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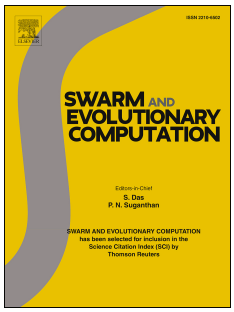

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A novel discrete water wave optimization algorithm for blocking flow-shop scheduling problem with sequence-dependent setup times

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Abstract

This paper considers *n*-job *m*-machines blocking flow-shop scheduling problem (BFSP) with sequence-dependent setup times (SDST), which has important ramifications in the modern industry. To solve this problem, two efficient heuristics are firstly presented according to the property of the problem. Then, a novel discrete water wave optimization (DWWO) algorithm is proposed. In the proposed DWWO, an initial population with high quality and diversity is constructed based on the presented heuristic and a perturbation procedure. A two-stage propagation is designed to direct the algorithm towards the good solutions. The path relinking technique is employed in refraction phase to help individuals escape from local optima. A variable neighborhood search is developed and embedded in breaking phase to enhance local exploitation capability. A new population updating scheme is applied to accelerate the convergence speed. Moreover, a speedup method is presented to reduce the computational efforts needed for evaluating insertion neighborhood. Finally, extensive numerical tests are carried out, and the results compared to some state-of-the-art metaheuristics demonstrate the effectiveness of the proposed DWWO in solving BFSP with SDST.

Keywords: Flow shop with blocking; Setup times; Scheduling; Heuristic; Metaheuristic;

1. Introduction

The blocking flow-shop scheduling problem (BFSP) widely exists in modern manufacturing and production systems, e.g., iron and steel industry [1], robotic cell [2], treatment of industrial waste, manufacture of metallic parts [3], chemical industry [4], serial manufacturing processes [5], etc. In BFSP, there are no buffers between consecutive machines. In other words, a job having completed processing on a machine has to remain that machine and block itself until the next machine is available for processing. Hence, accuracy scheduling is necessary to minimize machine blocking and idle time, which allows increasing the productivity level. It has been verified that the BFSP with more than two machines is NP-hard in the strong sense [6]. That is to say, with the increase of problem size, the BFSP becomes more and more complicated and is difficult to solve completely.

To tackle this challenge, during the past decade, many state-of-the-art approaches have been proposed to solve BFSP with different objectives including makespan, total flow time and total tardiness. These approaches include constructive heuristics and metaheuristics. Constructive heuristics use some specific rules to assign a priority index to each job to construct a scheduling permutation, which usually consume less time but obtain unsatisfied solutions. Metaheuristics start from previous generated solutions and subsequently approach the optimal solution by improving the solutions with domain knowledge. They can usually obtain fairly satisfactory solutions, whereas the solution processes are always time-consuming. We review some representative works dealing with BFSP in recent years as follows. For BFSP with makespan, Wang et al. [7] presented a hybrid discrete differential evolution (HDDE), in which new crossover and mutation operators were employed. Meanwhile, a speedup method was also proposed to evaluate the insertion neighborhood, which largely reduced the complexity of algorithm. Pan and Wang [8] presented two simple constructive heuristics, i.e., wPF and PW. Then, based on them three improved constructive heuristics, i.e., PF-NEH, wPF-NEH and PW-NEH were proposed. Lin and Ying [9] presented a