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Modular Simulation Model for Remanufacturing Operations

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Abstract

Today, remanufacturing is a key industrial discipline at the end of a product's life or use cycle. Due to high product and resulting process variety, static analytical approaches to assess and improve remanufacturing operations are not reliable. Whereas dynamic material flow simulation is a promising approach. Unfortunately, there is a lack of knowledge when it comes to simulation based improvement of remanufacturing operations. To close the lack of knowledge, this paper will show a modular simulation model to improve production systems of remanufacturing operations. The results will enable remanufacturing companies to assess and improve their production systems in an efficient way.

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Keywords: Material flow simulation; Production systems; Modularization; Remanufacturing

1. Introduction

To face challenges as increasing globalization and thus increasing competitive constraints, companies try to satisfy customers e.g. with more product variants. This increase in product complexity leads to increasing complexity in processes and production logistics as well [1]. The effort to produce goods increases with each new product variant. The degree of increasing effort depends on the occurring process complexity, which again depends on the product complexity [2].

Besides manufacturing companies, also remanufacturing companies face the challenge of increasing product and thus increasing process complexity, due to the broad spectrum of OEMs / OESs, product groups, quality levels etc. [3]. To the contrary of the new parts production, remanufacturing companies can only react passively on the increasing product complexity [2, 4]. Therefore, it is important to assess and improve remanufacturing processes and production systems.

Watts S. Humphrey descripted the *assessment* as an important topic to evaluate the own position: “If you don’t know where you are, a map won’t help” [5].

Material flow simulations allow to assess complex production systems in manufacturing as well as in remanufacturing. Unfortunately, the effort for such simulation studies is unneglectable. This paper shows a contribution to reduce this effort based on a modular simulation model for remanufacturing operations.

2. State of the Scientific Knowledge and Need for Action

In this chapter the state of the scientific knowledge and the need for action are described.

2.1. Remanufacturing

Remanufacturing is the industrial process to restore used products (cores) at the end of their life or use cycle to products with the same or a better quality than new products [6, 7].

According to Steinhilper, mechanical and electromechanical products have to be separated from mechatronic products. Mechanical products can be remanufactured in five main steps [8]. According to Freiberger, for mechatronic and electronical products it is useful to add a sixth step, which is the entrance diagnosis of the product [9]. The steps of remanufacturing according to Steinhilper respectively Freiberger can be seen in figure 1.

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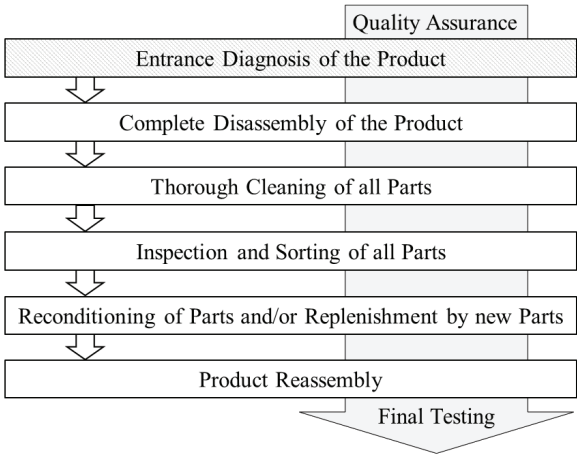

Fig. 1. The steps of remanufacturing according to [8] and [9].

2.2. Value Stream Mapping and Operator Balance Chart

Value stream mapping is a common approach to visualize production systems, holistically. Single process steps as well as material and information flows can be illustrated and assessed. Furthermore, potentials of improvement can be identified [10]. Operator Balance Charts (OBC) are an extension to value stream maps and allow to smoothen the material flow and takt times of the process steps [11].

2.3. Key Performance Indicators

Key performance indicators (KPIs) are qualitative information, which have been transformed into quantitative numbers to enable aggregated reporting [12]. The KPIs used for this paper are based on Peter [13]. An overview of the KPIs can be seen in figure 2.

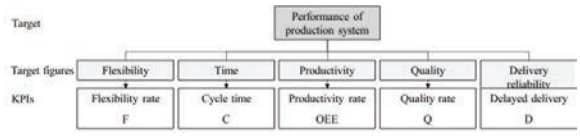

Fig. 2. Key performance indicators.

2.4. Material Flow Simulation

As value stream mapping, also material flow simulations are a common approach to assess and improve production systems. The advantage of material flow simulations is the possibility to assess complex models in detail [14].

The process model for simulation studies used in this paper is based on Rabe [15] and Wenzel [16], and is illustrated on figure 3.

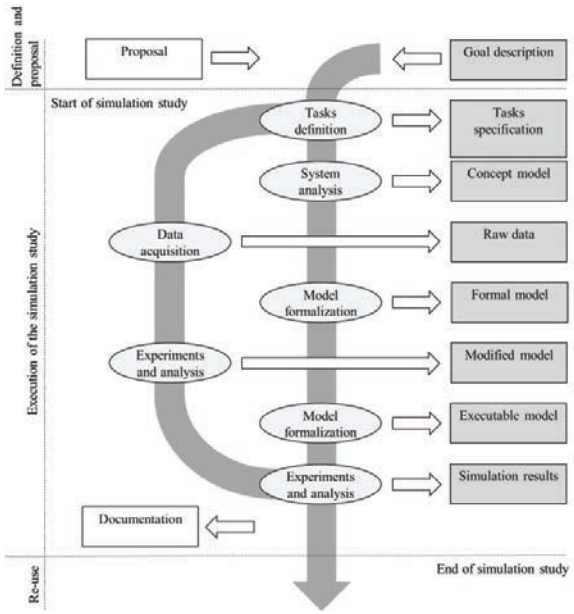

Fig. 3. Process model of simulation studies.

2.5. Need for Action

Approaches to assess remanufacturing processes have been shown already [17] especially focusing complexity [2, 3, 4, 18, 19, 20]. Unfortunately, there is a lack of knowledge when it comes to simulation based assessment and improvement of remanufacturing processes, both in research and industry. To close the lack of knowledge scientists from the Chair Manufacturing and Remanufacturing Technology at the University of Bayreuth developed a modular simulation model for remanufacturing operations.

This paper shows the development of the modular simulation model for remanufacturing operations. On the one hand, the modular simulation model for remanufacturing operations will enable remanufacturing companies to assess their processes, and on the other hand, the model will support them to evaluate the potentials of improvement.

3. Research Methodology

In the first step, a simulation model for a turbo charger remanufacturing process is elaborated. The relatively simple model, due to the relative simple product, is then adapted to simulate a more complex model of a combustion engine remanufacturing process. Based on the knowledge gained during the elaboration of the models, the generic and modular material flow simulation model for remanufacturing operations is developed.

The research methodology is illustrated in figure 4.