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Algorithms based on VNS for solving the Single Machine Scheduling Problem with Earliness and Tardiness Penalties

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Abstract

This work implements and compares four algorithms based on Variable Neighborhood Search (VNS), named RVNS, GVNS$_f$, GVNS$_r$ and GVNS$_{rf}$, for solving the Single Machine Scheduling Problem with Earliness and Tardiness Penalties (SMSPETP). Computational experiments showed that the algorithm GVNS$_f$ obtained better-quality solutions compared with the other algorithms, including an algorithm found in the literature. The algorithms GVNS$_r$ and GVNS$_{rf}$ obtained solutions close to the GVNS$_f$, and outperformed the algorithm of the literature, both with respect to the quality of the solutions and the computational times.

Keywords: Single Machine Scheduling, Sequence-Dependent Setup Times, VNS.

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1 Introduction

This work addresses the Single Machine Scheduling Problem with Earliness and Tardiness Penalties (SMSPETP). In the addressed problem there is a time window for each job. Machine idle is allowed, even if there is a job to be performed. Besides this, it is necessary to setup the machine between two consecutive jobs and the setup times are sequence-dependent. According to the notation employed by [5], the SMSPET is represented by $1/s_{jk}/\sum_{j=1}^{n} w'_j E_j + \sum_{j=1}^{n} w''_j T_j$.

The problem to be dealt consists of sequencing and determining the time in which jobs must be performed in order to minimize the weighted sum of earliness and tardiness penalties in the execution of the jobs. There are a variety of applications of this problem in JIT manufacturing, semi-conductor manufacturing, chemical processing, PERT/CPM scheduling, and video on demand services, among others [3]. Since it is NP-hard problem [1], it is usually solved by heuristic methods, among them [8,6,7].

In this work, algorithms based on Variable Neighborhood Search – VNS [2] for solving the SMSPETP are proposed and tested. The determination of the optimal starting date for the execution of each job belonging to the sequence generated by these algorithms is made by the Idle Time Insertion Algorithm (ITIA) of [7]. Computational experiments are realized in order to compare the proposed algorithms with the best algorithm of [7].

The remaining of this work is organized as follows. In Section 2 the SMSPETP is described in details. The proposed algorithms are presented in Section 3, while in Section 4 the results are showed and analyzed. In Section 5 the work is concluded.

2 Characteristics of the addressed problem

The SMSPETP has the following characteristics: (i) a single machine must process a set I of n jobs; (ii) for each job $x \in I$, there is a processing time P_x and a time window $[E_x, T_x]$ in which the job x should preferably be completed (E_x indicates the earliest due date and T_x is the tardiest due date); (iii) if job x is completed before E_x, then there is a cost of α_x per unit of earliness time; (iv) if job x is completed after T_x, there is a cost of β_x per unit of tardiness time; (v) the jobs completed within their time windows do not incur costs; (vi) the machine can perform only one job at a time and once the process is initiated, it cannot be interrupted; (vii) all jobs are available for processing starting from time 0; $(viii)$ between two consecutive jobs x and $y \in I$, a setup