International Journal of Latest Trends in Engineering and Technology
Vol.(7)Issue(3), pp. 402-409
DOI: http://dx.doi.org/10.21172/1.73.553
e-ISSN:2278-621X

Towards improving the performance of flexible manufacturing system: a case study

Dr. Amit Pradhan[1] and Mr. Yogendra Rathore[2]

Abstract: Increasing global competition has evolved a manufacturing environment which gleans vast product variety, reduced manufacturing lead times, inhanced quality parameters and competitive costs. Simultaneously, with a rising trend toward globalization, these manufacturing environments must be designed to cater new challenges to survive and grow in the marketplace. To deal with such multifaceted problems, new technologies support increased flexibility and automation. These objectives intended for the improvement of the manufacturing environment have been the key rationales for the introduction of flexible manufacturing systems (FMSs). In this paper a case study of a firm is presented with a contribution to suggest some methods of performance improvement for a flexible system of manufacturing. The study is based on the mathematical models illustrated in literature to estimate possible performance parameters like maximum production rate, make span time and overall utilization. Through this study, an effort is also made to present the improved design for existing flexible manufacturing system employed in the company. Various design and performance parameters are then evaluated and compared for the existing and improved FMS.

Keywords: flexible manufacturing system, performance parameters, production rate, makespan time

INTRODUCTION

Competitive business environment offers new pressures to be confronted by the manufacturing systems, such as variety of product with delivery on time along with emphasize conventional requirements of quality and competitive cost. Therefore, to sustain in the global scenario, the focus is to develop a manufacturing system that can fulfil all the demanded requirements within due dates at a reasonable cost. The introduction of Flexible manufacturing System (FMS) facilitates manufacturing industries to improve their performance along with the flexibility to make the customized product with medium volume. A Flexible manufacturing System (FMS) can be defined as a computer-controlled configuration of semi-dependent workstations and material-handling systems designed to efficiently manufacture various part types with low to medium volume. It combines high levels of flexibility with high productivity and low level of work- in-process inventory (Jang & Park, 1996). The exquisiteness of FMS is that it gleaned the ideas both from the

[1] Mechanical Engineering Deptt. Technocrats Institute of Technology Advance Bhopal (M.P.) India

[2] Mechanical Engineering Deptt. Govt.Polytechnic College, Raisen,(M.P.)India

flow shop and batch shop manufacturing system and is designed to imitate the flexibility of job shops while maintaining the effectiveness of dedicated production systems. Such FMS should be designed to improve productivity while fulfilling the demand with decreasing makespan time. A generic FMS is able to handle a variety of products in small to medium sized batches simultaneously. The flexibility of a flexible manufacturing system (FMS) has enabled it to become one of the most suitable manufacturing systems in the current manufacturing scenario of customized and varied products with shorter life cycles. With the aim of combining production flexibility and productivity, the design of flexible manufacturing system (FMS) is subject of high investments. Deterministic models based on discrete-event simulation can be utilized to design production systems such as FMSs. Distinctively these are used to design and size the hardware requirements of a FMS (buffer capacity, layout design, material handling layout design, and number of workstations with respect to the projected production) with an objective to raise the utilization of resources. In recent environment where a manager can make use of easily available computing power along with the various commercial tools and techniques,

LITERATURE REVIEW

The framework of flexible manufacturing systems (FMSs) combines high productivity, quality and flexibility needed for the fast response to changing market demands (Womack, Jones & Roos, 1990). The term flexible manufacturing system (FMS) is generally used to represent a wide variety of automated manufacturing systems. Flexible Manufacturing System (FMS) can be defined as an integrated system composed of automated workstations such as computer numerically controlled (CNC) machines with tool changing capability, a hardware handling and storage system and a computer control system which controls the operations of the whole system (Mac Carthy, 1993). Tempelemeier & Kuhn (1993) define FMS as a production system consisting of a set of identical and/or complementary numerically controlled machines, which are connected through an automated transportation system. Each process in an FMS is controlled by a dedicated computer (FMS cell computer). As per Parrish (1990), a flexible manufacturing system is a collection of production equipment logically organized under a host computer and physically connected by a central support system. The main impetus to switch from a traditional system to an FMS is to introduce flexibility in manufacturing operations so that a firm can compete more efficiently in the marketplace. Suresh and Sridharan (2007) described FMS as a growing technology mainly suitable for mid-volume, mid-variety production, they also defined FMS as an integrated production facility consisting of multifunctional numerically controlled machining centers connected with an automated material handling system, all controlled by a centralized computer system. An FMS is designed to have capability of concurrently handling a range of product types in batches (small to medium sized) and at a high efficiency as compared to that of traditional production systems which are designed to deal with low-variety parts in high volume. This system is able to process any part that belongs to specific families within the prescribed capacity according to a predetermined schedule. Generally, the system is designed in such a way that manual interference and change over time are minimized (Chan & Chan, 2004). One of the objectives of an FMS is to achieve the flexibility of small volume production while maintaining the effectiveness of largevolume mass production. The flexibility of a flexible manufacturing system (FMS) has enabled it to become one of the most suitable manufacturing systems in the current manufacturing scenario of customized and varied products with shorter life cycles. Ramasesh and Jaykumar (1991) stated that manufacturing flexibility can be of several different forms e.g. machine, operation, material handling, routing, program, expansion, process, product, volume, labor and material flexibilities. Sethi and Sethi (1990) gave the concept of eleven flexibility types, Browne et.al. (1984) illustrated only eight types, which are known as; machine flexibility, process flexibility, routing flexibility, operation flexibility, product flexibility, volume flexibility, part mix flexibility and production flexibility. An FMS can provide one or more of the above flexibilities. The consideration of a particular type of flexibility to be considered in the design of an FMS depends upon the system objectives. The increase in flexibility provides the alternative resources/machines to do the same processing (Shnits et al., 2004).

New Microsoft Office Excel Worksheet.xlsx

Part Range (mm)	Part Mix	Total Processing Time (Min)									
		Load/ Unload	Turning	Welding	Drilling	Milling	Surface Grinding	Lapping	Insp	Painting	Asly
40	0.0004	20	60	25	12	10	30	90	25	10	30
50	0.0247	20	75	30	15	15	45	120	30	10	30
65	0.0227	20	90	40	20	20	60	156	30	10	30
80	0.03	20	120	50	25	25	75	192	30	15	30
100	0.0379	20	150	60	30	30	90	240	30	20	30
125	0.0119	20	190	80	38	38	112	300	30	20	30
150	0.0305	20	225	95	45	45	135	360	30	25	30
200	0.0252	20	300	120	60	60	180	480	30	30	30
250	0.0101	20	375	150	75	75	160	600	30	30	30
300	0.0053	20	450	180	90	90	270	720	30	35	30
350	0.0053	27	525	210	105	105	315	840	32	35	32
400	0.0016	27	675	240	120	120	360	960	32	40	32
450	0.0013	28	750	270	135	135	410	1080	33	45	33

Table 1 Dual Plate Check Valve

DESCRIPTION OF CASE COMPANY AND PROBLEM DEFINITION

The Case Company is located in National Capital Region of India and specialized in the production of various types of valves (e.g. dual plate check valve, concentric butterfly valve, etc.) of large sizes and pressure ratings for the use in general fire safe and cryogenic applications whereas the material for these products ranging from the basic steels, superior alloys to titanium. The company is emerging and has become established among top five quality manufacturers internationally in this range with the certifications like CE, ISO & API 6D. The company's world class manufacturing base spans over more than 100000 square feet area equipped with modern machining centers, large size material processing and material handling equipment. The company is forward looking and has been investing in to infrastructure and R & D very regularly, thus giving better scope for the study and analysis. The study intends to conduct a performance analysis of the existing flexible system of manufacturing using the modeling technique mentioned above. The analysis very help full to us to predict the strategies for the improvements in performance parameters of the system

PERFORMANCE ANALYSIS AND MODELING OF CASE SYSTEM

Literature shows that deterministic study of FMS can reduce the uncertainty involved in the stochastic studies. There are various universal mathematical models available to performdeterministic study and therefore may be utilized. It is felt that better study of an existing system would also help in improving performance and in designing operational parameters of a new FMS. Getting the motivation from the earlier studies it was decided to adopt a well recognized mathematical mode.
proposedby Solberg (1981) and further modified by Mejabi (1988). These models have been duly verified and validated in the literature to provide primary estimates of operational parameters such as production rate, workstation load etc. Some assumptions have been considered for the implementation of the model to study the case.

S.No.	Workstations (Description)	Average Work Load (Min)
1.	Load / Unload Station	20.65
2.	Turning Center	148
3.	Welding Station	15.4
4.	Boring Machine	136.05
5.	Drilling Station	320.37
6.	Milling Center	8.14
7.	Grinding Machine	21
8.	Lapping Machine	265.62
9.	Rubber Matching	44.08
10.	Inspection	22.74
11.	Painting Station	21.51
12.	Assembly Station	46.25
13.	Mat. Handling System	220

Table 2 Average Workload on Workstations

PROPOSED FMS:

sizing and other issuesThe existing FMS in the company has been extensively analyzed and based on the data collected through questionnaire distributed to all levels. Various operational and performance parameters have been calculated using the mathematical models available in the literature, it is found that existing FMS is not really running efficiently and therefore the performance Table 2 Average Workload on Workstationsof existing system is less than the optimum level. The management of company was keen to invest in achieving more productive system and was desirous to see the designs and recommendations suggested by us. We decided to redesign the existing FMS and therefore proper design procedures
were followed and based on the inputs received from the management, the sizing of FMS, layout selection etc. have been done using a mathematical models found in the literature. After the calculation of desired operational parameters, it is decided to assess the performance of proposed system by developing the simulation models. Arena is SIMAN based simulation package which uses various inbuilt modules to model any situation in a graphical user interface. Models have been developed and critical performance parameters such as Average Machine Utilization, Production

Rate have been determined. The shift size used for the model run is 480 minutes and the production of parts per shift has been observed also the machine utilization has also been noted from the run for various conditions.The simulation results have shown the huge increase in the system performance.

Estimation of bottleneck station

The case FMS has a bottleneck station which can easily be found by calculating following ratio (Table 3).
Bottleneck station = Largest workload to no. of server ratio

S.No.	Workstations (Description)	Average Work Load (Min)	No. of Servers	Bottleneck? (WLi /
1	Load / Unload Station	20.65	40	0.51625
2	Turning Center	148	32	4.625
3	Welding Station	15.4	1	15.4
4	Boring Machine	136.05	16	8.503125
5	Drilling Station	320.37	4	80.0925 (Yes)
6	Milling Center	8.14	2	4.07
7	Grinding Machine	21	6	3.5
8	Lapping Machine	265.62	16	16.60125
9	Rubber Matching	44.08	4	11.02
10	Inspection	22.74	12	1.895
11	Painting Station	21.51	4	5.3775
12	Assembly Station	46.25	4	11.5625
13	Mat. Handling System	220	16	13.75

Table 3 Estimation of Bottleneck Station

Calculation of performance measures of proposed FMS

Initial sizing calculations in previous section are helpful for the estimation of performance measures for the proposed FMSThe increase station utilization and various performance parameters of proposed FMS have been shown in Table 4 and 5 respectively.

S.No.	Stations	Utilization(%)
1	Load / Unload Station	97.1
2	Turning Center	98.1
3	Welding Station	76.2

4	Boring Machine	95.1
5	Drilling Station	97
6	Milling Center	76
7	Grinding Machine	89.8
8	Lapping Machine	90
9	Rubber Matching	97.89
10	Inspection	92.89
11	Painting Station	88
12	Assembly Station	90.12
13	Mat. Handling System	98

Table 4 Increased Station Utilization in proposed FMS

S.No.	Performance Parameters	Estimated Value
1	Maximum Production Rate (Pc./Hr)	11.4306
2	Most Utilized Station	99.40%
3	New Bottleneck Station	Turning Station
4	Overall Utilization of System (%)	99.99%

Table :5 Performance Parameters of proposed FMS

RESULTS AND DISCUSSION

The performance analysis of existing as well as proposed FMS has been presented in the previous section. The summary of case calculations (Average workload, system utilizations, bottleneck, number of servers etc) has been presented in table 2, 3 4 and 5 Initially operational parameter like maximum workload on each workstation has been calculated and it is found that the average workload on drilling station is 320.37(minutes) with the total number of servers 4, on this basis the ratio of average workload to server comes out to be 80.0925 (maximum in all stations) which clearly indicates that the drilling station is creating a bottleneck in the processing of parts. Mathematical model explains that the performance of any system will mainly depend on the performance of the bottleneck station, therefore any performance improvement strategy can be thought either by shifting thisbottleneck to some other convenient station or by neutralizing the effect of bottleneck. This finding has been utilized while designing the proposed system and the bottleneck has been shifted to turning station with the adequate number of servers to cater the workload requirement. and it observed that few stations are underutilized (like load/unload, inspection, turning) whereas some are highly loaded (100% utilized like drilling), this kind of load distribution was creating a chaos in the system resulting in less overall system performance. This problem was considered as a major barrier in achieving the optimum performance level of the system and therefore has been addressed while the sizing of proposed FMS.

CONCLUSION

In this paper,a case study of a manufacturing firm is presented on the basis of the mathematical model given by Solberg (1981) and Mejabi (1988). The objective of the study was to analyze the existing system and prepare a plan to improve the performance of system. Various techniques like quantitative modeling, simulation modeling have been utilized to achieve the objectives. Initially various operational and performance parameters were calculated then the new FMS has been proposed with the optimum number of servers.
It is discovered that the maximum workload per server in the existing system is in drilling station which is also established by the fact that the machine utilization of this station is 99.99%. These results reveal that the drilling station is a bottle neck station. Since this station is crucial for the processing of all part types, It is suggested that the bottleneck should be shifted from this station to some other less important process in the proposed FMS.
The system utilization was another important issue which has been addressed in this study, The overall system utilization of existing system was 88.53% and the proposed FMS has been designed to deliver 99.99% overall utilization with appropriate loading on all stations. It is also found that in existing system the resources were not properly utilized as some stations like loading/unloading, inspection, grinding, milling and turning were underutilized ranging from 0.6% to 5.8%, and therefore it was mandatory to adequately distribute the workload on all stations.
In future it is also intended to conduct various simulation experiments so that system would be robust enough to handle all situation and dynamic market conditions.

REFERENCES

Ali, M., & Wadhwa, S.(2005). Performance analysis of partial flexible manufacturing systems. Global Journal of Flexible Systems Mgt, 6(1), 9-19.

Barad, M., & Sipper, D.(1988). Flexibility in manufacturing systems: definitions and Petri net modeling. International Journal Production Resesearch, 26, 237248. doi:10.1080/00207548808947856

Browne, J., Dubois, D., Rathmill, K., Sethi, S. P., & Stecke, K. E.(1984). Classification of flexible manufacturing systems. The FMS Magazine, 114.

Buitenhek, R., Baynat, B., & Dallery, Y. (2002). Prod capacity of flexible mfg. systems with fixed prod ratios. International Journal Flexible Manufacturing Systems, 4(3), 203–226.

Chan, F. T. S.(2003). Effects of dispatching and routing decisions on the performance of a flexible mfg systems. International Journal Manufacturing Technology, 21, 328-338. doi:10.1007/s001700300038

Chan, F. T. S., Bhagwat, R., & Wadhwa, S., (2006). Increase in flex: prod.or counterprod? A study on FMS. International Journal of Production Research, 44(7), 1431–1445. doi:10.1080/00207540500398959

Chan, F. T. S., Chan, H. K., (2004). Analysis of dynamic control strategies of an FMS under differentscenarios.Robotics and Computers International Manufacturing, 20, 423–437 doi:10.1016/j.rcim.2004.03.005

Chan, F. T. S., Wadhwa. S., Bibhushan (2007). Inventory performance of some supply chain inventory policies under impulse demands. International
Journal of Production Research, Manuscript ID: TPRS-2007-IJPR-0111.

Correa, H. L., & Slack, N.(1996). Framework to analyze flexibility and unplanned change in mfg systems. Computer-Integrated Manufacturing Systems, 9, 57–64.doi:10.1016/0951-5240(95)000380