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Remanufacturing Process Assessment – A Holistic Approach

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Abstract

Today, remanufacturing is a key industrial discipline at the end of a product's life cycle. Unfortunately, there is a lack of knowledge when it comes to the assessment of remanufacturing processes (technical and organizational processes within the production) and the comparability of remanufacturing processes. To close the lack of knowledge, both in industry and research, this paper shows the main aspects of a holistic approach to assess remanufacturing processes. The rudiments of the assessment approach are a maturity model, the value stream methodology and material flow simulations. On the one hand, the holistic approach will enable remanufacturing companies to analyze their processes, and on the other hand, the approach will enable them to manage the progress of improvement of their remanufacturing processes. At the end of the day, the holistic approach will support the remanufacturing industry to improve their competitiveness by increasing their cost and resource efficiency.

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1. Introduction

The corporate landscape has changed in the recent years, due to increasing competitive constraints [1]. An option, manufacturing companies have chosen to satisfy their customers is, increasing product variants. Increasing products variants and thus increasing product complexity leads to increasing complexity in the production and logistics as well [2].

In addition to increasing competition, increasing resource scarcity and increasing commodity prices endanger the profitability of enterprises [3]. An innovative approach to increase resource efficiency in (manufacturing) companies is the *Circular Economy*. The idea of a circular economy is described by the Ellen MacArther Foundation (EMF) in their Circular Economy System Diagram [4]. One key element of the Cicular Economy is remanufacturing.

Today, remanufacturing is a key industrial discipline at the end of a product's life cycle. According to Hauser and Lund, remanufacturing is the process to restore nonfunctioning, discarded or traded-in products to condition like new [5]. Nasr and Thurston described the condition of the remanufactured products "as-new" [6]. Automotive components such as starters, alternators and water pumps are products which are typical remanufactured [6]. Remanufacturing is performed due to economic, ecological and/or policy reasons [7].

In terms of the economic potential, remanufacturing facilitates multiple use of the value-added from new production by several life cycles. For preserving work, material and energy, effort costs of new production can be avoided. Ecologically, this leads to corresponding resource savings, avoiding of emissions and waste. The ecological performance of remanufacturing has been shown in many scientific studies. Sundin and Lee have gathered these studies in 2012 [8].

Nevertheless, remanufacturing companies face similar challenges as manufacturing companies. In terms of product and thus process complexity, remanufacturing companies have to be able to manage the broad spectrum of OEMs / OESs, product groups, product generations as well as quality and contamination levels of the cores, etc. [9]. Unlike manufacturing companies, remanufacturing companies can only react on the increasing product complexity [10, 11]. Therefore it is important to analyze and to improve remanufacturing operations.

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2. State of the Scientific Knowledge and Need for Action

In this chapter, the state of the scientific knowledge relating to remanufacturing processes and remanufacturing process assessment is described.

2.1. Remanufacturing Processes

According to Steinhilper, the remanufacturing process depends on the type and functionality of the products. Mechanical and electromechanical systems have to be separated from mechatronic systems. Mechanical products have to be processed in five main steps. [12]

According to Freiberger, it is useful to add the entrance diagnosis as a first step, for mechatronic and electronical products. Thus, products with electronical failures can be separated, directly. [13]

Figure 1 shown the five respectively sixth steps of remanufacturing.

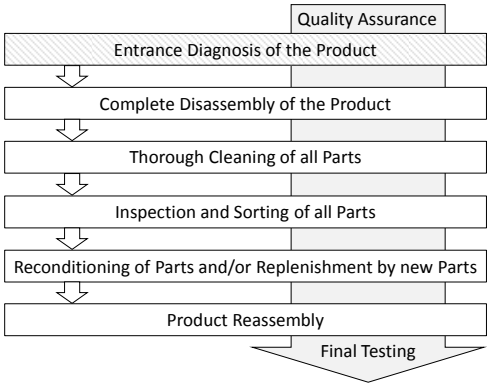

Fig. 1 Steps of remanufacturing according to [12] and [13].

To ensure the same product quality as new products, quality assurance steps are performed during and between the remanufacturing steps.

2.2. Challenges and Approaches for Remanufacturing Process

Several studies described the differences between manufacturing and remanufacturing processes [14, 15, 16, 17].

In terms of challenges, especially the planning and control activities of remanufacturing operations are mentioned [15, 16, 18].

According to Guide, seven characteristics complicate the production planning and control activities in remanufacturing [15]:

- Uncertainty in timing and quantity of returns
- Uncertainty in quality of returns
- Balancing returns with demand
- Product disassembly
- Requirement of a return collection system
- Return of an identical product (if applicable)
- Stochastic routings for materials within remanufacturing processes and highly variable process times

Kurilova-Palisaitiene and Sundin identified three major constraints in terms of remanufacturing, which are product quality, process lead time and inventory level [16, 19].

The most promising approach to face the challenges of remanufacturing operations, in terms of planning and control, is *Lean Remanufacturing* [16, 19, 20].

2.3. Need for Action

Already in 2000 and 2003, Guide as well as Ferrer and Guide pointed out, that most of the approaches to improve the planning and control processes for remanufacturing are limited to narrow aspects [15, 21].

Unfortunately, there is still a lack of knowledge when it comes to the assessment and improvement of remanufacturing processes (technical and organizational processes within the production), the comparability of remanufacturing processes, as well as the targeted improvement of remanufacturing processes. To close the lack of knowledge, both in industry and research, this paper shows the main aspects of a holistic approach to assess and improve remanufacturing processes.

3. Development of a Holistic Approach

The rudiments of the holistic approach are a maturity model, the value stream methodology and material flow simulations. The methodologies as well as the respectively developed tools are described in this chapter.

3.1. Maturity Models

Humphrey described the *assessment* as an important topic to evaluate the own position: “If you don’t know where you are, a map won’t help” [22]. Thus, the first model of the holistic approach is a maturity model. Maturity models enable the evaluation of operations and processes. The rudiment of each maturity model is a stage model which characterizes the levels of ability.

To archive a higher level of ability, defined criteria must be fulfilled [1]. Scientists from Bayreuth developed a maturity model, especially for remanufacturing operations. Following are the criteria respectively topics, which are assessed by using the maturity model for remanufacturing operations [23].

- Parts management (cores, spare parts and finished products)
- Technology know how
- Costs
- Information flow
- Material flow
- Quality management and assurance
- Technical cleanliness
- Resource efficiency (sustainability)

For gathering the data and to present the results, an Excel based questionnaire and calculation tool was developed. On the one hand, the maturity model and the tool enable remanufacturing companies to benchmark their processes