

ABSTRACT

In the recent era of sustainability manufacturing, scheduling has become a complex and critical operational challenge. Uncertainty and energy consumption are becoming substantial considerations nowadays, which can affect process efficiency. Variability in processing durations and strict due-date commitments both influence throughput and customer satisfaction, while energy consumption directly impacts costs and environmental goals. To deal with these issues, we adopt robust optimization using absolute robustness by generating worst-case scenarios to improve the computational effectiveness and enhance the adaptability in various situations. This research extends the energy-efficient scheduling scope for Unrelated parallel machines (UPMS) by incorporating sequence-dependent setup times (SDST), machine capabilities, and uncertain processing time, thereby aligning with practical applications in real-world contexts. We first develop a Mixed Integer Linear Programming model (MILP) capturing these objectives under processing-time uncertainty and propose two metaheuristics: Genetic Algorithm (GA) and Adaptive Large Neighborhood with Simulated Annealing (ALNS-SA) for solving UPMS-SDST to minimize makespan, total energy consumption, and total tardiness. This study also introduces a new suite of UPMS-SDST benchmark instances. Varying due-date tightness and uncertainty levels to reflect practical scenarios. Processing times vary across scenarios due to machine performance degradation and operator skill disparities. Comprehensive computational experiments demonstrate that both GA and ALNS-SA perform impressively, with significantly accelerated computational time than a leading commercial MILP solver in resolving the small problems. In addition, GA performs slightly less than ALNS-SA in resolving the large problems.

Keywords: energy-efficiency, robust scheduling, unrelated parallel machine, multi-scenario, genetic algorithm, adaptive large neighborhood search.