their effects in minimizing makespan. Effects of number of vehicles and dispatching rules on various FMS layouts are also studied.

Sanjibkumar and others [14] presented detailed review of FMS based on modeling and simulation approaches. They covered, very effectively, simulation techniques used in early age and in modern age. They identified use of various simulation softwares in analysis of FMS.

Safitra and others [15] integrated experimental design approach with simulation modeling of FMS. Effects of various inputs such as material handling configuration and layouts of FMS on its performance were investigated. Performance measures such as total productive cost, total flow time and throughput were considered. ARENA simulation software was used to prepare simulation model of FMS. Optimization analysis was carried out using response optimizer tool.

IV. CONCLUSION

After reviewing different literatures, it can be said that different researcher has used different approach for design and analysis of FMS. Simulation modeling and performance evaluation of FMS are carried out on basis of mathematical models and computer simulation models as well. It can be said that complex system like FMS can be modelled and analyzed effectively and easily using computer simulation software rather than using mathematical modeling approach. Simulation softwares are considerably used as decision making tools. Moreover, changing simulation inputs and observing outputs give important insights into which variables are most affecting to the system performance. Simulation modeling allows to experiment and interact within proposed system to predict its performance. FMS performance can be improved considerably using various optimization methods and optimization tools as well.

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