A maturity-based improvement method for eco-efficiency in manufacturing systems

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Abstract

Eco-efficiency has been portrayed by various global organizations in recent years, as an effective way of reducing industry’s carbon footprint and safe-guard natural resources. It is a concept that has been reduced for simplicity into “doing more with less”. However, very few studies address eco-efficiency through a holistic approach that can guide practitioners in achieving better control over their manufacturing practices. Using design research methodology and based on previous empirical work, the authors present a method that intends to help practitioners in factories achieve environmental performance improvements by identifying system strengths and weaknesses. The method can be seen as consisting of two main modules: a maturity self-assessment process and a practitioners’ workshop. Two case studies are presented here to show how the method can be applied and help practitioners simplify and make eco-efficiency a manageable target.

1. Introduction and research objectives

Sustainable manufacturing (SM) is defined as a way of making products that eliminates environmental hazards (pollution prevention) and waste in energy and materials [1]. Abdul Rashid et al., identify eco-efficiency as an important improvement strategy [1]. WBCSD proposes that: “Eco-efficiency is achieved by the delivery of
competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle to a level at least in line with the earth’s estimated carrying capacity”[2]. Helfat and Peteraf move that proposition under the lens of maturity stages: “The maturity stage entails capability maintenance. This involves exercising the capability, which refreshes the organizational memory. If exercised regularly, the capability becomes more deeply embedded in the memory structure of the organization”[3].

The particular focus in this study is the role of manufacturing practices as internal capabilities that enable or prevent companies from enacting eco-efficiency or doing more with less. Manufacturing practices are defined as: “a bundle of behavioural routines, tools, and concepts used to accomplish a certain task” [4]. The paper builds up from previous work by the same authors on maturity models and the way that practice maturity can be an indicator of eco-efficiency in manufacturing systems [5]. The research objective in this study is to empirically understand the role of practice maturity as ingredient of a sustainable manufacturing strategy [5]. Extending their work with their practice maturity framework for eco-efficiency [5], the authors here set out to explore the following research question: “How can manufacturing practice maturity be used to facilitate the development of long-term eco-efficient solutions in factories?” The authors in this study are testing the idea of embedding maturity profiles assessment into a process that can be used to identify strong system capabilities.

2. Research Methodology

This work is part of a greater doctoral research plan on eco-efficiency in manufacturing systems. The research plan follows the design research methodology framework that has been developed by Blessing and Chakrabarti [6]. The methodology consists of four stages: 1) Research Clarification, 2) Descriptive Study I, 3) Prescriptive study and 4) Descriptive Study II.

2.1. The steps of the improvement method

In descriptive study I, the maturity grid was tested as a tool in three different ways: a) as a self-assessment tool, b) through a workshop with industrial practitioners and c) as a case study interview guide [5]. The first two options are combined in this study to form a process that can help the authors answer their research question. The authors propose a two-phase process based on practice maturity assessment.

The first phase is a self-assessment process where the authors collect maturity profiles from practitioners working within manufacturing systems. These maturity profiles are then reviewed by the authors in regards to the maturity variability and the overall level of maturity. Particular focus in the analysis of the maturity profiles is given to the alignment of profiles across three cascading organizational layers: top-management, management systems and production processes (see figure 1. a,b,c). These layers are subdivided in dimensions of performance as in table 1 [5]. Each dimension is described in five maturity stages which have been populated with examples of manufacturing practices. These practices are sorted in maturity stages based on their potential to enhance eco-efficiency. The assumption behind that design is that the potential for eco-efficient manufacturing increases as manufacturing practices move upwards in maturity. Practice maturity is described within the maturity grid with examples of practices that are found in relative literature.

Table 1. The dimensions of the practice maturity assessment grid for eco-efficiency as per Litos and Evans, 2015 [4].

<table>
<thead>
<tr>
<th>Processes</th>
<th>Management systems</th>
<th>Top-management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy usage</td>
<td>Energy management</td>
<td>KPIs &amp; information management</td>
</tr>
<tr>
<td>Materials usage</td>
<td>Resources management</td>
<td>Company norms &amp; values</td>
</tr>
<tr>
<td>Water usage</td>
<td>Waste management</td>
<td>Supply chain configuration</td>
</tr>
<tr>
<td>Process waste/pollution</td>
<td>People management</td>
<td>Product &amp; process development</td>
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<tr>
<td>Human factor impact</td>
<td>Suppliers relationships</td>
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<tr>
<td>Equipment performance</td>
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