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Reconfigurable Manufacturing – An Enabler for a Production System Portfolio Approach

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Abstract

The purpose of this paper is to investigate how the development of a strategically integrated product and production system portfolio could be enabled by the concept of reconfigurable manufacturing. In previous research, several critical challenges related to developing production system portfolios have been identified, but it has not been investigated how developing a reconfigurable manufacturing concept could aid some of these. Therefore, through a multiple case study, these critical challenges have been investigated in two companies that have recently developed reconfigurable manufacturing concepts for multiple variants and generations of products. The findings reveal that the companies need to deal with several challenges in order to enable a functioning RMS. By running the project separately from the NPD project and to include several product types and production sites the company overcome several challenges.

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Keywords: Production system portfolio; changeability; reconfigurability; production development; portfolio management

1. Introduction

The need for developing product families and managing a product portfolio that meets customer needs is widely accepted as a means for handling product development in a global competitive market place with rapidly changing technologies, shorter product life cycles, and increased need for variety [1]. Production system development on the other hand is often carried out relatively close to its introduction, and the introduction of new product generations generally triggers numerous changes in production that often prescribe costly changes to the production system [2]. Therefore, adopting a long-term planning perspective to the production system development is of major importance for competitiveness and innovation. To create, visualize, and manage a production system portfolio in line with the product portfolio reveals a large potential. The results of this approach is a matching portfolio of tentative products and production systems, which allows for efficient, fast, and sustainable development [1]. However, numerous challenges have been identified in production system portfolio development, related to information management, resources, production system design mindset, equipment supply, monitoring of the environment, competences, production strategy, and development process [3]. Thus, developing production systems that enable change in accordance to the product portfolio is a main concern. The concept of the reconfigurable manufacturing system (RMS) has been described as a way to rapidly react to market opportunities and changes [4]. The RMS enables reconfigurability and adaptability on system and machine level [5], which prepares operations for new generations and updates of products, resulting in a more efficient and sustainable production system development approach. For that reason, RMS can be viewed as an enabler for strategic and integrated portfolio planning of products and production systems. Therefore, working with reconfigurable manufacturing development could potentially aid some of the critical challenges that have been previously experienced within developing integrated product and

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production portfolios. This paper is based on a multiple case study, including two companies that have recently initiated the development and implementation of RMS concepts in order to handle product variations. The purpose of this paper is to describe how a production system portfolio mindset could be enabled by the RMS concept and propose further research in order to deal with the identified challenges in production system portfolio development.

2. Frame of Reference

2.1. Challenges in Production System Portfolio Management

In this approach, a company manages a portfolio of production systems in the same way as product portfolios are usually managed and planned. However, in previous research, several challenges have been identified in production system portfolio development [3].

Having a long term perspective on production development requires an ability to wisely use available information about the future plans. However, this represents a dilemma since on the one hand there is a general reluctance to release early information on e.g. upcoming product families, and on the other a tendency to use incomplete information when designing the production system [3]. The tendency to stick to incomplete information could be explained by the challenge in managing information. The effectiveness of information management needs to be based on the capability to avoid situations in which the production system development process is either being subjected to information overload or getting information too late or not at all.

Competencies in production development and operations is another critical issue in order to enable re-use and reconfiguration of production systems [6]. The challenge is both to have the right competence within the company and that the competent persons have dedicated time for development activities. Production engineers often struggle with the trade-off between working with firefighting activities in operations and long-term production system development. Thus, they are seldom dedicated for long term production system development including pre-technology development or advanced engineering (AE) activities [6].

Previous research identified that it is challenging to have a long-term view on production development and often production systems are designed according to current products, which decreases capacity utilization and increases risk and investment considerably [7]. Meanwhile, the production system concepts are strongly influenced by previous production system developments [8]. A clear production strategy supporting a long term perspective in production development is urgent since the production developers needs mandate to invest in long term solution like reconfigurable production solutions.

Another challenge in production system portfolio development is the collaboration with equipment suppliers. Collaboration with equipment suppliers in production technology development creates interdependencies and involves uncertainties and information asymmetry [9]. However, several scholars have found that a strong collaboration between equipment suppliers and the users, i.e. the receiver of the production equipment, is positively related to the performance in acquiring and implementing production technology [10, 11] and close collaboration with suppliers is a precondition for building trust, mutual understanding, and commitment from the supplier [12].

To always be updated on relevant process innovations monitoring the external environment of the company is required. Benchmarking and networking are two critical activities that can provide new insights to the manufacturing companies.

Development of production systems is still not an area that is as prioritized as product design [8, 13]. To coordinate the production system development process and work in a structured and systematic way is important for a long term view on production system development [6, 14] and structured processes have been proposed by several scholars [15, 16]. In practice, production system development is however typically based on past experience and judgement based on experience which require numerous iterations and correction stages [17] and the production system development process is not regarded as a means to design the ultimate production system [15].

2.*2 Reconfigurable manufacturing systems*

RMS can be viewed as an enabler for strategic and integrated portfolio planning of products and production systems and working with reconfigurable manufacturing development could thus aid some of these critical challenges described above. The RMS was initially introduced in the 90's by Koren [4] as an intermediate manufacturing paradigm combining the high throughput of dedicated manufacturing lines and the flexibility of the flexible manufacturing systems. The RMS is designed for continuous change of capacity and functionality in accordance with product, process, and demand changes [5]. The reconfigurability of the RMS is enabled by six core characteristics; customization, convertibility, scalability, modularity, integrability, and diagnosability [18]. Convertibility and scalability refer to modifying the capacity and functionality of the system, which is accomplished through modularity, integrability, and diagnosability. The last characteristics, customization reduces the traditional trade-off between efficiency and flexibility, as it refers to machine and system flexibility being limited and customized to a specific part or product family [18]. Thus, the RMS concept entails a high degree of integration with product development, where analysis of the current and future product portfolio in the analysis of need for reconfigurability, determining product families for the design, and updating the system in accordance with new products are essential parts of its design and operation [2, 19]. The concept of co-evolution has been proposed to describe this continuous adaption of the production system and the product family [20], where the progression of product design and technological breakthroughs of manufacturing capabilities are viewed as symbiotic relationship that evolves over time [20]. Therefore, the process of developing adaptable and reconfigurable manufacturing systems is closely linked to the idea of maintaining high interrelatedness between the