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Identifying Complexity Drivers in Discrete Manufacturing and Process Industry

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Abstract

Complexity management methods in the field of strategic and operational complexity management are usually conceived for the discrete manufacturing industry and are hardly transferable to the process industry. In this paper, complexity management practices, as well as complexity drivers, in the discrete manufacturing industry and the process industry are identified and collected. Furthermore, an analysis is conducted regarding similarities and differences between the approaches in the two industries. In future research suitable evaluation criteria will be identified and combined in an evaluation model, which may help to show applicable complexity management methods from the discrete manufacturing industry for the process industry. Through a survey of 136 participating companies, the implementation degree of complexity management methods and the impact of complexity drivers within various industries were investigated. Based on these results, the process industry was identified as lagging behind in the field of complexity management. By conducting an interview study with five successful companies identified from the survey's sample, the researchers gained detailed information on the applied methods. Supported by a Delphi study with three companies of the process industry, specific complexity drivers and the main challenges to apply existing complexity management methods in their businesses were identified. To show the difference between the applied methods in the process industry and the discrete manufacturing industry, three cases are described. Two of them are from the process industry. The first one is representative for complexity management in the process industry, comes from a participating company from the Delphi study and is rated as less experienced in this field. On the other hand, the other case, rated as a successful practice case from the survey's sample, shows a high implementation degree of complexity management methods from the discrete manufacturing industry. In the third case, the approach of an automotive supplier with long experience in complexity management and a high implementation degree of complexity management methods is described. First results show, that the challenges in the process industry are mainly resulting from external complexity drivers, like legal and political factors. Whereas internal complexity drivers like product structure as well as the dynamic of technology, are rather influencing the discrete manufacturing industry. Hence methods for gaining transparency on materials and resources seem to be more valuable for companies in the process industry than others.

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1. Introduction

Nowadays the environmental factors and internal processes of companies are dominated by high variety, volatility and dynamic. The resulting complexity can be induced through various reasons along the whole supply chain.

Crucial for the design of a product and process is the understanding of the complexity drivers. These drivers are influencing factors which affect the complexity in various functional departments. In general, the drivers can be distinguished between internal and external factors. To gain an understanding of the complexity, these external and internal drivers need to be identified first and their dependency on

products and processes needs to be described subsequently. [1] Thus the increased transparency on the complexity within the company can help to identify further activity fields.

Related publications describe complexity drivers in manufacturing companies and their supply chain. The authors classify the complexity drivers into internal and external factors including different sub-categories. [2,3,4,5] Nevertheless, the complexity drivers are related to manufacturing companies in general and don't differentiate between different industries like process and discrete manufacturing industry.

The automotive industry was a pioneer in the past and is still the benchmark meeting external requirements with effective internal product and process structures. Modular product architectures in the automotive industry are a well-known example of how to manage external requirements more efficiently. Furthermore, standardizing manufacturing processes into modules, applicable for all global production sites, led to an increase of flexibility within production. As a next step, industries strive for automatization of maintenance processes of machines through, for instance, the application of "Industrie 4.0" methods and technologies in order to reduce the process complexity of the company.

By looking at other industries, especially companies with continuous processes, we can conclude that modular structuring of products doesn't seem to be easily applicable. Only a few companies applied this method to manage the external complexity as there are not only positive effects of modularity. Modular systems are much more difficult to design than comparable interconnected systems as the inner working of products and processes must be understood. [6] Apparently, there is a difference in the applied methods between the process industry and the discrete manufacturing industry.

For that purpose, the paper will first provide an overview of the identified internal and external complexity drivers and cluster them into two groups – process industry and discrete manufacturing industry. Additionally, applied complexity management methods will be described and linked to the setup of complexity drivers in the industry. After a short analysis of the differences between the approaches, the paper will close with a statement of extracted reasons for the different implementation degree of complexity management methods in the two industries. In future research, an evaluation model will be designed to rate the applicability of methods from the discrete manufacturing industry in the process industry.

2. Definitions

Complexity management is a business methodology embracing engineering as well as exploitation of variety and guidance of complex systems, hence complexity management can be understood as mastering complexity [7]. Furthermore, it embraces the activity fields prevention and systematic reduction [8].

Modularization is one of the manifold methods to reduce complexity and its importance is pointed out by various researchers [9]. It combines several methods which are important to overcome complexity [10]. Modularity can either be linked to products or processes. Using standardized product

modules, which can be easily assembled and combined in various product variants, is the principle of product modularity. Process modularization aims at standardizing manufacturing sub-processes, enabling an easy re-sequencing or adding new modules. Process modularization increases the flexibility of the production and allows to react faster on changing product requirements. [11]

The complexity within a company can be induced by the market, product and production which intercorrelate and result in various challenges [12].

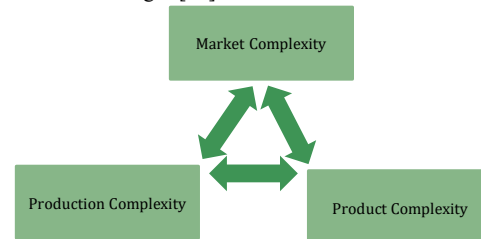


fig. 1: Dependencies between the different fields of complexity

2.1. Market complexity

Managing external requirements like customer needs, global competition, foresight, market turbulence [12] and transferring them into product functions is a challenge in the current globalized world. Hence the complexity in the fields of market, product and production as well as their dependencies, as depicted in fig. 1, need to be understood.

2.2. Product complexity

Product complexity is referred to as the number of product offerings in order to meet diverse customer demands [13].

As a reaction to the increasing market variety, volatility and dynamic suitable methods within the product development are necessary. Methods to manage the product complexity are, for example structuring products into independent modules, or designing standards and interfaces. [11, 14]

2.3. Production complexity

Production complexity is created by high variety in possible production processes as well as in processed raw materials and components. It is defined as "the interrelations between product variants, work content, layout, tools and support tools, and work instructions" [15].

Between market, product and production complexity a direct link has been identified. The methods applied in the two upstream areas must be transferred efficiently into the production processes. Successful practices embrace e.g. modular production structures to compete with current challenges like high variety and heterogeneity of machining processes [16]. Schäfer describes different kinds of modules within a production. A module can be a standard machine, a cell, a work station or an element. Defining modules on an element level increases the flexibility of the production system

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