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Methodology for the evaluation of forecast reliability of production planning systems

Günther Schuh, Till Potente, Annika Hauptvogel *

Laboratory for Machine Tools and Production Engineering (WZL) at Aachen University, Steinbachstraße 19, Aachen 52074, Germany
* Corresponding author. Tel.: +49-241-80-28390; fax: +49-241-80-22293. *E-mail address*: a.hauptvogel@wzl.rwth-aachen.de

Abstract

The high dynamics of markets are only one reason for the increasing complexity of production planning and control. To handle this complexity manufacturing companies have implemented IT systems to support decision-making in detailed scheduling processes. However, applied IT systems often do not provide a reliable forecast of delivery dates, because the planning models are implemented uniquely and have never been adapted due to changes in the production system. This paper presents an approach to verify the forecast reliability of detailed planning systems by identifying deviations between the predicted production schedule, determined by the IT system, and the observed production processes in reality. The paper introduces the reasons for deviations and explains how they can be determined. The approach represents how categorical and continuous verification methods can be applied to identify the described deviations. Depending on the determined deviations the forecast quality index of detailed planning systems is developed. Besides the assessment of the forecast quality the reasons for deviations are of interest to production planners. Identified reasons are the starting point for adaptions in planning models to enable a reliable forecast of re-configurable production planning systems in the future.

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1. Introduction

Due to the increasing need for high quality customized products at competitive prices dynamics in manufacturing processes have risen further [1]. To cope with this challenge a capable production planning and control (PPC) is essential [2]. Therefore, IT systems are indispensable. IT systems supporting the user in production planning such as Advanced Planning and Scheduling Systems (APS Systems) are called production planning systems. Their functional model and data model should be changeable according to the high dynamics in manufacturing processes [3]. However, there is a gap between the implemented models and the reality on the shop floor as analyses in manufacturing companies confirm. The similarity between the planning determined by the planning system and the real situation on the shop floor decreases to 25 % after just 3 days, as analysis in companies with individual and small series production show [4]. Because a high adherence to delivery dates is the main logistic target [5], every manufacturing company is interested in the reliability of the forecasted production plan to use it as a basis for secured delivery date confirmations. Following lacks of current planning systems can be summarized:

- Insufficient image of the actual situation in terms of feedback
- Rigid structures and a lack of adaptability of planning systems
- No continuous adjustment of master and transaction data as well as models to the real environment
- No regard of deviations between the model implemented in the planning system and the real situation of the manufacturing processes

These problems result in unreliable predictions about the future situation in the manufacturing. Hence, an accurate

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image of the manufacturing will be even more important in the future.

Within the publicly funded research project “ProSense” a high resolution production management based on cybernetic assistance systems and smart sensors is developed [6]. Using intelligent sensors more data is generated to get a more detailed image of the situation of the manufacturing processes. Based on second order cybernetic control problems in the planning and manufacturing processes are identified to define measures in order to prevent these problems in the future. This paper focuses on the determination and adaption of deviations in the plans determined by detailed scheduling system to ensure a reliable manufacturing planning.

2. Requirements

Today companies rely on detailed planning systems to manage the complexity of the production and to support the PPC. Requirements for such IT systems include a reliable statement on the completion date of all orders and thus the reliable attainment of the customer agreed date. The presented lacks of current planning systems, which are applied in manufacturing, results in several requirements for planning systems:

- Continuous adaption of the data used for planning
- Continuous adjustment of the models used for planning
- Always representing the real situation on the shop floor
- Determination of deviations between the planning and reality
- Determination of the reasons for the deviation from the plan generated by the applied planning system
- Determination of the forecast reliability

In the following current approaches are described in the state of the art considering the mentioned requirements. In the second part of the paper an approach to identify deviations between planned and real manufacturing processes is described. Afterwards a forecast quality index of detailed planning systems is introduced.

3. State of the Art

3.1. Self-Optimization

The demand for continuous adaption is also regarded within the approach of self-optimization. The principle of self-optimization is approved to face the complex environment of manufacturing processes [7]. Self-optimization consists of three actions: Analyzing the current situation, determining the system’s objectives and adapting the system’s behavior [8]. The current concepts of self-optimization in manufacturing processes can be reduced to three initial approaches: the fractal company [9], the holonic manufacturing system [10] and the bionic manufacturing System [11, 12].

The fractal factory is defined by several fractals which represent independently acting manufacturing units. Fractals can be described as self-similar, self-organizing and self-optimizing. Each fractal follows its own goal, which lies within a goal system. The fractals are linked through a dynamic and self-regulating network. [9]

A Holonic Manufacturing Systems (HMS) is made up of holons. Holons are autonomous and co-operative building blocks that carry and process information or physical objects arranged within a system of cooperation to achieve a common goal, the so called “holarchy”.[13]

Bionic approaches replicate the structure of a living organism. The manufacturing system is arranged hierarchically into several components. Furthermore, the concepts of differentiation and proliferation of cells, the genetic function, evolution and self-organization as well as an enzymatic function and the autonomous distributed system are reflected within a so called life software.[10]

These approaches are transferable to the organizational structure of production systems. Within these approaches decisions are taken based on current data from production. Since the highly decentralized approaches prevent a prediction of their future behavior, they react quickly to current events rather than to plan prospectively.

3.2. Automatic Model Generation

An approach to face the demand for continuous adjustment of the models used for planning and representing the real situation on the shop floor is the application of automatically generated models of the manufacturing system. This so called automatic model generation (AMG) was developed to accelerate the generation process and enhance the accuracy of the simulation models [14]. Four approaches are regarded in the following.

Selke describes a solution to generate models automatically from the analysis of applied strategies and operations regarding scheduling, sequencing and determination of lot sizes in production and logistics [15]. The approach mainly focuses on the development of a strategy analysis [16]. Plan data generated by detailed scheduling systems is not regarded and the approach is not feasible for daily use in production planning and control.

Horn develops a scheduling and sequencing system, which is based on a simulation-based optimization combined with an AMG [17]. The simulation models are automatically generated from mini-templates and parameterized with data from a simulation-repository database. This database is filled by the production-related databases (ERP, MES). The simulation models are automatically generated based on the current data provided by the applied IT systems. An adaptation of the models depending on identified deviations in process times does not take place.

Pfeiffer develops a simulation system using an AMG and focuses on the sensitivity analysis and off-line validation of schedules as well as on a plant-level disturbance handling [18]. The relevant data is extracted from the MES and enriched by information from the ERP system. Beside the heavily customized model generation to fit the enterprises IT structure, Pfeiffer implements several dispatching rules and loading logics [19, 20]. The hereby generated model is used to evaluate new scheduling rules under consideration of the WIP, queue sizes and output. This approach considers plan

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