Chapter 7
An Integrated Methodology for Order Release and Scheduling in Hybrid Manufacturing Systems
Considering Worker Assignment and Utility Workers

Ömer Faruk Yılmaz
Istanbul Technical University, Turkey & Yalova University, Turkey

Mehmet Bülent Durmuşoğlu
Istanbul Technical University, Turkey

ABSTRACT

There are three main problems that could impact the performance of a Hybrid Manufacturing System (HMS): (1) order release (OR), (2) batch scheduling and (3) worker assignment. This paper deals with these three main problems hierarchically for an HMS. Three different mathematical models are developed to describe the problems more clearly. A novel methodology is proposed to adopt a holistic approach to these problems and find an effective solution. Implementation of the proposed methodology permits integrating batch scheduling and worker timetabling. Feasible solutions in the best-known Pareto front are evaluated as alternative solutions. The goal is to select a preferred solution that satisfies worker constraints, creates effective worker teams in cells, minimizes the number of utility workers, and the average flow time. The study also presents several improvements, which are made following the application of the proposed methodology to a real company that produces expansion joints.

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INTRODUCTION

In today's manufacturing systems, a high variety of parts are produced to meet customer expectations. Some of the parts produced belong to the early stages of life cycle, whereas others belong to later stages. Demand variability is usually high for parts in the early stages and low for parts in the later stages. A manufacturing system, which can produce both types of parts, is the hybrid manufacturing system (HMS). HMS is a manufacturing system comprised of both cells and functional area. Parts with low and erratic demand are produced in the functional area, whereas parts with high and stable demand are produced in the cells (Durmusoglu and Satoglu, 2011). Studies conducted in real manufacturing environments show that many cellular manufacturing environments are designed to have a hybrid structure. That is why studies on HMS are highly relevant for industrial applications.

The problems in an HMS can be classified mainly into the design and the operational classes. Design problems include HMS formation and layout decisions whereas operational problems include order release, scheduling of batches/parts and worker assignment decisions (Aglan and Durmusoglu, 2015). Operational problems have not been considered extensively in the literature as compared to design problems (Satoglu and Suresh, 2009). This chapter deals with the problems of order release, batch scheduling and worker assignment in the HMS consisting of a number of parallel independent manufacturing cells and a functional layout.

Decisions on the order release, the batch scheduling, and the worker assignment problems are typically made independently. However, the efficiency of the HMS can be increased when these decisions are made concurrently due to the interrelation among these problems. The objective of this study is to propose a methodology to adopt a holistic approach to the order release, the batch scheduling and the worker assignment problems in the HMS.

The proposed methodology consists of four stages. In the first stage, an optimization model is developed for the OR problem. In the second stage, the multi-objective mathematical model developed by Yılmaz and Durmusoglu (2017) is used for the batch scheduling problem in HMS. In the third stage, the goal programming model is used to make the worker assignment decisions. Decision rules to select a preferred solution are used in the fourth stage.

The first stage of the proposed methodology concerns order release (job release). The goal is to improve system performance by using OR to control the order flow. It decides which parts (jobs) be allowed to be released to the shop floor, at what time and under what conditions they are to be released (Cevikcan and Durmusoglu, 2014). Answers to these questions make OR one of the main components of the workload control (WLC) mechanism. Hence, it is possible to release parts to the shop floor in a controlled way and make efficient use of the capacity of the cells and the machines.

In the OR stage, which is the first stage of the proposed methodology, the aim of the optimization model is to release the maximum number of parts (jobs) to the shop floor. No attention is given to the batch scheduling problem. The multi-objective optimization model used in the scheduling stage, which is the second stage of the proposed methodology, has the following objectives: (1) minimizing the maximum number of workers, (2) minimizing the maximum number of worker transfer and (3) minimizing the average flow time. In the third stage of the methodology, the optimization model has the following objectives: (1) minimizing deviations from the number of workers assigned to operations in the scheduling stage, (2) minimizing utility workers and (3) minimizing deviations from the desired team synergy.