Chapter 64
Cell Loading and Family Scheduling for Jobs with Individual Due Dates

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ABSTRACT

In this chapter, cell loading and family scheduling in a cellular manufacturing environment is studied. What separates this study from others is the presence of individual due dates for every job in a family. The performance measure is to minimize the number of tardy jobs. Family splitting among cells is allowed but job splitting is not. Even though family splitting increases number of setups, it increases the possibility of meeting individual job due dates. Two methods are employed in order to solve this problem, namely Mathematical Modeling and Genetic Algorithms. The results showed that Genetic Algorithm found the optimal solution for all problems tested. Furthermore, GA is efficient compared to the Mathematical Modeling especially for larger problems in terms of execution times. The results of experimentation showed that family splitting was observed in all multi-cell solutions, and therefore, it can be concluded that family splitting is a good strategy.

INTRODUCTION

Cell Loading is a decision making activity for planning the production in a Cellular Manufacturing System (CMS) including more than one manufacturing cell. The products are assigned to the manufacturing cells where they can be processed. This assignment is done based on the demand, processing times and due dates of the products and the production capacity and capability of the manufacturing cells (Süer, Saiz, Dagli & Gonzalez, 1995 and Süer, Saiz, & Gonzalez, 1999). Family Sequencing is a task of deciding the order by which product families are processed in a particular cell as determined by the Cell Loading process. In this chapter, a product

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family can be split and they can be sequenced in the same cell or different cells. Obviously, each time a new family starts in a cell, a new setup is required. Finally, Family Scheduling consists of determining start times and completion times of the product families and the individual products based on the family sequence established. Typically in a complex cellular system, we need to address Cell Loading, Family Sequencing and Family Scheduling tasks all in a satisfactory manner to obtain the desired results in terms of the selected performance measure.

In this study, we are considering minimizing the number of tardy job as the performance measure. Even though the problem has been observed in a shoe manufacturing company, it is applicable to many cellular systems. The products are grouped into families based on their processing similarity. On the other hand, products in a family might have different due dates. The overall objective of this chapter is to solve cell loading and product sequencing problem in such a multi-cell environment. To accomplish this, we propose two different approaches to tackle this complex problem namely, mathematical modeling and genetic algorithms. An experiment is carried out using both approaches and later the results are compared and a sensitivity analysis is also performed with respect to due dates and setup times.

BACKGROUND

Group Technology (GT) is a general philosophy where similar things are grouped together and handled all together. GT is established upon a common principle that most of the problems can be grouped based on their similarities and then a single solution can be found to the entire group of problems to save time and effort. This general concept has been also applied to the manufacturing world. This approach increases productivity by reducing work-in-progress inventory and improves delivery performance by reducing leadtimes, thus helping manufacturing companies to be more competitive. Thus, a Cellular Manufacturing System can be specified as an application of GT to the manufacturing system design (Askin & Standridge, 1993). Cellular Manufacturing System aims to obtain the flexibility to produce a high or moderate variety of low or moderate demand products with high productivity. CMS is a type of manufacturing system that consists of manufacturing cell(s) with dissimilar machines needed to produce part family/families. Generally, the products grouped together form a product family. The benefits of CMS are lower setup, smaller lot sizes, lower work-in-process inventory and less space, material handling, and shorter throughput time, simpler work flow (Suresh & Kay, 1998).

In this chapter, the performance measure used is minimizing the number of tardy products (n_T). If a product is completed after its due date, then it is considered as tardy product. If product is completed before its due date, then the tardiness for this product will be zero (early or on-time product). Therefore, tardiness for a product takes a value of zero or positive, $T_i = \max \{0, c_i - d_i\}$; where T_i is the tardiness for product (i), c_i is the completion time of product (i), and d_i is the due date for product (i). The number of tardy jobs is computed as $n_T = \sum_i^n g(T_i)$ where g(x) = 1 if x > 0, and zero otherwise.

The problem has been observed in a shoe manufacturing company where twelve product families have been already defined. There are multiple cells and the most critical component of each cell is the rotary injection molding machine. Even though Rotary Molding Machine is a single machine, scheduling shoes on that machine resembles to a parallel machine scheduling problem as it can hold multiple pairs of molds/shoes at any time. The Rotary Molding Machine is defined in detail in Section 3.

Several researchers focused on cell loading problem [Süer, Saiz, Dagli & Gonzalez, (1995)