Dissertation title:

Integrated Product and Assembly Configuration for the Volume Assembly of Customized Products

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The ongoing trend to individualized products under a high competitive pressure by the globalization of the enterprises and the markets, forces the companies to respond to unforeseen changes in a short period of time. Due to this trend, the realization of intelligent structures for highly efficient and changeable manufacturing is an important competitive factor. This thesis introduces a possibility to increase efficiency and especially changeability in the volume assembly of customized products, by the provision of systemic information. It aims at the information provision to improve the coordination of measures to adapt the product and the assembly system and to guarantee the mounting capability of complex products in an available assembly environment. Therefore the integrated product and assembly configuration was developed as a model based decision support. It contains a procedure for a situation-based system configuration and an information system which uses an ontology-based model of the integrated product and assembly system.

The configuration is based on an integrated comprehension of the product and its assembly. Therefore the elements and their relations in the system are conceptualized by the means of common system theory. The elements get modularized to independent, self-contained functional units. Through the interaction of these modules, the function of the overall system gets fulfilled. The permanent change of the considered systems and their environment is identified as a great challenge for the conceptualization and monitoring of the integrated product and assembly system. To increase the tangibility of these changes, they get analyzed and categorized into product, system and assembly specific change drivers. Discrete changes of the system, its environment or single modules get identified, analyzed and synchronized with a focus on a short to mid-term interval using the configuration calendar. Continuous changes are considered through the monitoring of the development of the performance of the system using learning curves. These changes are understood as disturbance values in a control circuit between the physical system and its conceptualized model, to reduce the gap between the real and the digital world to increase the information quality.

The following virtual product and assembly configuration has three stages. Firstly, possible adaptation measures are determined to respond to the identified needs for change. Secondly, the consequences of specific adaptation measures on the behavior of the integrated product and assembly system is analyzed. This stage is supported by a proprietary developed information system. The information system is predicated on an ontology-based model of the conceptualized product and assembly system. Three apps are realized for a situational extraction and flexible representation of the desired

information. These apps allow the visualization of information in a tabular, graph-based and matrix-based form. Thirdly, valid system alternatives can be configured by this target-oriented provision of reliable information about the consequences of specific adaptation measures. Therefore, not only information about executable states of the system are provided, but also information about the necessary measures to convert the present system into the targeted system.

The configured system alternatives have to be compared to select the best option. Therefore, an evaluation scheme was developed to realize a comprehensive assessment in consideration of the efficiency, the reliability and the changeability of the respective system configurations. These criteria are subject to a case-based weighting, to realize a situation-oriented comparison of the system alternatives taking into account the present conditions and targets. This evaluation scheme enables a reliable selection of the optimal configuration of the integrated product and assembly system at low effort.

The industrial usability could be verified by a practical execution in a company that assembles car seats. Thus, the feasibility of the integrated product and assembly configuration in an industrial environment could be demonstrated and the low effort for the situation-based creation and flexible provision of relevant information for the reliable prediction of the system behavior which gets adapted by configuration-based measures could be verified. The mounting capability of a new product variant could be assured and the coordinated operation of adaptation measures could be realized.