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A hybrid genetic algorithm and variable neighborhood search for multi-family capacitated lot-sizing problem

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Abstract

The paper presents a genetic algorithm (GA) hybridized with variable neighborhood search (VNS) to solve multi-item capacitated lot-sizing multi-family problem with setup times. The problem has a practical application in production planning e.g., in foundry industry, so test cases for computational experiments were based on the data from the real production process in a foundry. The VNS algorithm is used after a certain number of GA generations for all individuals in the population to improve solutions. The presented method applied for large instances of the problem outperforms both a dedicated genetic algorithm and a CLPEX Solver-based rolling horizon methods known from the literature.

Keywords: lot-sizing, genetic algorithm, VNS, local search

1 Introduction

Manufacturers are struggling with increasingly demanding customers. Orders are accepted in small batches, lead times are short, and for newly designed

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products, there is a risk of defective production. In addition, customers can change the parameters of orders, delivery conditions or requirements for further processing. In this context, efficient planning of production is becoming increasingly important, especially at the operating level, which directly reflects on customer satisfaction and, above all, operating costs of manufacturing. Operational planning can be usually supported by optimization models, which can be generally divided into: scheduling problems, batching problems, lot-sizing problems, and various combinations of these models.

In the presented article, we are focusing on the lot-sizing problem, we will show its practical use in the foundry industry, and above all, we propose an efficient hybrid GA and VNS method, which in a relatively short time is able to obtain results better than the solutions proposed so far in the literature.

2 Literature review of the solution methods

Lot-sizing problems are NP-hard and are solved using mixed integer programming methods (branch and bound, constraint programming, relaxation or reformulation for more complex problems) or by applying some metaheuristic methods like evolutionary algorithms, simulated annealing or tabu search [6]. The method most frequently analyzed in the literature is definitely evolutionary approach. Goren et al. [4] presented a review of 28 scientific papers in which mainly genetic algorithms were used to solve uncapacitated and capacitated lot-sizing problems. They also noticed that majority of solutions concerned a single-level problem. Most recently Particle Swarm Optimization approach has been proposed for more complex problems of lot-sizing and scheduling [1][7].

Only a few examples of VNS applied to lot-sizing problems can be found in the literature. Hindi et al. [5] used VNS to improve a smoothing heuristic for the multi-item, single-level, capacitated, dynamic lot-sizing with setup times. Xiao et al. [11] used a reduced VNS with randomized cumulative WagnerWhitin approach to solve the multi-level uncapacitated lot-sizing problem. Zhao et al. [13] used a variable neighborhood decomposition search (VNDS) combined with mixed integer programming to solve the multi-item lot-sizing problem. The similar approach was proposed by Seeanner et al.[9] to solve general multi-level lot-sizing and scheduling problem. Xiao et al.[12] presented a VNS algorithm that used Ancestors Depth-first Traversal Search as a local search method to solve capactiated multi-level lot-sizing problem. Finally, recently Chen [2] has presented a VNS algorithm with fixed-and-optimize method for the multi-level capacitated lot-sizing problem.