Metaheuristic Optimisation Algorithms for Solving Energy-Efficient Production Scheduling Problems via Machine On/Off and Speed Control Mechanisms

by

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I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

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ACKNOWLEDGMENT OF AUTHORSHIP

I hereby certify that the work embodied in this thesis contains published papers and preprints of which I am a joint author. I have included below a written declaration endorsed in writing by my supervisor, attesting to my contribution to the joint work.

By signing below I confirm that Mehdi Abedi contributed as a main author to the published papers and preprints entitled

- A hybrid particle swarm optimisation approach for energy-efficient single machine scheduling with cumulative deterioration and multiple maintenances, M Abedi, R Chiong, N Noman, R Zhang - 2017 IEEE Symposium Series on Computational Intelligence (SSCI), 2017, pp. 2930-2937, doi: 10.1109/SSCI.2017.8285316.
- A multi-population, multi-objective memetic algorithm for energy-efficient job-shop scheduling with deteriorating machines, M Abedi, R Chiong, N Noman, R Zhang - Expert Systems with Applications, 2020, 157: 113348.
- A metaheuristic framework for energy-intensive industries with batch processing machines, M Abedi, R Chiong, N Noman - IEEE Transactions on Engineering Management (under revision)

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Contents

Abstract

The manufacturing sector consumes more than one-third of the world's required energy, and is thus one of the main contributors of greenhouse gas emissions and their related environmental effects. A significant amount of energy can be saved in manufacturing industries by using production scheduling as an approach to enhance efficiency.

In this thesis, we propose new problems to address research gaps in the literature on energy-efficient scheduling problems related to the role of machine control mechanisms, including speed control and switching on/off, to reduce energy consumption in energy-intensive industries with either deteriorating or batch-processing machines. These types of machines are commonly used in metal and chemical industries, in which efficiency in the production process saves a considerable amount of energy.

Considering energy-related factors in the proposed production scheduling problems imposes new variables and constraints and subsequently increases the complexity of the problem. Therefore, to solve the problems in this thesis, we develop new population-based and individual-based metaheuristic algorithms incorporated with problem-specific heuristics. These algorithms have shown great success to deal with complex problems efficiently in the literature. To pursue our aim, we raise five research questions. We conduct three studies to answer these research questions, while filling some of the gaps in the literature. The three studies are: (i) a hybrid particle swarm optimisation approach for energy-efficient single-machine scheduling with cumulative deterioration and multiple maintenance; (ii) a multi-population, multi-objective memetic algorithm for energy-efficient job-shop scheduling with deteriorating machines; and (iii) an individual-based metaheuristic framework for energy-intensive industries with batch-processing machines.

We evaluate the performance of the proposed metaheuristic algorithms and their components in the three studies by using comprehensive experimental analysis and comparing them with the existing algorithms for similar problems in the literature. The results confirm that the proposed metaheuristic algorithms in this thesis outperform their competitors in solving the new energy-efficient scheduling problems. Finally, we indicate some directions for future studies.