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Modeling and Analysis of Flexible Manufacturing System with FlexSim

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ABSTRACT

Flexible manufacturing system (FMS) is a highly integrated 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. Also the FMS components are very sophisticated and costly. If FMS has to be implemented then it is better to analyze its results using simulation which involves no loss of money, resource and labour time. As a typical discrete event system FMS have been studied in such aspects as modeling and performance analysis. In this paper, a concept and implementation of the Flexsim for measuring and analysis of performance measures of FMS is applied. The other well defined mathematical technique, i.e. bottleneck technique has also been applied for the purpose of comparison and verification of the simulation results. An example FMS has been taken into consideration and its flexsim model and mathematical model has been constructed. Several performance measures have been used to evaluate system performance. And it has been found that the simulation techniques are easy to analyze the complex fexible manufacturing system.

Keywords: *Bottleneck, Flexible Manufacturing System (FMS), FlexSim, Simulation.*

I. 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.

The optimal design of FMS is a critical issue and it is a complex problem. There are various modeling techniques for FMS; the most common one are based on mathematical programming. FMS is a highly integrated manufacturing system and the inter-relationships between its various components are not well understood for a very complex system. Due to this complexity, it is difficult to accurately calculate the performance measures of the FMS which leads to its design through mathematical techniques. Therefore, computer simulation is an extensively used numeric modeling technique for the analysis of highly complex flexible manufacturing systems.

Modeling and simulation of FMS is a field of research for many people now days. However, they all share a common goal; to search for solutions to achieve higher speeds and more flexibility and thus increase manufacturing productivity. FlexSim is a discrete event manufacturing simulation software developed by FlexSim Software Products, Inc. The FlexSim family currently includes the basic FlexSim simulation software and FlexSim Healthcare Simulation (FlexSim HC). It uses an OpenGL environment to realize real-time 3D rendering.

In this research work, FMS is modeled with the help of Flexsim to analyze its performance measures. In addition, the bottleneck technique has been applied to compare and verify the results obtained from the simulation techniques.

II. Literature 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.

Bennett et al. (1992) identifies the factors crucial to the development of efficient flexible production systems, namely: effective integration of subsystems, development of appropriate controls and performance measures, compatibility between production system design and organization structure, and argues that the flexibility cannot be potentially exploited if its objectives are not defined and considered at design stage.

Delgadillo and Llano (2006) introduced a Petri net-based integrated approach, for simultaneously modeling and scheduling manufacturing systems. A prototype that simulates the execution of the production plan, and implements priority dispatching rules to solve the eventual conflicts, is presented. Such an application was tested in a complex flexible job shop-type system. Scheduling is a difficult task in most manufacturing settings due to the complexity of the system. Hence there is a requirement of powerful tools that can handle both modeling and optimization.

Shnits et al. (2004) used simulation of operating system as a decision support tool for controlling the flexible system to exploit flexibility.

Tu¨ ysu¨ z and Kahraman (2009) presented an approach for modeling and analysis of time critical, dynamic and complex systems using stochastic Petri nets together with fuzzy sets.

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.

III. Flexible manufacturing system

Flexible manufacturing system (FMS) is a class of manufacturing system that can be quickly configured to produce variety of products. Over the last few decades, the modeling and the analysis of FMSs has been closely studied by control theorists and engineers. An FMS is a production system where a discrete number of raw parts are processed and assembled by controlled machines, computers and/or robots. It generally consists of a number of CNC machine tools, robots, material handling, automated storage and retrieval system, and computers or workstations. A typical FMS can fully process the members of one or more part families on a continuing basis without human intervention and is flexible enough to suit changing market conditions and product types without buying other equipment (the concept ‘‘flexible’’ can refer to machines, processes, products, routings, volume, or productions). The concept of FMS is credited to David Williamson, a British engineer employed by Molins during the mid 1960s. Molins applied for a patent for the invention that was granted in 1965. The concept was called System 24 then because it was believed that the group of machine tools comprising the system could operate 24 h a day. One of the first FMS installed in US was a machining system at Ingersoll-Rand Company. (Fig. 1). There are three capabilities that a manufacturing system must possess in order to be flexible:

(1) The ability to identify and distinguish among different incoming part or product styles processed by the system.

(2) Quick changeover of operating instructions.

(3) Quick changeover of physical setup.

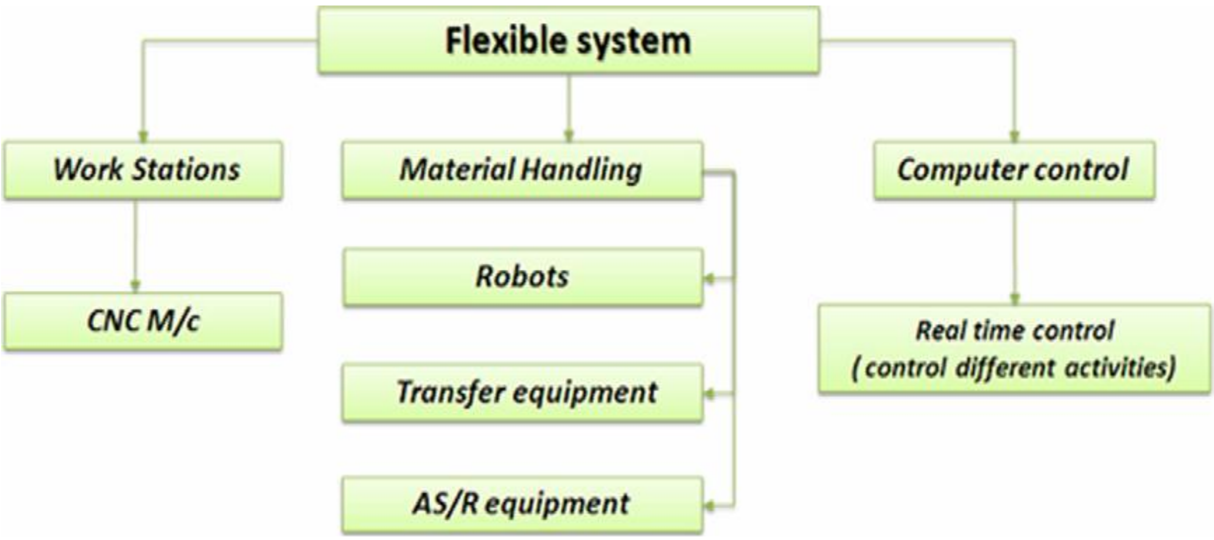

Figure 1 Flexible manufacturing system configuration**.**

IV. FlexSim

FlexSim is a powerful analysis tool that helps engineers and planners make intelligent decisions in the design and operation of a system. With FlexSim, you can build a 3-dimensional computer model of a real-life system, then study that system in a shorter time frame and for less cost than with the actual system. As a "what-if" analysis tool, FlexSim provides quantitative feedback on a number of proposed solutions to help you quickly narrow in on the optimum solution. With FlexSim's realistic graphical animation and extensive performance reports, you can identify problems and evaluate alternative solutions in a short amount of time. By using FlexSim to model a system before it is built, or to test operating policies before they are actually implemented, you will avoid many of the pitfalls that are often encountered in the startup of a new system. Improvements that previously took you months or years of trial-and-error experimentation to achieve can now be attained in a matter of days and hours using FlexSim.

V. Bottleneck technique

Important aspects of the FMS performance can be mathematically described by a deterministic model called the bottleneck model developed by Solberg (1981). The bottleneck model is simple and intuitive but it has a limitation of a deterministic approach. It can be used to provide starting estimates of FMS design parameters such as production rate, number of work stations, etc. The term bottleneck refers to the fact that an output of the production system has an upper limit, given that the product mix flowing through the system is fixed. This model can be applied to any production system that possesses possess this bottleneck feature.

Terminology and symbols

Part mix, a mix of the various parts or product styles produced by the system is defined by pi. The value of pi must sum to unity

$$\sum . P_i = 1.0$$

The FMS has a number of distinctly different workstations n and s_i is the number of servers at the i^{th} workstation. Operation frequency is defined as the expected number of times a given operation in the process routing is performed for each work unit.

$$f_{ijk} = \text{operation frequency}$$

For each part or product, the process routing defines the sequence of operations, the workstations where operations are performed, and the associated processing time.

$$t_{ijk} = \text{processing time for operation}$$

The average workload, Wl_i

$$WL_i = \sum_j \sum_k t_{ijk} f_{ijk} p_i$$

The average of transport required completing the processing of a work part, n_t

$$n_t = \sum_i \sum_j \sum_k f_{ijk} p_i - 1$$

The workload of handling system, WL_{n+1}

$$WL_{n+1} = n_t t_{n+1}$$

where t_{n+1} = Mean Transport time per move, min.

The FMS maximum production rate of all part, R^*_p, Pc/min

$$R_p = S^*/WL^*$$

Where WL^* is workload min/Pc and S^* = Number of machines at the bottle-neck station.
The part (*j*) maximum production rate, R_{pi}, Pc/min.

$$R^*_{Pi} = P_i(R^*_{Pi}) = Pi\frac{S*}{WL*}$$

Mean utilization of a station (i), U_i

$$U_i = \frac{WLi}{Si}(R^*_p) = \frac{WLi}{Si} \times \frac{s*}{WL*}$$

Average Utilization of FMS including Transport system

$$\overline{U} = \frac{\sum_{i=1}^{n+1} U_i}{n+1}$$

Overall FMS utilization

$$\overline{U_s} = \frac{\sum_{i=1}^{n} S_i U_i}{\sum_{i=1}^{n} S_i}$$

VI. Case study

A flexible manufacturing system consists of two machining workstations and a load/unload stations. Station 1 is the load/unload station. Station 2 performs milling operations and consists of two servers (two identical CNC milling machines). Station 3 has one server that performs drilling(one CNC drill press). The stations are connected by a part handling system that has four work carriers. The mean transport time is 3.0min. The FMS produces two parts A and B. The part mix fractions and process routings f_{ijk}=1.0 for all operations.

Table 1 List of operations and process time on different machining centers.

Part j	Part Mix P_j	Operation K	Description	Station i	Process time t_{ijk} (min)
A	0.4	1	Load	1	4
		2	Mill	2	30
		3	Drill	3	10
		4	Unload	1	2
B	0.6	1	Load	1	4
		2	Mill	2	40
		3	Drill	3	15
		4	Unload	1	2

6.1 Solution methodology

Two types of techniques are applied to find the parameters of the given FMS; the one is simulation techniques and another one is mathematical technique. The simulation technique is Flexsim. The mathematical one is the bottleneck technique. The system is modeled in simulation technique and then the results are compared with the mathematical technique.

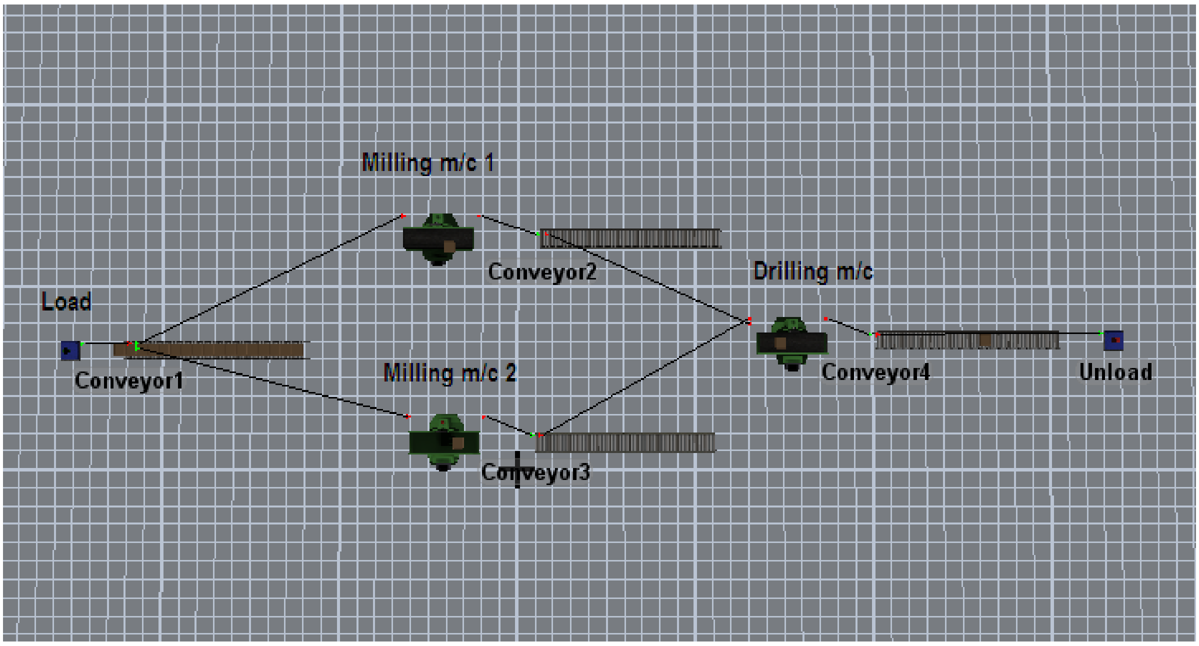

Figure 2: Flexsim model of the FMS of case study

6.1.1 Modeling in flexsim

The system consists of loading and unloading station, three process stations, four work carriers. To start a cycle, raw parts and the work carriers must be available. Then only firing will take place. The conveyor carries a raw part from loading station to the process station according to the given sequence for the different parts. After the completion of an operation in one station the part is again carried by another conveyor to its next required station. At the end the part is carried to the unloading station.

Place representing the stations have tokens according to the number of machines they have. The Flexsim model is simulated to get the overall productivity of the given system. The Flexsim model is shown in Fig 2.

6.1.2 Bottleneck technique

A C program has been developed to get the performance measures of the FMS system using bottleneck technique.

6.1.3 Results

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

Solution Techniques	Utilization	
Operations	Flexsim	Bottle-neck model
Milling	0.9865	0.9989
Drilling	0.7162	0.7225

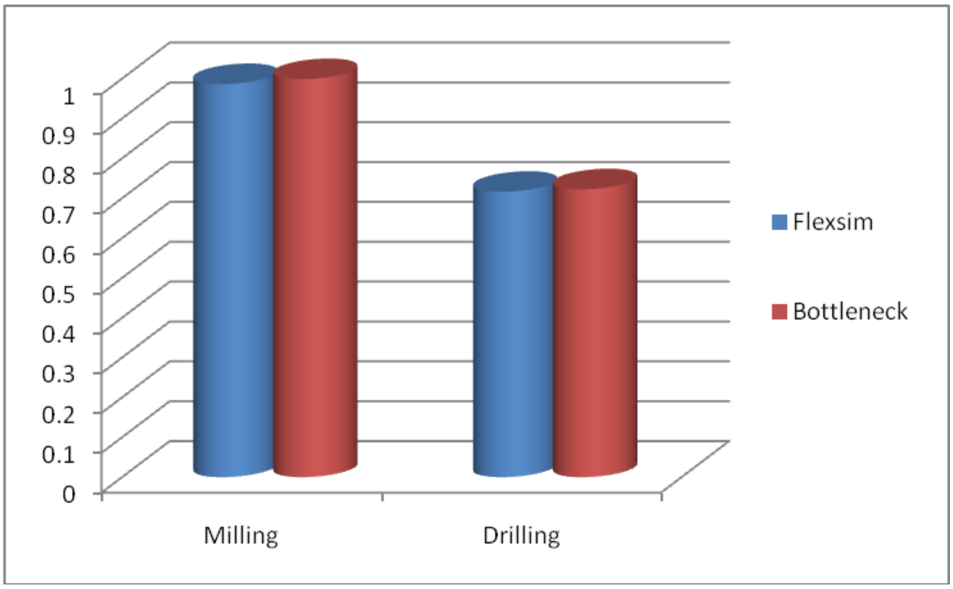

Fig 3. Comparison of utilization from different techniques

VII. Conclusions

In this research, a concept and implementation of the Flexsim for measuring and analysis of performance measures of FMS is applied. The other well defined mathematical technique, i.e. bottleneck technique has also been applied for the purpose of comparison and verification of the simulation results. An example FMS has been taken into consideration and its flexsim model and mathematical model has been constructed. Several performance measures have been used to evaluate system performance. Then finally the utilization of two techniques are approximately same. And it has been done that the simulation techniques are easy to analyze the complex fexible manufacturing system. FMS has to be implemented then it is better to analyze its results using simulation which involves no loss of money, resource and labour time

References

[1] Bennett, D., Forrester, P., Hassard, J., 1992. Market-driven strategies and the design of flexible production systems: evidence from the electronics industry. Int. J. Oper. Prod. Manag. 12 (2), 25–43.

[2] Browne, J., Dubois, D., Rathmill, K., Sethi, P., Steke, KE., 1984. Classification of flexible manufacturing systems. FMS Mag., 14–27.

[3] Bruccoleri, M., Sergio, NL., Perrone, G., 2003. An object-oriented approach for flexible manufacturing controls systems analysis and design using the unified modeling language. Int. J. Flexible Manuf. Syst. 15 (3), 195–216.

[4] Cheng, T.C.E., 1985. Simulation of flexible manufacturing system. Simulation 45 (6), 299–302.

[5] Delgadillo, G.M., Llano, S.B., 2006. Scheduling application using petri nets: a case study: intergra´ ficas s.a.'. In: Proceedings of 19th international conference on production research, Valparaiso, Chile.

[6] Gupta, D., Buzacott, JA., 1989. A framework for understanding flexibility of manufacturing systems. J. Manuf. Syst. 8 (2), 89–97.

[7] Kumar, R., Tiwari, MK., Shankar, R., 2003. Scheduling of flexible manufacturing systems: an ant colony optimization approach. Proc. Inst. Mech. Eng. 217 (10), 1443–1453.

[8] Nandkeolyar, U., Christy, D.P., (1989). Using computer simulation to optimize flexible manufacturing system design. In: Proceedings of the 1989 Winter Simulation Conference.

[9] Narakari, Y., Viswanadham, N., 1985. A Petri net approach to modeling and analysis of flexible manufacturing system. Annu. Oper. Res. 3, 449–472..

[10] Ruiz, C.M., Cazorla, D., Cuartero, F., Macia, H., 2009. Improving performance in flexible manufacturing systems. J. Logic Algebra Program. 78, 260–273.

[11] Santarek, K., Buseif, I.M., 1998. Modelling and design of flexible manufacturing systems using SADT and Petri nets tools. J. Mater. Process. Technol. 76, 212–218..

[12] Shnits, B., Rubinovittz, J., Sinreich, D., 2004. Multi-criteria dynamic scheduling methodology for controlling a flexible manufacturing system. Int. J. Prod. Res. 42, 3457–3472.

[13] Tavana, M., 2008. Dynamic process modelling using Petri nets with applications to nuclear power plant emergency management. Int. J.Simul. Process Mod. 4 (2).

[14] Tu¨ ysu¨ z, F., Kahraman, C., 2009. Modeling a flexible manufacturing cell using stochastic Petri nets with fuzzy parameters. Expert Syst. Appl.

[15] Wang, FK., Yen, PY., 2001. Simulation analysis of dispatching rules for an automated interbay material handling system in wafer fab. Int. J. Prod. Res. 39, 1221–1238.