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Scheduling of Products for Reconfiguration Effort in Reconfigurable Manufacturing System

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Abstract

Reconfigurable manufacturing system is a responsive manufacturing system which can easily adjust its capacity and functionality with least effort and time when demand of the product changes. Reconfigurable manufacturing system (RMS) has the exactly capacity and functionality whenever is required.
In the present work a methodology has been presented for scheduling of the products on the basis of reconfiguration effort in a multi-product line. For scheduling of products, three criteria have been considered; reconfiguration effort, profit over cost and due date. Integrated approach of Shannon entropy and TOPSIS has been used for scheduling of the products.

*Keywords:*reconfigurable manufacturing system; reconfiguration effort; scheduling; entropy

1. Introduction and literature review

In the era of globalization, the product variety is increasing very fast and it has necessitated the production of mass-customized products of increasingly short product life cycle. It has necessitated that manufacturing enterprises should find a way to adjust production capacity and capability quickly at low cost. Reconfigurable manufacturing system is a such type of system. 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 response to sudden changes in market or in regulatory requirements [1].

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Reconfigurability of a manufacturing system can be defined as the ability to be reconfigured at a low cost and in a short period of time [2]. Reconfigurable manufacturing system consists dedicated machines, CNC machines and modular machines. RMS has six key characteristics which are modularity, integrability, scalability, convertibility, customization and diagnosability.

Reconfigurable machine Tool (RMT) is the core component of reconfigurable manufacturing system.The concept of modular machines have been used for many years [3].Many definitions of modularity have been presented in [4]. Reconfigurable machine tools are the modular machines which have different modules basic modules and auxiliary modules. The basic modules are larger and bigger and are fixed for the machine such as base, slide ways etc. Auxiliary modules are smaller and lighter and can be added, removed or adjusted easily such as spindle head, tool changer etc. Machines can easily and quickly change its configurations by adding, removing or changing the auxiliary modules while basic modules are fixed [5].The benefits of modular concept are; it provides opportunity for both short- term and long-term objectives, it enables the integration of machine system, process, tools, information flow, etc., it helps the reuse of machinery [3].

In [2] three factors of reconfigurability have been discussed. These are design of manufacturing systems for reconfigurability, design of components for reconfigurability and integrated design of components and manufacturing systems. In this paper machine relocation rules have been defined. In [6] a methodology has been presented for selection of part family that minimizes cost of reconfiguration and underutilization.

Hassan [7] presented a review and consolidation of the machine layout problem in modern manufacturing facilities that adopt GT, FMS, JIT, and robots. Kaebernick et al. [8] presented an integrated approach to design of cellular manufacturing. In this approach, the decision maker was provided with multiple efficient alternative solutions according to different cell-partition strategies. It offered the flexibility to assess each alternative against tangible and intangible benefits and criteria. Perronet et al. [9] proposed a set of analytical models for strategic IMS design for effective resource utilization and system configuration.

Renna et al. [10] proposed a CMS (cellular manufacturing system) with reconfigurable machines to handle the turbulent market conditions.Sethi et al. [11] discussed various flexibilities (such as machine flexibility, material handling flexibility, operation flexibility, process flexibility, product flexibility, routing flexibility, volume flexibility, expansion flexibility, program flexibility, production flexibility and market flexibility) for responsiveness of the system and discussed the methods to measure them.

Dahane et al. [12] proposed a mathematical model for machine selection problem for machine reliability constraints.Youssef et al. [13] proposed RMS Configuration Selection approach.Pattanaik et al.[14] proposed an approach to design machine cells using modular machines. Hasan et al. [15] used the concept of bowl phenomenon for RMS planning.

In the present work a methodology has been presented for scheduling of the products for reconfiguration effort in multi-product line manufacturing system. In a multi-product line problem arises which product should be manufactured if many type of products are in queue. This methodology provides the solution of this type of problem.

2. Reconfiguration effort

Reconfiguration effort (RE) is the effort for changing its configuration from one type of product to another type of product. It can be calculated by using following equation.

$$RE = \alpha \frac{No.\,of\ modules\ added}{Tota\ no.\,of\ modules} + \beta \frac{No.\,of\ modules\ removed}{Total\ no.\,of\ modules} + \gamma \frac{No.\,of\ modules\ readjusted}{Total\ no.\,of\ modules}$$

where, α, β, γ are the constants; $\alpha > \beta > \gamma$ and $\alpha + \beta + \gamma = 1$

If in a manufacturing system, there are n machines which are needed to be reconfigured for another type of product, total number of modules added, removed or readjusted can be calculated by using following formulas.