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Simulation-based Assessment of Segmentation and Control Strategies within Multi-variant Productions

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Abstract

The increasing individualization of products is an enormous challenge for manufacturing companies. An increase of product variants and thus product complexity leads to increased process complexity within productions. An option to face this challenge is the segmentation of productions. Unfortunately, it is hardly possible to assess segmentation and the corresponding control strategies by using common methods, such as value stream mapping. Therefore, a simulation-based approach to assess segmentation and control strategies within multi-variant productions is shown in this paper. The approach is applied for a multi-variant production for medical equipment. Besides the development of the approach, the paper also shows the assessment results for the case study production.

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Keywords: Segmentation Strategies; Multi-variant Production; Material Flow Simulation; Lot Size Configuration; Sustainable Production

1. Introduction

Increasing globalization of the markets and increasing competition are two of today's challenges for manufacturing companies. Besides increasing globalization and competition, also the individualization of products is an enormous challenge for manufacturing companies.

Thus, the importance of strategic production planning, to increase the efficiency and profitability of productions, increases [1].

Nevertheless, cost efficiency respectively minimization is not the only target dimension, which has to be optimized. This leads to the conflicting goals, to manufacture customized products in the right quality, at the right time and to the right price [1].

An option to face these conflicting goals is the segmentation of productions. Segmentation of productions means the division of product variants and processes into small and transparent units. Thus, the conflicting goals are faced by renunciation of process orientated production structures towards product oriented production structures which are aligned with the customers' demand [2].

2. State of the Scientific Knowledge and Need for Action

2.1. Production Systems

The aims of modern productions are based on the endeavor of companies to save and extend their market success. To do so, manufacturing companies have to face today's trends and effects [3,4]. For productions, that means unsteady incoming orders, an increasing number of variants as well as the trend towards short dated orders, and at the same time shorter life cycles as well as faster technological progress [5,6].

Due to the variety of internal and external influencing factors, productions are subjected to intense performance and market complexity. To stay competitive and to be able to produce efficient, there is a trend towards holistic and comprehensive production systems [3,4,5].

A production system is described as a production organization, including all concepts, methods and tools. Those components influence the effectivity and efficiency of the production process through their interactions [7]. The advantage of (holistic) production systems is the ability to

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react targeted and continuously on market changes and technological progress [6,8]. The most noted production system is the Toyota Production System. Topics as wastage reduction, continuous improvement, standardization, teamwork, transparency etc. are the base for many modern production systems. Nowadays, some of the concepts and methods are assigned to Lean Production or Lean Management [4,9,10]. The application of a Lean Production enables the reduction of lead times as well as the increase of flexibility and planning certainty [8,9].

2.2. Variant Management

Variant management is described as the holistic approach to control the variety of variants [11]. For manufacturing companies, mastering the increasing variety of variants is one of the key tasks of the production planning and control (PPC). Wildemann distinguishes between three measures to be taken within variant management, which are: complexity prevention, complexity reduction, and complexity control [8]. Thus, the aim of variant management is the extensive prevention or reduction of complexity and the control of the remaining complexity.

2.3. Methods and Approaches for Production Optimization

In this section, methods and approaches to analyze and optimize processes within multi-variant productions are described.

Value Stream Methodology

The aim of the value stream methodology is to analyze productions regarding wastages and to design lean material and information flows [12]. According to Erlach, the value stream methodology can be subdivided into the value stream analysis and the value stream design [1].

Digital Factory

According to the VDI manual 4499, the term Digital Factory is described as the comprehensive network of digital models, methods and analysis tools, which are integrated through a consistent data management. Key element of the Digital Factory is the simulation of production and logistic processes. The aim of the Digital Factory is the continuous analysis, standardization and optimization of productions.

2.4. Production Planning and Control (PPC) Strategies

Due to the high number of variants and the volatile customer demand, it is reasonable to control productions flexible and customer oriented. Fig. 1 illustrates the four strategies to control productions, according to Selke [14].

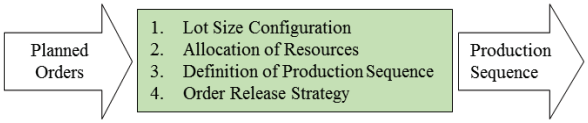

Fig. 1. Strategies to control productions, according to [14].

Lot Size Configuration

Within the lot size configuration, it is defined, how many orders of one variant are pooled to one lot. The optimal lot size is oriented at the customer takt time respectively the order size as well as at the efficient usage of the production capacities. Besides the optimization of the starting lot size, there are also several strategies available, to change lot sizes within the production flow. Due to technical or organizational reasons, it can be useful to pool or separate lots before defined process steps. Furthermore, the parallel processing of lots on several machines can be useful. [14,15]

Allocation of Resources

Within the allocation of resources, the production processes are allocated to the available resources, according to defined criteria. Criteria to allocate resources are, among others: workload, set-up effort and process time. [14]

Definition of Production Sequence

The definition of the production sequence can be done according to certain rules, e.g. First In - First Out (FIFO). Other criteria to prioritize orders are the completion date, the shortest or longest total process time or the shortest set-up time. [14,15]

Order Release Strategy

The strategy to release orders defines when and where the production orders are released. Strategies are, among others, control according to manufacturing order, load oriented order release or control by the Kanban principle. The Kanban principle is a decentralized order release strategy which works according to the pull system. Thus, overproduction is avoided, as production resources produce only if there is a demand. [16]

2.5. Segmentation Strategies

The segmentation of products and processes is a common strategy within variant management in order to manage complexity within productions. Especially in case of a high number of variants, segmentation can reduce cycle and set-up times and thus make productions more efficient. The segmentation of productions is done due to product and process specific criteria or due to demand and market oriented criteria. For each of the segments, it is necessary to develop an own production strategy. [8]

The segmentation of a production leads to targeted division and aggregation of products (product segmentation) and processes (process segmentation). The segmentation is done based on detailed analysis of the variants spectrum, such as cluster or ABC-analysis. Criteria are, among others, similarities, quantity, customer demand, lot size, delivery times, lead times and set-up times. [2]

Segmentations are useful, if the demand of single variants as well as the variation are predictable, intermediate-term and long term [2].

The conflicting goals of the segmentation are to reach a high utilization of resources, despite the division into product and process segments [2].