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Virtual Cellular Multi-period Formation under the Dynamic Environment

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Abstract

Virtual cellular manufacturing is an innovative way of production organization which both in the production of flexibility and efficient to meet today's rapid development of science and technology and replacement of products. The key process of the design of virtual cellular manufacturing system—cell formation is the focus of research. In order to meet the characteristics of small batch and dynamically changing market demand, this paper studies the problems of virtual cellular multi-period dynamic reconfiguration. A reconfigurable system programming model is developed. The model incorporates parameters of the problems of product dynamic demand, machine capacity, operation sequence, balanced workload, alternative routings and batch setting. The objective of mixed integer programming model is to minimize the total costs of operation, moving raw materials, inventory holding and process routes setup. Though a case study, demonstrates the feasibility and validity of the model in reality.

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Keywords: virtual cellular; manufacturing system design; reconfigurable system modeling; mixed integer programming;

1. Introduction

With the development of science and technology, the product of the rapid upgrading and demand for the diversification of products, manufacturing is developing from the traditional mode of large-scale production to many varieties, small batch mixed flow mode of production, in order to meet the need of the shift, internal manufacturing resources of the enterprises have to reconfigure rapidly[1]. However, there are a lot of problems in production organization of enterprises, namely the design of the manufacturing system. Therefore, the

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enterprise must consider using advanced mode of production and scientific management method, so that enterprise can response to the market rapidly at a lower cost. Virtual cellular manufacturing system[2] is increasing to become a kind of advanced manufacturing mode in recent years. In the dynamic environment, the product mix is difficult to predict and virtual cellular has overcome the limitations of the traditional cellular production mode which gradually become an effective mode to realize many varieties and small batch production.

In the virtual cellular manufacturing system, machines don't move from one location to another, but logically form a virtual dynamic entities, and the logic reconfiguration has greatly reduced the time and cost of reconfigurable system and improved the flexibility of the system[3]. In order to make advantages of virtual cellular manufacturing system, and the key design of cellular manufacturing system is cell formation. Based on different environments, different scholars put forward different strategies of cell formation. For example, Bai Junjie[4] has studied the problems of virtual manufacturing cell formation in reconfigurable manufacturing system about the different delivery times with production orders coexisted, and 0-1 integer programming model is established.J. Slomp[5] has put forward to add labor force to virtual cellular manufacturing formation. First, group tasks and equipment, then assign workers to virtual cell, and goal programming model is established. Niu Li[6] has studied the problem of the selection of processing routes and batch setting up in a static environment. But many problems of cell formation are based on the ideal production environment, assuming that demand is stable, and the related production information is known and complete. But there are a large number of random disturbed factors in the actual manufacturing system. As a result, the first phase of cell formation may not meet successive periods. R.Jayachitra[7], R.Raju [8], etc have considered the reconfigurable system to respond to the dynamic environment. R.Kia [9], K.Rafiee[10] have analyzed the problems that are based on multi-period, multi-processing routes, and by optimizing production batch to reduce the total costs of production. But in the research of cell formation, if enterprises use the formation strategy of traditional cellular manufacturing system, there will be generated a lot of cost by manufacturing resources's layout again, and because of machines can't be moved that influence the cell formation. Hassan Rezazadeh[11], Iraj Hassan[12] have studied the design of virtual cellular manufacturing system.

The design of virtual cellular manufacturing system still need to improve, the paper presents a virtual cell formation model. In the model the demand of parts not only consider the size of the production batch, but also consider the inventory levels, dynamic of production batch size affect virtual cell formation in different periods. Enterprise considered the master production planning in the manufacturing system design will be more actual in production needs. Through the establishment of the virtual cellular manufacturing reconfigurable system model, which not only intends for supplement to the existing of the study on the theory of virtual manufacturing cell, but also provides certain guiding significance for the manufacturing enterprises to implement virtual cells.

2. Problem description

In the virtual cellular manufacturing system, when the product mix and technological requirements of manufacturing enterprises are made changes, the existing virtual manufacturing cells can't meet the production requirements, then manufacturing enterprises need to reconfigure manufacturing resources, the frequency of reconfiguration depends on new tasks to cause changes in volumes and mix of demand.

To design a more actual dynamic cell formation strategy, this paper establishes a mixed integer programming model of virtual cellular multi-period dynamic formation. The target of this model is to minimize the sum costs of the operating, raw material moving, inventory holding and setting up. The model includes the actual parameters that including the capacity of manufacturing resources, inventory balanced constraints, product dynamic requirements and operation sequence, and each job in the manufacturing system