Heuristics for the unrelated parallel machine scheduling problem with setup times

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The problem addressed in this paper is the non-preemptive unrelated parallel machines scheduling problem (m | Sijk | Cmax) with the objective of minimizing the makespan. Machine-dependent and job sequence-dependent setup times are considered. The problem is a generalization of the PMSP (m | | Cmax) and is known to be NP-hard. Meta-RaPS, a new meta-heuristic is proposed and evaluated by comparing its solutions to the solutions of an existing heuristic for the same problem. The results show that Meta-RaPS found all optimal solutions for the small problems and outperformed the solutions obtained by the existing heuristic for larger problems.

Keywords: Scheduling, unrelated parallel machine, setup times, heuristics, Meta-RaPS

1. Introduction

The non-preemptive unrelated parallel machines scheduling problem (m | Sijk | Cmax) is known to be NP-hard even when m = 2 (Karp, 1972; Garey and Johnson, 1979). Since the PMSP (m | | Cmax) is a generalization of the latter problem, then it is also NP-hard. Having multiple resources with different capabilities in parallel is common in many industries to obtain adequate capacity. In addition, setup times are usually incurred when switching from one item to another. Applications for parallel machine scheduling with setup are common in many industries including painting, plastic, textile, glass, semiconductor, chemical, and paper manufacturing as well as some service industries (e.g., Guinet, 1991; Franca et al., 1996; Radhakrishnan and Ventura, 2000; Kurz and Askin, 2001; Randhawa and Kuo, 1997). The motivation for this paper comes from the truss manufacturing industry where manufacturing roof trusses requires different setup times depending on the manufacturing sequence and on the type of manufacturing apparatus used.
Rabadi et al. (1993), and more recently, Horn (1973) had examined the problem. Martello et al. (1999) presented a survey on scheduling problems. (2001) respectively. Martello et al. (2002, 2003) developed heuristics for the unrelated PMSP to minimize the weighted mean completion time and included machine-independent sequence-dependent setup times. They presented and tested seven heuristics based on Lagrangian relaxation, which showed to be better than other environments (Dhaenens-Flipo, 2001). In addition, Allahverdi and Sin (1990), Lawler and Lancia (2000) who developed branch-and-bound algorithms to find optimal solutions for the unrelated PMSP, it is worth mentioning that many papers addressed the problem including most recently Dunstall and Wirawan (2005), Kurz and Askin (2001), and Lin and Wenhua (2004).

The unrelated PMSP has been far less studied than other environments. However, some researchers developed exact algorithms for the problem without setup times, where the objective is to minimize the total completion time, while Azizoglu and Kirca (1999) addressed the unrelated PMSP to minimize the total weighted sum of earliness and tardiness. They also tried a strategy where they assigned jobs to the machine in which they either assigned a job to the machine with the least cost contribution, or to the machine in which the job has the shortest processing time. This paper later considered the problem with setup times. Kim et al. (2002) developed heuristics for the same problem. In this paper, some researchers developed heuristics for the unrelated PMSP including Liaw et al. (1997) who addressed the same problem. In this paper, some researchers developed heuristics for the unrelated PMSP including Liaw et al. (1997) who addressed the same problem. In this paper, some researchers developed heuristics for the unrelated PMSP including Liaw et al. (1997) who addressed the same problem.