

Research Article

Green Scheduling of Jobs and Flexible Periods of Maintenance in a Two-Machine Flowshop to Minimize Makespan, a Measure of Service Level and Total Energy Consumption

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The success of an industry today depends on its ability to innovate. In terms of energy performance, this innovation is reflected in the ability of manufacturers to implement new solutions or technologies that enable better energy management. In this regard, this paper aims to address this gap by incorporating energy consumption as an explicit criterion in flowshop scheduling of jobs and flexible preventive maintenance. Leveraging the variable speed of machining operations leading to different energy consumption levels, we explore the potential for energy saving in manufacturing. We develop a mixed integer linear multiobjective optimization model for minimizing the makespan and the total energy consumption. In the literature, no papers considering both production scheduling and flexible periods of maintenance with minimizing both objective the total of energy consumption in flowshop and makespan. The performance of the proposed mixed binary integer programming model is evaluated based on the exact method of branch and bound algorithm. A study of the results proved the performance of the model developed.

1. Introduction

In industrial sectors, energy efficiency is the ratio between the energy required to produce and the total energy consumed by the plant. Increasing energy efficiency is a very important avenue for financial savings in industry. Indeed, this energy is responsible for almost 80% of greenhouse gas emissions. As demonstrated ten years ago, the potential for improving energy efficiency in the EU is very high and relatively unexploited. It is estimated that the use of energy efficiency would save 150 billion euros per year. This is the basis for the 20/20/20 strategy, which provides for a 20% reduction in greenhouse gases, an increase in the share of renewable energies to 20%, and a 20% reduction in energy consumption by 2020 [1].

It potentially becomes a vital necessity for the well being of our communities and our economy. According to the International Energy Agency [2], by 2040, global energy

demand will increase by 37%. In parallel with the process of energy production and consumption, an enormous amount of greenhouse gases have been and will be emitted into the atmosphere.

As part of our research work, we have integrated energy constraints into the scheduling of production and maintenance jobs of flexible duration in the flowshop. We use variable processing times with different energy consumptions to analyze the trade-off between energy consumption and energy consumption in a two-machine sequence, a scheduling problem flowshop has pending. Our research is partly based on similar trade-offs between speed and fuel emissions in vehicle routing [3]. We argue that, in flowshop manufacturing, there is a trade-off between makespan optimization (which depends on processing and preparation times) and energy consumption. Therefore, the analysis of trade-offs in an efficient way can help decision-making when scheduling production operations [4]. To our knowledge,

