Chapter 11

A MILP and Genetic Algorithm Approach for a Furniture Manufacturing Flow Shop Scheduling Problem

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ABSTRACT

A MILP and genetic algorithm optimization model for the sequencing of jobs in a medium-sized factory, dedicated to the manufacturing of home furniture, where different categories and types of articles are produced and whose routes and manufacturing processing times vary widely, are proposed. Different scenarios are considered for the objective function based on minimizing makespan and tardiness. The results of the optimization for an instance of 24 jobs on five machines, chosen as a representative instance of the order sizes that are handled by the company, show important reductions in the productive system’s usage times, oscillating between 10% and 20% with respect to a random initial sequence in the production plan. Improvements were similar in both techniques, the main difference being the solution time of each one.

INTRODUCTION

The task-sequencing problem within a factory, also known as a Job-Shop Scheduling Problem (JSSP), is very common and of great importance for companies in the manufacturing sector. Due to globalization and increasing market competitiveness, there is an urgent need for companies to reduce their manufacturing costs. This implies that productive system’s technological resources, machinery and processes should be used in the most efficient possible way, attempting to maximize throughput and minimize makespan for a given production program.

In general, the benefits of considering the optimal sequence in which work must be carried out on the production floor, include revealing bottlenecks and imbalances within the system, giving certainty when acquiring delivery commitment dates with customers, reducing costs due to the use of machinery and infrastructure, reducing inventories of work in process, synchronizing the arrivals of raw materials with the production program, improving the use of floor space, avoiding loss of contracts with customers for non-compliance in delivery dates of merchandise, amongst others.

The above becomes more complicated when it comes to a make-to-order manufacturing system with a batch scheme where there is a high mix of products with medium or low volume demand, as is the case of study described in this chapter; therefore, for companies of this type to achieve their cost objectives, it becomes essential to calculate the production or task sequence within the system that allows to take the most advantage of their technological resources.

Currently, many medium-sized companies, and even some large ones, give little or no importance to job sequencing; they simply release production orders to the floor and, in most cases, these are executed in ascending chronological order, without any kind of analysis. Depending on the number of jobs to be carried out, the probability that the first selected job sequence is the best option decreases drastically.

The main objective of this chapter is to propose a mathematical model and make use of quantitative techniques that would allow the company’s operations management team to consider sequencing the jobs in their production system, as a fundamental factor to achieve efficiency and guarantee customer satisfaction. Similarly, the pros and cons of using Mixed Integer Linear Programming (MILP) vs Genetic Algorithms (GA) to find solutions to different instances of the problem under study are presented. Additionally, it is intended to prove that, even though GAs by their stochastic nature do not necessarily converge to exact solutions, it might be convenient to rely on them in contexts such as the one presented in this chapter. This is because they can produce solutions that are close enough and with much more acceptable run-times for instances such as the ones that the company in question handles in its planning horizons.

BACKGROUND

One of the techniques used in this study is MILP, which is one of the most important techniques in operations research and mathematical optimization, where mathematical models are used to describe various types of problems where optimal decisions are to be made. Some of these decision include how to allocate resources of a given system in the most efficient manner (Kondili, Pantelides, & Sargent, 1993; M. L. Pinedo, 2008) To be able to use such a technique, the following conditions are required (Hillier & Lieberman, 2014; Rao, 2009).