1. Introduction

A lean and efficient company organization has become increasingly important in today's increasingly dynamic world. In recent years, many companies have begun initiatives and projects to introduce Lean methods into production, thereby trying to minimize non-value-added processes while aligning the value stream with the customer. Lean Thinking was developed by Taiichi Ohno [1] in the Toyota production lines as a philosophy to concentrate on waste reduction and value adding processes. After its success in the American motor industry [2] the Lean Management principles were spread around the world. Typical Lean methods were applied for many years for the design of lean production processes in multinational corporations in the automotive industry and later on also in other industrial sectors and also for smaller firms.

In addition to production, Lean methods have also been adopted in other sectors, adapting them to the specific needs and used to increase efficiency and to reduce waste. For example, the adoption of Lean methods in non-repetitive production such as Engineer-to-Order (ETO) environment [3]. Further also the health sector is increasingly concerned with Lean topics (Lean Healthcare) [4] and similarly the tourism sector is more and more interested in such methods (Lean Hospitality) [5]. In the company itself Lean methods are used not only in the production, but also in the administrative area (Lean Administration) [6] or for the optimization of the installation of components on site (Lean Construction) [7]. It is therefore not surprising that Lean methods also find their place in the field of engineering under the term Lean Product Development (LPD) and often also Lean Engineering.

Based on actual trends towards shorter product life cycles we can identify a great need to accelerate the time for product development and to reduce costs on the product and the product development process. It is therefore important to configure and design the product development process as
efficient as possible [8]. The product development area is rich in opportunities for improvement: the length of time it takes to develop a new product; the degree to which the product satisfies the requirements of the customer; and the ease with which new products can be produced are all areas in which most companies can make dramatic improvements when compared to the most successful companies [9].

After the Lean trend, completely new opportunities are arising from new and modern technologies. The term "Industry 4.0" created some years ago, describes the potential based on the introduction of web technologies, an increased digitalization and networking of virtual and physical value chains. Therefore, also product development has to leave traditional ways coming closer to the development of Industry 4.0 [10].

This paper is organized as follows: after a first introduction in section 1 the authors bring a brief summary of the theoretical background from literature. In section 3 the research method and the survey design are explained. Section 4 shows the results of the survey and contains a short discussion of the answers. In section 5, critical factors for the introduction of Lean Product Development in SME are identified and discussed. Finally the paper ends with a conclusion and outlook for further need of research.

2. Theoretical background of Lean Product Development

In this section the readers will receive an overview of the concept of Lean Management in Product Development. In addition, the growing role of small and medium sized enterprises for a countries economy is explained.

2.1. Lean Product Development

The use of Lean methods in engineering and product development has been discussed only marginally in the scientific literature and is currently in its early stages [11]. Lean Product Development (LPD) is the application of lean principles to product development, aiming to develop new or improved products that are successful in the market. It is a cross-functional activity, which seeks to uncover product knowledge hidden within the end-to-end production flow, typically in the hand-over points between functional units. LPD deals with the complete process from gathering and generating ideas, through assessing potential success, to developing concepts, evaluating them to create a best concept, detailing the product, testing/developing it and handing over to manufacturer [12]. Liker and Morgan [13] defined LPD as: “a knowledge work job shop, which a company can continuously improve by using adapted tools used in repetitive manufacturing processes to eliminate waste and synchronize cross-functional activities.” LPD is a cross-functional activity that seeks to uncover product knowledge hidden within the end-to-end production flow, typically in the hand-over points between functional units. Morgan and Liker [13] proposed 13 methods of LPD categorized in three groups: process, people, and technology. Hoppman et al. describe a model for Lean Product Development [14] consisting of 11 elements that are linked together. Tortorella et al. [15] present four LPD enabler: set based concurrent engineering, value focus, knowledge focus and continuous improvement. Aikhuele and Turan [16] add some more enabler like the adoption of a Chief Engineer and cross-functional teams, poka-yoke, supplier integration, top management support and workforce commitment. Also Value Stream Mapping is used in LPD. Tyagi et al. [17] describe in their case study based research the impact of value stream mapping to reduce the lead time in the product development process of about 50%. In addition to just mentioned methods and tools Tyagi et al. [18] refer to visual tools like A3 and spaghetti diagram or checksheets and Scrum to enable fast feedback. Dombrowski and Schmidtchen [19] show a quite complete catalogue of the most important lean methods in Lean Product Development categorizing them in seven principles (see Fig. 1).

2.2. The emerging role of small and medium sized enterprises

Small enterprises have been ignored for a long time in Lean Management research and special investigations about this topic were rarely. Considering statistical data and analysis about the economic importance of small enterprises we can see, that they are numerous and create a notable part of total value added in the non-financial business economy [20]. The use of Lean methods in SME has been and remains a subject of much debate in the last few years, but the focus of the application of methods remains limited to production [20, 21]. In the area of product development, there is actually a lack in specific models for the introduction of Lean into engineering departments.

The following data are intended to show why SMEs play an important role in industry and in the economy as a whole: small, and medium-sized enterprises are numerous and usually the backbone of the economy [22]. SMEs are defined by the European Commission as having less than 250 persons employed. In 2012 SME made up 99.8% of all enterprises in the EU28, representing about 22.8 million companies employing almost 67.1% of total employees. SMEs accounted for 57.3 % of the EUR 6.18 billion of value added generated in 2012 [23].

The importance of SME should not be underestimated. With the introduction of Lean methods in the Engineering department of these companies, the efficiency and probably the impact on innovation could be significantly increased.
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