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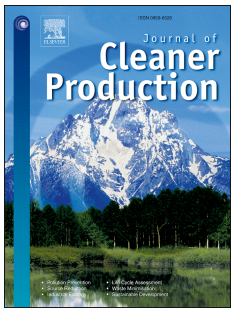

Scheduling for sustainable manufacturing: A review

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Scheduling for Sustainable Manufacturing: A Review

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Abstract

Most of the sustainable scheduling research deals with some environmental issues such as electricity consumption or carbon emissions although there are many other environmental and social indicators. Whereas, more and more manufactures are executing many solutions not only via implementation of environmentally-oriented but also socially responsible economically sound and management program. This proposed research has an objective to get a comprehensive view of the state and progress of sustainable scheduling by considering more sustainable indicators to assist many manufacturers to apply environmentally sound technological solutions. To achieve this objective, we, first, create a pool of sustainable manufacturing indicators that refers to some previous research that focus on applicable-proven indicators. Then, we employ an iterative process that is adapted from the general guidelines for literature review. We conceptualize, search, evaluate, analyze, and synthesize all 50 relevant papers resulting a completely new research framework to characterize the research. We use mathematical model components, i.e. manufacturing model, the system of objectives, objective function, constraints, model type, and optimization method, as the dimensions to classify the papers that were included in our analysis. We also apply the triple bottom line pillars – economic, environmental, and social to specify attributes and categories for the objective function and constraints. In literature classification step, the framework seems very sensitive since it can identify 49 different sustainable scheduling configurations from 50 reviewed papers. It means the framework can easily grasp the contributions of each paper. Then, in the analyses phase, we use 'sustainable link' to indicate if one research can be classified as sustainable scheduling research. The results show that energy cost and greenhouse gas indicators become the most frequently used indicators in sustainable scheduling. On the other hand, the mapping shows that some links have been rarely or never included, indicating potential areas for further research. We also list four main directions for future research which are: implementing other optimization methods; adding sustainability indicators; extending the model to a larger scale of manufacturing system; and loosening some assumptions.

Keywords: scheduling, sustainable, manufacturing, framework, the triple bottom line

1. Introduction

One definition of sustainable manufacturing is "the creation of manufactured products through economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources. Sustainable manufacturing also enhances employee, community, and product safety (U.S. Environmental Protection Agency, 2017)." This definition indicates that sustainable manufacturing deals with at least two elements of the triple bottom line, i.e., the economic pillar along with the environmental or social pillar. Sustainable manufacturing covers the four lifecycle stages (Pre-manufacturing, Manufacturing, Use, Post-use) and follows a 6R (Reduce, Reuse, Recycle, Recover, Redesign, and Remanufacture) methodology (Badurdeen and Jawahir, 2013). To achieve sustainable production, the three integral elements of manufacturing—product, process, and system—should reduce negative environmental impact, improve the efficiency of energy and resources, minimize waste, provide operational safety, and improve personal health while maintaining and/or improving the quality of the product and the process (Jawahir et al., 2013). Moreover, improved models, metrics for sustainability evaluation, and optimization methods are needed in all the integral elements as tools for realizing sustainability in manufacturing (Jayal et al., 2010).

Garretti and Taish (2012) divide the research in sustainable manufacturing topic into four clusters: business models and processes, asset and product lifecycle management (PLM), resource and energy management, and enabling technologies. Table 1 shows the research issues in each cluster.

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