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## An overall multi-criteria approach to sustainability assessment of manufacturing processes

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### Abstract

The paper depicts an overall multi-criteria approach for sustainability assessment of manufacturing processes. The analytic hierarchy process method is used to determine ranking of activity areas for manufacturing processes in terms of sustainability objectives. An analytical technique is also employed to assess the degree of sustainability in manufacturing. The paper introduces “improvement scenario” between existing and new processes, but is based on an approach which can be applied to perform the sustainability assessment of manufacturing processes requiring less detailed data, time, and expert knowledge, but still providing a company-level analysis. The results show biggest (significant) improvement is represented by painting (40%), then cleaning (30%), and cutting (19%). The applicability and usability of the proposed assessment method was verified by the case study in company producing heating devices.

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## 1. Introduction

The increasing concern about sustainability initiates the necessity of assessment manufacturing activities. Hence, it has become mandatory to assess the degree of sustainability in manufacturing in order to set plans on how to improve processes [1,2]. Sustainable development in manufacturing process requires improvements in material, resource, and energy efficiency, adequate reductions in exposure to toxic substances, significant opportunities for stable, rewarding, and meaningful employment, better safety and effective maintenance as well as production planning and scheduling at production operation level [3]. Following the concept, it requires the development of metrics for sustainability [4,5,6] in order to identify interactions between manufacturing processes [7,8]. The area of sustainable manufacturing is a developing field [9], but there are still area activities to be taken into consideration during the analysis of manufacturing technologies on the companies' sustainability. Although in recent years, various methods and approaches have been developed for sustainability assessment of production processes at the national level or for cross-country comparisons, but the issue of developing a combined method as multi-criteria at the process level is not properly addressed [10,11]. From the literature, although generic methods to evaluate sustainability performance are not available, manufacturing process specific sustainability performance evaluation models are under development [2] and require major technological changes [12,13]. To assess and improve sustainability performance in manufacturing, it is needed to develop standard, ease of use method, convenient sustainability assessment approach without compromising significantly on comprehensiveness involves the use of the analytic hierarchy process (AHP), which can be applied in diverse manufacturing scenarios.

Many researchers have applied various tools for sustainability assessment based on multi-criteria decision analysis (MCDA) (e.g. AHP and fuzzy logic) allowing companies to manage a wide variety of information types, parameters and uncertainties [14,15,16]. It also enables to assess manufacturing processes without the necessity of monetary valuation or quantifying. Quantifying is difficult if it deals with social and technical aspects. AHP aims to determine overall preferences among alternative options according to the different criteria being difficult while comparing with one another. This means that MCDA tools can be customized to incorporate value judgments of individual or multiple decision makers.

Considering this research gap, there is a lack of holistic focus on development of criteria and sustainability (Technical, Environmental, Economic, Social) for different sustainable manufacturing assessment from Small and Medium-Sized Enterprises (SME). Additionally, sustainability assessment of manufacturing SMEs was not yet considered on the process level and applicable in a proactive company in its continuous efforts to improve sustainability performance. Time consuming assessment due to the complexity and amount of data required is usually quite limited. Besides, the use of the technical sustainability is a novel objective and a contributor in the sustainability assessment of manufacturing.

The present study develops an overall multi-criteria sustainability approach for sustainability assessment of manufacturing processes of central heating boilers based on a single facility. It allows to apply an integrated approach based on AHP and 5-point scale to serve the purpose of the study. A rationale for sustainable assessment in production is treated as a core requirement in sustainability-related research, where both qualitative and quantitative information can be used [14]. Any attempt to assess sustainability in manufacturing processes will require consideration of the activity areas between their differing sustainable objectives using decision-making methods. In this case, a new approach has been developed for rapid sustainability assessment - based on a combination of methods.

## 2. Developing a sustainability assessment approach for manufacturing processes

The present study designed an information model for assessing the manufacturing sustainability performance for a company producing heating devices. In this paper, the AHP method and 5-point scale was used to serve the purpose of the study.

Production process involves multiple sub-processes represented by various kinds of performance data. The data provided by the company is incomplete and not necessarily sufficient. What is more, the complexity of manufacturing processes may make sustainability assessment impossible according to the various parameters. From the other hand, the sustainability assessment procedure must also be sufficiently generic and broad to cover as much

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