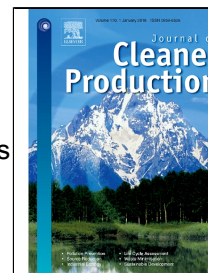


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A Green Scheduling Algorithm for Flexible Job Shop with Energy-Saving Measures

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# A Green Scheduling Algorithm for Flexible Job Shop with Energy-Saving

## Measures

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**Abstract:** We study how to save energy from the viewpoint of operation management. When to turn-on/off machines and which speed level to choose are two measures we employ to save energy. We focus on the flexible job shop scheduling problem. To begin with, a model is formulated for the flexible job shop scheduling problem when the two energy-saving measures are under consideration. An energy consumption model is proposed to compute the energy consumption for a machine in different states. Then, a non-dominated sorted genetic algorithm is developed to solve the problem. In the non-dominated sorted genetic algorithm, a green scheduling heuristic is presented to optimize the makespan, the energy consumption and the numbers of turning-on/off machines simultaneously. Finally, the comprehensive experiment results prove that the proposed model and the algorithm can solve the problem effectively and efficiently.

**Key words:** flexible job shop scheduling problem; energy-saving measure; turn-on/off machines; multi-speed machine; a green scheduling heuristic

## 1 Introduction

Reducing greenhouse gas emissions is one of the most important challenges facing by the manufacturing industry today. According to US Energy Information Administration (EIA, 2010), the industrial sector currently contributes about one-half of the world's total energy consumption, which has almost doubled over the last 60 years. In China, for instance, the average proportion of industrial GDP, 40.1%, is obtained by consuming 67.9% of national energy and emitting 83.1% of national carbon dioxide since 1978 (Chen, 2009). Energy-saving and emission-reduction has attracted more and more concerns from governments and researchers recently. For example, China "13th Five-Year Plan" (2016) requires the energy consumption in 2020 to be reduced by 15% as compared with 2015. The existed study on reducing manufacturing energy consumption has largely centered on developing more energy efficient

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