Chapter 13
A Simulation–Optimization Approach for the Production of Components for a Pharmaceutical Company

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ABSTRACT

The considered problem (P) concerns the production of strains (also called jobs or batches), which are the used components in the final products that are bought by the consumers. (P) contains two components that have to be tackled sequentially: the inventory management problem (IMP) and the job scheduling problem (JSP). (IMP) is solved with a reorder-point policy, defined on the basis of critical demand coverage. To tackle (JSP), a descent local search (DLS) is used, based on swap moves. In other words, for a given job sequence, a series of modifications is performed on it in order to try to improve the solution, where each modification consists of exchanging the positions of two jobs. Because of random events (some jobs might be rejected if they do not meet predefined standards) and stochasticity (the duration of each job follows a normal distribution), simulation is required to evaluate any sequence of jobs that is a solution to (JSP). A simulation-optimization approach is therefore proposed to accurately tackle (JSP). This work is motivated by a real pharmaceutical company.

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INTRODUCTION

The problem (P) considered in this chapter concerns the production of strains (also called jobs or batches hereafter), which are the used components in the final products that are bought by the consumers located at the very end of the supply chain. Problem (P) contains two components that have to be tackled sequentially. The first one is called the inventory management problem and it is denoted as (IMP), whereas the second one is called the job scheduling problem and it is denoted as (JSP).

(IMP) is solved with a reorder-point policy, defined on the basis of critical demand coverage. More precisely, it must assure a minimum amount of stock at all time, for each product type. To tackle (JSP), a descent local search (DLS) is used, based on swap moves. In other words, for a given job sequence, a series of modifications is performed on it in order to try to improve the solution, where each modification consists of exchanging the positions of two jobs. Because of random events (e.g., some jobs might be rejected if they do not meet the predefined standards) and stochasticity (e.g., the duration of each job follows a normal distribution), simulation is required to evaluate any sequence of jobs that is a solution to (JSP). A simulation-optimization approach is therefore proposed to accurately tackle (JSP). The reader is referred to (Silver & Zufferey, 2011) for more information on such type of solution methods.

This work is motivated by a real pharmaceutical company, denoted here as PHARMA. It cannot be named because of a non-disclosure agreement. For this reason, the accurate data and results will not be provided, as it is highly confidential. The presented information will however allow the reader to fully capture all the features of the considered problem (P), as well as the associated methods used to solve (IMP) as well as (JSP). To highlight the success of the proposed overall approach, it is important to mention that the resulting decision-making tool is planned to be used in PHARMA for the inventory management and the production planning of the concerned strains.

The reminding part of this chapter is organized as follows. The next section describes the optimization elements that are necessary to better understand the proposed solution methods. It will be discussed that quality is not the only criteria for measuring the efficiency of a solution method. Next, (IMP) is formally presented, along with the proposed inventory management policy, based on the well-known reorder-point policy. (JSP) is described afterwards (in a production environment corresponding to a flow shop), for which an optimization model and an optimization method are successively designed. Finally, a discussion and a conclusion are provided at the end.

OPTIMIZATION ELEMENTS

As presented in (Zufferey, 2015), let f be an objective function that has to be minimized (e.g., a production cost, a shortage function, a sum of lateness and/or earliness penalties) over a solution space (i.e., the set of all the possible solutions to a problem). A solution s is optimal for f if there is no better solution than it; that is, there is no solution s' such that $f(s') < f(s)$. An *exact* method guarantees the optimality of the provided solution. However, for a large number of applications and most real-life optimization problems (as for the studied problem (P)), such methods need a prohibitive amount of time to find an optimal solution, because such problems are *NP-hard* (Garey & Johnson, 1979). For these difficult problems, one should prefer to quickly find a satisfying solution, which is the goal of heuristic and metaheuristic solution methods. The reader is referred to (Blum & Roli, 2003; Gendreau & Potvin, 2010) for accurate information on several metaheuristics, and to (Zufferey, 2012; Hertz & Widmer, 2003) for general