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Additive Manufacturing – enabling technology for lifecycle oriented value-increase or value-decrease

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Abstract

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Keywords:

1. Introduction

The Internet has radically altered the proposition that listening to your customers can help you improve your products and services. Customers are now able to be so intimately involved in the development and usage of what you have to sell that they can become co-creators of value. Co-creation adds a new dynamic to the producer/customer relationship by engaging customers directly in the production or distribution of value. Customers, in other words, can get involved at just about any stage of the value chain. Some managers liken the transformation to turning customers into "employees." Consequently, managers must learn new techniques to motivate customers to co-create value as well as ways to successfully monitor and manage the process along the way.

Additive Manufacturing (AM) seems to have the potential to substitute traditional manufacturing technologies in different branches [1]. The effects thereby are that the "printing" of AM-Parts is location-independent, time-independent, scalable (down to batch sizes of one) and almost know-how independent [2, 8]. In addition to the Open Innovation approach, AM enables the customer to become a manufacturing partner with relevant impact on the value creation network [3, 9].

So far, customized products are manufactured with different procedures. The current development of fabrication methods shows that 3D printing gets increasingly established [4]. Many individualizable products can already be produced via 3D printing methods; not only on the level of consumer goods like cell phone cases but also on the level of medical equipment goods like personalized hearing aids, fitting to the individual ear shape [5, 6].

Due to these trends in consumer behavior and technology, 3D printing of individualizable mass products offers potential for new business concepts [7] – but it seems also to have the potential for loosing creation of value because of the ability to easy print respective to copy parts.

The focus of this paper is the use of AM in industrial businesses. As mentioned above, industrial goods are also more and more customer individual. Therefore industrial businesses have to figure out how they can benefit by using AM for individualization purposes. In addition, AM seems to have potential to improve the efficiency of spare part logistics by printing spare parts at the location of use. But thereby they also have to consider with respect to their business models keeping service and maintenance far from printing spare parts by the user themselves.

2. Research Question and Research Design

Assuming that especially within Mass Customization scenarios industrial goods are not printed completely but rather individual parts are manufactured additively, manufacturers have to decide on which level of the bill of material (BOM) the AM-parts can be placed to fulfill both:

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enable customers to print low value spare parts by themselves but also to prohibit losing business relevant maintenance activities.

Therefore the approach described in this paper aims at answering the following questions:

What is the influence of manufacturing in the value chain during the whole product life cycle and on which level of the BOM have AM-parts to be placed to increase value best possible?

Based on literature work, an in depth case study was carried out within a medium sized industrial company to capture the product lifecycle and facets of customer individualization within industrial goods. The company itself is a typical SME and is developing and producing medical equipment like lighting for operation rooms at one location in the southern part of Germany. The products are sold worldwide. The service and maintenance is also delivered from the location in Germany. Within the case study, two scenarios are derived. With the aid of the scenarios a concept is deduced which considers the potential of AM with respect to mass customization as well as value increasing.

3. Mass Customization and Additive Manufacturing

The most fundamental principle of low-cost, high-volume mass customization is modularity, which enables the supplier to do only and exactly what each customer needs. Not only the product should be modular, the supporting processes also should be able to retain the modularity till the end when a customer exercises his choice. In mass-individualization, new product design and -development is fully linked to the concurrent design of the related business processes. Managing business processes and product-service systems through life-cyle in many cases is just possible within collaborative networks.

For realizing the benefits of Mass Customization, companies usually start from its product design by introducing a common platform. Platform-based approach enables a number of product variants to be developed from a common platform, which can largely reduce the time and cost of new product development. Platform commonality means to standardize and share components among products.

Within this concept, the role of the customer is a passive one: he can only make his choice/customization out of the predefined options of the manufacturer. The predeveloped options are generated by following strict design rules (e.g. DFMA - Design for Manufacturing and Assembly) in order to achieve the cost-saving and time-saving effects for the manufacturer.

Parallely to the product module or plattform strategy, the corresponding manufacturing and assembly processes are also designed in modules. The principle is to postpone the socalled "Order Penetration Point" as late as possible in the value stream – this will result in a postponement of the time- and cost-consuming customized processes towards the end of the value chain. As a result, manufacturers produce a generic product and become more flexible and responsive to customer demand.

Within this concept, the customer usually is not at all involved – only the partners of the predefined supply chain of the manufacturer take influence on the processes and on the position of the OPP.

By using the AM technology, the "classical" Product-Development-Process (PDP) can be enlarged in two directions:

- Towards the Front-End-Process (FEP) where the design concept of product and processes takes place: the customer becomes active member of the product design team by generating the final geometrical dimensions of the product by himself.
- Towards the Back-End-Process (BEP) where the production from the early beginning of the product lifetime until the final usage takes place: the customer can become active member of the supply chain network by overtaking the manufacturing of product components with AM by himself.

<table>
<tr><td>new: FEP</td><td rowspan="5">SOD (start of development)</td><td>old: PDP</td><td rowspan="5">SOP (start of production)</td><td>new: BEP</td></tr>
<tr><td>Customer interface</td><td>Requirements Engineering internal value chain</td><td>new business model</td></tr>
<tr><td>Active product configuration</td><td>modular based product configuration modular based process configuration</td><td>Integrated process configuration</td></tr>
<tr><td>Community innovation (Open Inno 2.0)</td><td>Open Innovation Lean Production</td><td>Collaboration Network (Industry 4.0)</td></tr>
<tr><td>Design for Additive Manufacturing</td><td>Design for Manufacturing Design for Value stream</td><td>Design for Value Network</td></tr>
</table>

Table 1: FEP, PDP and BEP

4. Use Case scenarios

The use case under consideration is - as mentioned above - a manufacturer of medical equipment. Initial point of the use case is, that a new product design for a carriage arm was necessary in order to realize the different customer variants more cost efficiently. The carriage arm has to be individualized in geometry, for example with a logo of the clinic or the name of the company. Within the use case, two scenarios of MC with respect to AM are derived: scenario 1 - value decrease and scenario 2 – value increase.