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Method for a situation-based adaptation and validation of the manufacturing capability of assembly systems

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Abstract

This paper presents our approach and the developed method for a situation-based adaptation and validation of the manufacturing capability of assembly systems. After motivating the research the problem statement and the state of the art in the field of assembly planning will be discussed. Afterwards the overall approach will be introduced. The method, which is developed based on the approach will be discussed and the derived software tool, which will support the planner in his daily activities, will be presented and explained. The paper concludes with a summary and an outlook.

Keywords: Assembly System, Modeling, Factory Planning, Manufacturing Capability

1. Introduction

There are three major challenges concerning the efficient and economic operation of assembly systems. These are the increasing number of product variants and shorter product life cycles, the increasing alteration rate of the order composition and based on this the increasing numbers of set up procedures considering machines and equipment [1]. Additionally, external factors from the global market like the demand of customers for innovative, state-of-the-art and individual products, supply bottle necks or different types of crises affect the assembly systems, as well. The challenges derive from the so called mega trends – individualism, ageing, innovations in technology, sustainability – which directly influence the operation of assembly systems, through increased turbulences. [2]. This matter of fact, is already known in the scientific community and is approached by strategies to increase the flexibility and changeability of assembly systems [3][4][5][6][7][8]. Although, these strategies mainly focus on increasing the middle – long term changeability of assembly systems and their structures. To ensure an efficient and economic operation of assembly system in this turbulent environment, approaches and methods for short term adaptations, which allow a permanent and situation-based adaptation of assembly systems, have to be developed [9]. Thereby our approach aims at the manageability of the systems complexity, the enabling of an intuitive model development and the acceleration of optimization and adaptation processes.

After emphasizing the potential and the benefits of such a method, an overview of the Method for a situation-based adaptation and validation of the manufacturing capability of assembly systems is given. Afterwards the state of the art regarding contemporary methods for assembly planning and optimization is presented and the approach as well as the developed method will be introduced. The paper concludes with a roadmap for future research activities, which can be undertaken to drive the research for short term adaptions of assembly systems even further.

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2. Problem statement and Motivation

Today's manufacturing is influenced by enormous short term influences, considering product variants, order compositions and technical innovations. Customers are able to influence their orders even if they are already processed in the assembly system. Additionally, short term orders done by key account customers disrupt the already executed production plan. Furthermore customers are able to place last minute changes on the configuration or production process of the product, due to the increasing competition. This leads to permanent adaptations of the operation and the structure of assembly systems and cause failures of machines as well as ends in downtime of the whole system. In this environment a permanent adaption of the assembly system structure is not any longer optional. In fact it is a critical factor to ensure the competitiveness, to operate in an turbulent environment.

However, the modeling and subsequent simulation of an assembly system, with all the relevant data and information, is a time and knowledge intensive task. Today, commercial digital tools indeed support the modeling and simulation process through an efficient data and information management, resource libraries and process management, but do support the process of the model development and the integration of knowledge into a model in an insufficient way [10].

Thus a new approach has to be found to provide a valuable support for engineers in the production planning and control department. To ensure this valuable support the method has to support the modeling of the current situation of the assembly system and subsequently the analysis. Furthermore a procedure to identify discrepancies considering the optimal operation has to be provided. Thus the planer knows exactly if there is a need for an adaptation and when he has to initiate it. Additionally the method has to provide assessment criteria to evaluate adaptation concepts. This coherence is depicted in Figure 1.

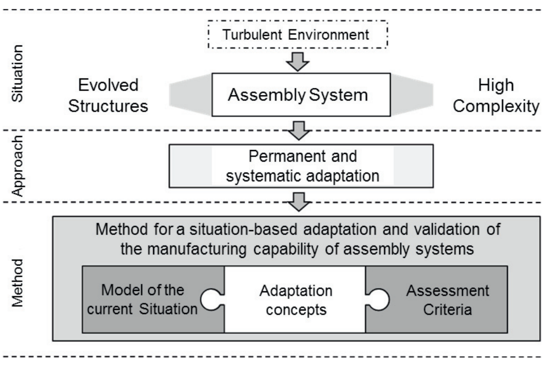

Fig.1: Approach and method for an situation-based adaptation of assembly systems

3. Assembly planning and optimization – today

This chapter provides the state of the art considering the assembly planning and optimization methods. Additionally it presents approaches to structure assembly systems and increase their changeability.

3.1. Structure of modern assembly systems

To enable an active adaptation of the complex structure of assembly systems, different approaches have been developed. However all of these approaches employ the basics of System Theory [11]. This method is suitable to structure complex systems and provides a generic approach to describe them by consistent terms to be able to predict the future behavior and performance of a system. Thus a model developed from the system theory perspective comprises an arrangement of elements, which are defined through specific attributes, connections and different activities within a determined system boundary [12].

An important foundation for the structuring of assembly systems was provided by WESTKÄMPER. In this approach a production system consists of performance units, which are able to operate in turbulent environments, due to their system immanent characteristics. They contain factory objects and workers and operate self-controlled and self-organized. A performance unit additionally has relations to other performance units which enable an active cooperation. Thus a system is structured horizontal and vertical through performance units. This enables an efficient and short-time reaction to fast changing environments [5] (Figure 2).

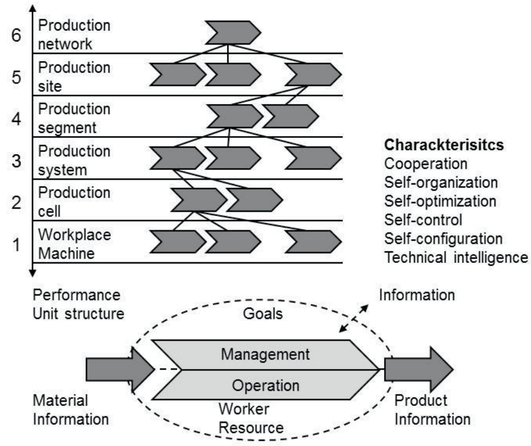

Fig.2: Structure of performance units in the Stuttgart Enterprise Model

Additionally there are further approaches to structure assembly systems and to increase their changeability. Thereby these approaches focus whether on the organizational or the technical aspects of an organization. Organizational approaches are developed by WILDEMANN and WARNECKE. Wildemann pursues the approach of a modular factory. Thereby the assembly system will be divided in modules which perform a specific production task [13]. However, WARNECKE follows an approach called the fractal factory. The assembly system in this approach is clustered in independent fractals, which perform their production task independently [14]. These