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A REVIEW OF PERFORMANCE MEASURES FOR SYSTEM CONFIGURATION IN RECONFIGURABLE MANUFACTURING SYSTEM

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Abstract

Reconfigurable Manufacturing System (RMS) is capable of adapting the configuration of manufacturing system to meet the dynamic demand volume and design changes. A RMS can be arranged into various configurations comprises machines and their equipment. Different configurations affect system performance in terms of initial capital cost of configuration, system availability, throughput, operational capability, quality, processing time and reconfigurable time. This paper presents a review of the core performance measures considered to select and compare alternate configurations.

I.INTRODUCTION

The manufacturing industry is facing challenges that include unpredictable product demand, many customizations in product designs and short product life cycles[1].Hence, manufacturing sector is under intense pressure to meet the fluctuating necessities of a manufacturing system. A large number of products are produced utilizing dedicated manufacturing systems (DMS) or flexible manufacturing systems (FMS). DMS is based on fixed automation intended for producing a single product at high volume [2]. Despite the fact that DMS produces a low-cost product at high volume but is unable to handle frequent product design changes. Other than DMS, FMS is capable of taking care of product design rapidly. However, the cost of FMS is high and accordingly, it finds less worthiness among the manufacturers due to its complexity and low production rate [3]. Because of low production rate, FMS cannot deal efficiently with huge production volume fluctuations. Owing to these limitations of DMS and FMS manufacturing industry is focusing towards a new perspective known as Re-configurable Manufacturing System(RMS)[4].

RMS was proposed to meet fluctuating demand volume and different types of products by combining the merits of DMS and RMS [5]. Koren et al. [6] defined RMS as "A Reconfigurable Manufacturing System (RMS) is designed at the outset for rapid change in structure, as well as in hardware and software components, in order to quickly adjust production capacity and functionality within a part family in responseto sudden changes in market or in regulatory requirement". According to Mehrabi et al. [7] there are several characteristics of RMS, such as manufacturing system communication software, new machine controllers, configuration of flexible machines, flexible processes and system configurations for product flow as shown in Fig. 1. The main focus of this paper is on the performance evaluation measures adopted to select an efficient system configuration.

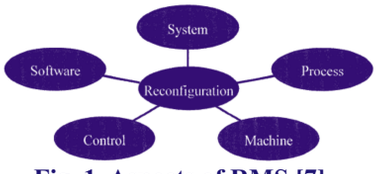

Fig. 1. Aspects of RMS [7]

System configuration is the organization of machines and their interrelations [8]. RMS can be planned in numerous arrangements such as serial, parallel and hybrid configurations, as shown in Fig. 2.

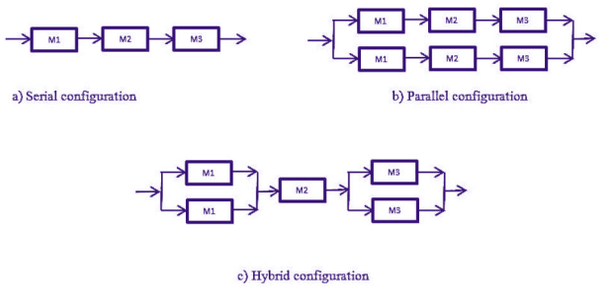

Fig. 2. Types of system configurations

A serial configuration has only one product flow path and each machine performing a definite number of operations required to finish the product. Then again a parallel configuration has several duplicate product flow paths. A hybrid configuration is a combination of serial and parallel configurations and may have multiple product flow paths.

II. NEED OF PERFORMANCE MEASURES

At the point when there is a variation in the product demand volume or design, configuration arrangement is to be redesigned to meet new product demand volume and design. Hence, it becomes necessary for the maker to choose themost productive configuration among the alternates by some performance criterion. However, current approaches are mainly focused on the single performance measure, namely the initial capital cost of the manufacturing system, ignoring other important aspects. This paper reviews the performance measures adopted for the analysis of system configurations and comparing alternate configurations in a RMS. These performance measures enable the manufacturers to choose a configuration from an aggregate system point of view.

The next section reviews the performance measures for system configuration selection approaches. In section IV the paper concludes with a summary of the literature review and an outlook on future research issues.

III. LITERATUREREVIEW

This section presents a review of the literature related to key performance criterion for the system configuration selection, initial capital cost of configuration, system availability, throughput, operational capability, quality, processing time and reconfigurable time.

A. Configuration Capital Cost

Many researchers considered initial capital cost for selecting a suitable system configuration that takes account of the cost of machines, tools, and material handling equipment. Xiaobo et al. [9] presented a structure for a stochastic model of RMS, which generates optimal configurations using classical optimization theory at the design stage. They considered initial investment cost of a configuration as a performance measure for configuration selection. Rahman et al. [10] developed algorithms to find possible solutions for the reconfigurable manufacturing automation system by using investment cost of a configuration as a selection parameter. Kimms [11] developed a framework for the cost minimization of a production flow line configuration. Spicer and Carlo [12] proposed mathematical model which was able to determine and compare the investment cost of machines and a number equipment of two system configurations. Dou et al. [13] presented a methodology that could create a set of optimized configurations for a part family in RMS. In their methodology, configurations selection criterion was investment capital cost of machines and their equipment. Some of the researchers also considered other aspects of performance measure, such as operational capability, utilization, quality of the product, reconfigurable time along with the investment cost. The following paragraphs discuss the serelated performance measures.

B. System Availability

System availability is a measure that allows a system to repair when a failure occurs [14]. It is measured by the recording the system up and downtime. Yousuf and EIMaraghy [15] considered system availability along with capital investment in the system configuration as an additional performance measure. They developed a RMS configuration selection approach intended for the best configuration selection. Their approach considered multiple aspects at the system level, such as the arrangement of machines, equipment selection, and assignment of operations.

C. Throughput

Throughput is another critical part of a system configuration performance. It is the average output of the system configuration per unit time. At a point of time when there is demand volume fluctuation, throughput is considered as an essential part of performance assessment for a configuration. Tang et al.[16] presented a methodology for generating system configuration that produces multiple parts. They used a genetic algorithm for the configuration and task allocation for a multiple product flow configuration. The optimized configuration was selected by minimizing the ratio of investment capital cost to throughput. Yang and Hu [17] developed reliability models to study the effect of series and parallel configurations on the system throughput.

D. Operational Capability

Operational capability is the number of operations that can be performed by a machine, more the number of operations a machine can perform its contribution to the operational capability increases. Subsequently, when a configuration is to be re-organized to take care of new demand volume and product design, machines with higher operational capability leads to less number of alterations with minimum effort. Goyal et al. [18] presented a methodology which selects the optimum set of machine configurations by machine reconfigurability, operational capability and capital cost of reconfiguring a manufacturing system. It generates a possible set of machine configurations using a multi-objective optimization algorithm. Later, the best solution is identified using sorting theory.

E. Quality and Processing Time

The rate of rejection measures the product quality. Furthermore, processing time is defined as the cumulative time required to carry out all the required operations on the job. A configuration producing a product at the lowest rate of rejection in the least time will be considered as best performing configuration. Tesfamariam [19] developed a model for the selection of manufacturing system configurations. They identified various parameters, such as quality, time and cost for evaluating alternative system configurations. They also applied simulation based on system dynamics to explore the fitness of an currentsystem configuration. Zhong et al. [20] developed a methodology that determines the quality and throughput of a product in a system configuration. They used simulation model that provides the mean and standard deviation of key product dimensions.

F. Reconfiguration Time

To meet the new demand volume and product design, system configuration is to be changed to another arrangement. Reconfiguration time includes time taken in adding, removing, adjusting and transportation of machine and their equipment or tools. Mittal and Jain [21] developed a mathematical model to determine the optimal sequence of configuration. The objective function of the model was only to minimize the reconfiguration time.

G. Comparative Summary of Literature Review

Table 1 shows the overview of the literature review on configuration selection performance measures for RMS.It also highlights the gaps in the performance measurement of system configurations

TABLE 1 A COMPARATIVE SUMMARY OF THE PREVIOUS STUDIES ON RMS

S. No.	Authors	Performance measures
1	Xiaobo et al. [09]	Capital cost
2	Rahman et al. [10]	Capital cost
3	Kimms [11]	Capital cost
4	Spicer and Carlo [12] [12]	Capital cost
5	Dou et al. [13]	Capital cost
6	Yousuf and ElMaraghy [15]	Capital cost and system availability
7	Tang et al. [16]	Capital cost and throughput
8	Yang and Hu[17]	Throughput
9	Goyal et al.[18]	Capital cost, operational capability and reconfigurability
10	Toenshoff et al.[19]	Processing time and throughput
11	Zhong et al.[20]	Quality and throughput
12	Mittal and Jain [21]	Reconfiguration time

Most of the research work is centered on the capital cost of system configuration. Few researchers considered multiple aspects of system configuration performance assessment.

IV. CONCLUSION

In the present study, a review of system configuration performance measures has been presented. The study brings the consideration towards the requirement for efficient system configuration selection. Most of the past research has been centered on the initial capital investment of configurations. However, some research included measures, specifically system availability, throughput, operational capability, quality, processing time and reconfigurable time as a secondary goal. Subsequently, there is an intense need to develop a performance index enabling manufacturers to select efficient system configuration. The performance index will give the overall performance of a system configuration byusing multiple measures.

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