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Two-machine flow shop scheduling problem with blocking, multi-task flexibility of the first machine, and preemption

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Abstract

Blocking flow shop scheduling problem has been extensively studied in recent years; however, some applications mentioned for this problem have some additional characteristics that have not been well considered. Multi-task flexibility of machines and preemption are two of such characteristics. Multi-task flexible machines are capable of processing the operations of at least one other machine in the system. In addition, if preemption is allowed, the solution space grows, and solutions that are more efficient may be obtained. In this study, the two-machine flow shop scheduling problem with blocking, multi-task flexibility of the first machine, and preemption is investigated by considering the minimization of makespan as criterion. It is proved that the complexity of the problem is strongly NP-hard. Because of preemption and multi-task flexibility, there are infinite schedules for each sequence; however, it is shown that a dominant schedule can be defined for each sequence. Two mathematical models are proposed for optimally solving the small-sized instances. Furthermore, a variable neighborhood search algorithm (VNS) and a new variant of it, namely, dynamic VNS (DVNS), are presented to find high quality solutions for large-sized instances. Unlike the VNS algorithm, the DVNS algorithm does not need tuning for the shaking phase. Nevertheless, computational results show that DVNS has even a slightly better performance. The VNS and DVNS algorithms are also compared with some of the best-performing metaheuristics already developed for the flow shop scheduling problem with blocking and minimization of makespan as criterion. Computational results reveal that both algorithms are superior to the others for large-sized instances.

Keywords: Blocking flow shop scheduling, Multi-task flexibility, Preemption, Makespan, Variable neighborhood search.

1. Introduction

In the flow shop scheduling problem, which is one of the most famous scheduling problems, there are *n* jobs and *m* machines and each job should be processed on machine 1 to machine *m*, sequentially. According to the general assumptions of this problem, there are buffers with infinite capacities between the machines. However, in some real applications, because of technological requirements or process characteristics, there is not any intermediate buffer [1]. The flow shop scheduling problem without any buffers is called the blocking flow shop scheduling problem (BFSP). In the BFSP, a job completed on a machine blocks it until the next downstream machine becomes free. Process of no other job can be started on a machine while it is being blocked by a job.

Hall and Sriskandarajah [1] proved that the two-machine BFSP with a regular criterion is equivalent to the two-machine no-wait flow shop scheduling problem (NWFSP) with the

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