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An Overview of Performance Measures in Reconfigurable Manufacturing System

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Abstract

Reconfigurable manufacturing systems (RMS) are considered as manufacturing systems that are capable of providing the exact functionality and capacity as and when desired. Unpredictable demand, requirement of variety of products, rapid development in product and process technology has forced the manufacturing systems to adapt the changing requirements efficiently. There are various performance measures like ramp-up time, cost, reliability, availability, lead time, reconfiguration time etc. that affects performance of the reconfiguration manufacturing system. This paper focuses on the performance measures and the way to find the best configuration for reconfigurable manufacturing system.

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keywords: RMS; performance measure; configuration

1. Introduction

In the manufacturing industry, some of the challenges faced by manufacturers include reducing the lead time, increasing the quality, providing variety of products. Although dedicated manufacturing lines (DMLs) the traditional manufacturing system are capable of producing the similar products in bulk but are incapable of accommodating the product variety. On the other side, Flexible manufacturing system (FMSs) are capable of accommodating the product variety but in comparison to DML the productivity is low [1]. Besides that the cost of FMSs are very high and therefore have very limited acceptability among the manufacturers [2]. Reconfigurable manufacturing systems (RMS) a new type of manufacturing system has the capability to adjust both capacity and functionality in order to

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cope up with product variety and production volume [3]. The overall vision of reconfigurable manufacturing systems (RMSs), as systems of equipment, having a modular structure, that have customized flexibility so one can easily reconfigure the entire system to produce a family of products at different production volumes. Koren et al. [9] was the first to describe how the system configuration has a significant impact on the performance of the RMS in terms of throughput and quality. Koren et al. [9] described the effects of system configurations for RMS sand concluded that parallel configurations with cross-over yield significant benefits in throughput, performance and scalability when identical machines are used throughout the system. . Other publications such as [10,11] discuss various method of making capacity decisions for reconfigurable manufacturing systems taking into account issues such as equipment selection, multipart production, and stochastic demand. However, little focus has been given on the modularity of Reconfigurable Machine Tool (RMT). RMS having its core component Reconfigurable Machine Tool (RMT).The Reconfigurable Machine Tools are developed as modular machines having different modules [4, 5,15].The RMTs having basic and auxiliary modules. The basic modules are such as base, slide ways and auxiliary modules are such as spindle heads, tool changer which are relatively smaller and lighter than the basic modules. The auxiliary module can be quickly and easily changed with minimum effort. By adding or removing the RMTs can be reconfigured into many other configurations [6, 7, 8, 15].

2. Necessity of the performance measure

Reconfiguring the system components over the time for a diverse set of individualized products often required in small quantities and with very short delivery lead time. This necessitates the requirement of mapping the manufacturing system capabilities and other characteristics by developing a suitable performance measure. To measure the performance of RMS, their various core characteristics such as modularity, scalability, convertibility and diagnosability should be considered [16]. A lot of work has been carried on the modeling of Reconfigurable manufacturing systems. The major strategy of modeling the RMS is to handle the varying functionality and capacity demands over the planning cycle consisting of multiple time horizons. In most of the RMS modeling, the reduction in cost and reconfiguration effort is considered an objective. Many researchers have addressed the problem in two phases. In the first phase, solutions are recorded for each stage based on cost as a criterion. In the subsequent stage, the best alternatives are chosen from the previously recorded alternatives for each time horizon based on the objective to minimize the reconfigurations required at various stages [12]. A new manufacturing paradigm, called Reconfigurable Manufacturing Systems (RMSs) is designed for rapid adjustment of production capacity and functionality, in response to new circumstances, by rearrangement or change of its components. These new systems provide exactly the functionality that is needed, exactly when it is needed [1]. Therefore, a RMS is designed to be easily reconfigured such that it is able to process a family of parts and accommodate new and unanticipated changes in the product design and processing needs. The utility of a RMS is greatly increased if it is designed for multiple configurations, where the combinations of individual configuration form the product. The term configuration is used to describe the use of common units to create product variants. Through configuration, the number of different parts to be manufactured for a product family may be significantly reduced while achieving a sufficient variety by combination of different configuration (see fig. 1). The benefits of configurability include economies of scale, increased feasibility of product / component change, increased product variety, and reduced lead time [13].

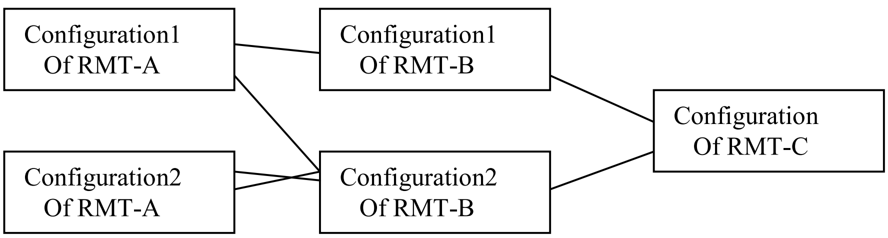

Fig 1. Machine configuration at different stages.

From fig.(1) there are two configurations of Reconfigurable Machine Tools A and two configuration of Reconfigurable Machine Tools B and one configuration of Reconfigurable Machine Tools C. For performing an operation at each stage from A to C, the possible combinations of RMTs are:

- A1+B1+C
- A1+B2+C
- A2+B1+C
- A2+B2+C

To find out the best combination among the combination listed above there is a need of performance parameter. The various performance parameters are

- Cost
- Reliability
- Utilization
- Quality
- Availability
- Lead time
- Ramp –up time
- Reconfiguration time

3. Performance measure

Reconfigurable manufacturing system (RMS) is able to adjust production capability and functionality by adding system equipment or changing system configuration. System productivity and flexibility are influenced by system configuration, currently, how to evaluate the performance of hybrid series-parallel and hybrid parallel-series configuration, and develop a configuration model to meet the requirement of RMS, is still an open issue. [14]
The selection of a feasible machine configuration for performing an operation is based upon four parameters:

- Cost
- Reliability
- Utilization
- Quality

The cost depicts the economy of the feasible alternative, while the reliability, utilization and quality represent the responsiveness. In the following section, four performance indices are proposed for finding the overall suitability of a feasible alternative machine configuration.

3.1. Cost(C)

The cost of a configuration at any stage is calculated using

$$C=n*C_m$$

Where n=D/p

n is no of machines required to satisfy the demand (D) and
p is the production rate of machine
Cm is the cost of machine

The cost is a non-beneficial attribute and is to be minimized.

e.g. If the combination A1+B1+C is considered , the demand is 200 units, the production rate of A1,B1&C are 100,150&200units and the cost of A1, B1& C are 50,70&90units respectively. The no of machine required for A1, B1& C are 2, 2 & 1 respectively. Then the cost of the combination is 50x2+70x2+90x1=330

3.2. Reliability(R)

It is the probability of a product performing its intended function for a stated period of time under certain specified conditions. Reliability is predicated on "intended function:" Generally, this is taken to mean operation without failure. However, even if no individual part of the system fails, but the system as a whole does not do what was intended, then it is still charged against the system reliability. The system requirements specification is the criterion against which reliability is measured.

If we are using single machine in each stage for each configuration then the Reliability is given by

$$R_{series} = \prod_{i=1}^{n} R_i$$

and if the no of machines at each configuration are more than one then the Reliability is given by

$$R_{parallel} = 1-\prod_{i=1}^{n}(1 - R_i)$$

Where R_i is the Reliability of the i^{th} configuration

Reliability is a beneficial attribute and is to be maximized.

e.g. If the combination A2+B2+C is considered , and the no of machines at each configuration are 1.The reliability of each machine is assume to be 0.7,The reliability of the combination is given by

R=0.7x0.7x0.7=.343

3.3. Utilization (U)

One is the "engineering" or "technical" definition, according to which potential output represents the maximum amount of output that can be produced in the short-run with the existent stock of capital. Thus, a standard definition of utilization is the ratio between the actual output of firms to the maximum that could be produced per unit of time, with existing plant and equipment. Obviously, "output" could be measured in physical units or in market values, but normally it is measured in market values. Utilization can also be defined as the ratio of actual processing time to the total production time

Utilization is a beneficial attribute and is to be maximized.

e.g If the processing time of a configuration is 30 units and the production time is 80 units then the utilization is 0.37

3.4. Quality (Q)

Quality can be defined as the fitness for use. It can also be defined as the conformity to requirements. Quality means the responsiveness of the system. A system is highly responsive if its reliability and utility is high. So the Quality can be the average of utilization and reliability.

$$Q = \frac{R + U}{2}$$

e.g If the reliability of a configuration is 0.7 and the utilization is .4 then quality is 0.55

4. Conclusion and future scope

The persent work, propose performance measures enabling responsive reconfigurable manufacturing system, shop floor operations. On the shop floor we plan to improve responsiveness on a set of RMT (Reconfigurable Machine Tools). This would enable the system to adjust functionality and capacity according to feedback from demand and market fluctuations. The performance measures of the Reconfigurable manufacturing system gives an indication to choose the configuration in each stage. In the present study the performance parameter cost, reliability, utilization and quality have been discussed. These performance parameters are helpful in finding of best combination among the alternative combinations. In future the authors plan to develop more performance parameter to the manufacturing system. The performance parameter may be studied for varying demand rate. This research gives a baseline for future research on quantifying reconfigurability of reconfigurable manufacturing systems. There are many ways to extend this work in the future. Effects of material handling devices, tools, fixtures, etc. can also be considered in the process of finding the reconfigurability of the system. Furthermore, work can be done on sensitivity of the reconfigurability.The problem can be extended to account for more complex architectures of the reconfigurability function.

References

[1] M.G Mehrabi,K Ulsoy, Reconfigurable manufacturing systems: key to future manufacturing, J. Intell. Manuf. 11 (2000) 403-419.

[2] M.G., Mehrabi, A.G Ulsoy,Y. Koren, P.Heytler, Trends and perspectives in flexible and reconfigurable manufacturing systems, J. Intell. Manuf. 13 (2002) 135–146.

[3] H.A ElMaraghy, Flexible and reconfigurable manufacturing systems paradigms, Int. J. Flex. Manuf Syst. 17(4) (2006) 261-276.

[4] Y.Koren, Reconfigurable manufacturing systems, Annals of the CIRP, 48 (2) (1999)527–540.

[5] Y. Koren, What are the differences between FMS & RMS. Paradigms of manufacturing—a panel discussion, 3rd Conference on reconfigurable manufacturing, Ann Arbor, Michigan, USA, (2005).

[6] Y.Koren, S.J. Hu, T.W.Weber, Impact of manufacturing system configuration on performance, CIRP Ann, 47(1) (1998) 369–372.

[7] A.M.A Youssef, H.A ElMaraghy, Optimal configuration selection for reconfigurable manufacturing, Int. J. Flex. Manuf. Syst. 19 (2007) 67–106.

[8] A.M.A.Youssef, H.A. ElMaraghy, Assessment of manufacturing systems reconfiguration smoothness, Int. J. Adv. Manuf. Technol. 30(1–2) (2006) 174–193.

[9]Y. Koren, and A.G. Ulsoy, " Reconfigurable manufacturing systems", Engineering research center for Reconfigurable machining systems (ERC/RMS) Report # 1, The University of Michigan, Ann Arbor,1997.

[10] ElMaraghy,Investigating optimal capacity scalability scheduling in a reconfigurable manufacturing system, Int J Adv Manuf Technol32 (2006) 557– 562.

[11]Alejandro , Armando , Joel Design, refinement, implementation and prototype testing of a reconfigurable lathe-mill, Journal of Manufacturing Systems 32 (2013) 364– 371.

[12] ElMaraghy, A. M. Deif ,Effect of reconfiguration costs on planning for capacity scalability in reconfigurable manufacturing systems, J. Intell. Manuf. 18 (2006)225–238 .

[13] A. S. Yigit , A. Allahverdi,Optimal selection of module instances for modular products in reconfigurable manufacturing systems, int. j. prod. res. 41(17) (2003) 4063–4074.

[14]Chao Lv, AiPing Li and LiYun Xu ,Research and optimization of reconfigurable manufacturing system configuration based on system reliability ,Kybernetes39 (6), (2010) 1058-1065.

[15]K.K.Goyal, P.K. Jain, M. Jain, Multiple objective optimization of reconfigurable manufacturing system. In: K. Deep, et al. (eds.) Proceedings of the International Conference on Soft Computing for Problem Solving, Springer (2011) AISC 130, 453–460.

[16] K. Gumasta,. Developing a reconfigurability index using multi-attribute utility theory,International Journal of Production Research. 49 (6) (2011)1669–1683.