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Engineering Environment for Production System Planning in Small and Medium Enterprises

David Goerzig[a*], Dominik Lucke[b], Juergen Lenz[a], Timo Denner[b], Michael Lickefett[a,b], Thomas Bauernhansl[a,b]

[a] *Institute of Industrial Manufacturing and Management (IFF), University of Stuttgart, Nobelstrasse 12, 70569 Stuttgart, Germany*
[b] *Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Nobelstrasse 12, 70569 Stuttgart, Germany*

* Corresponding author. Tel.: +49 711 970 1995, E-mail address: David.Goerzig@ipa.fraunhofer.de

Abstract

Today, factories have to be adapted permanently in order to follow the developments towards fast changing customer demands and faster life cycles of products. Key aspects to cope with these developments are the reduction of the unit costs and the planning duration as well as the improvement of the planning quality. In order to overcome these challenges, digital tools can support all phases of factory and process planning. Most of them provide a wide range of functionalities, which require a large invest in software and high operation costs to use them efficiently. Often, small and medium enterprises (SME) cannot afford such invests and operation costs. Therefore, new digital factory planning tools tailored for SMEs supporting the production system planning are required. Main goal of the “WiES-Pro” project, funded by the Ministry of Finance & Economics Baden-Württemberg, was to develop an engineering environment for production system planning suitable for SMEs. The “WiES-Pro” approach connects small specific software tools for production system planning in an integrated platform, capable to share information and knowledge easily. The challenges in the development are to cope with both the heterogeneous data from different sources like machine master data, work plans or product data and the applicability to SMEs. This paper presents the results of the project, consisting of the approach and its implementation. Also the architecture of the browser-based platform and the developed digital factory planning tools for priority graph optimization, assembly process time planning, similarity-based product search and material flow simulation are presented shortly.

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Keywords: Production system planning; process planning; digital factory tools;

1. Introduction

Today, factories have to operate in a highly dynamic environment. The trend towards high customization of products with an increasing number of variants, the globalization of market structures and shorter product life cycles require a permanent adaption of the factory to the current situation. In this turbulent environment only robust and flexible factories survive [1,2,3]. Key aspects to cope with these developments are the reduction of the unit costs and the planning duration as well as the improvement of the planning quality [4]. Life cycle-based approaches for products and factories help to overcome these challenges. This requires the availability of data along the whole product and factory life cycle. Here, digital tools support all phases of factory and process planning.

2. Motivation

While large enterprises actively use tools of the digital factory, many small and medium enterprises (SMEs) have not yet engaged with this topic [5]. This is mainly a result of the gap between expenditures for capital and license costs, know how as well as lack of experts [5] and the generated output in form of improvements like planning quality and quantity [6]. The solutions offer too many functions and are too complex and expensive for small and medium enterprises [7]. But through the trend of globalization even small and medium enterprises are part of global supply chains. As a consequence

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they are confronted with the same challenges as large enterprises [8]. Especially when it comes to cooperation with large enterprises, small and medium enterprises are forced to adapt digital solutions [9].

Small and medium enterprises need fast and simple solutions that can be used instantly. As a consequence, most of the SMEs use office-based solutions. The planning know-how is mostly owned by a few employees and is not written down or defined in a clear process [9]. In small and medium enterprises factory planning is still accomplished by cost-saving 2D-planning tools like AutoCad® or Microsoft Visio® [6,10]. However, these tools are isolated applications. This complicates the exchange of data along the product life cycle [7]. Therefore, new digital factory planning environments tailored for SMEs supporting the production system planning are required.

3. State of the Art

In the field of digital factory planning, several approaches covering different aspects of the planning phases have to be mentioned. An overview of the different approaches is given by Landherr [11] and shortly presented in the following. The grid engineering for manufacturing approach aims at facilitating planning process and the management of the information of the product and factory life cycle by adapting ideas and technologies from grid computing [13,12]. Other approaches for digital factory planning are presented in [5] and [14] interlinking the processes, data, systems and user through a suited data management platform. Commercial planning platforms of the digital factory such as Siemens PLM Teamcenter® and Technomatix® [15], Delmia 3DEXPERIENCE® [16], PTC Windchill® [17] provide a large number of planning functions. Due to their development history to match the requirements of the automotive and aerospace industry they are oversized in most cases for SMEs.

4. Approach

The main idea of WiES-Pro is to support the planner in a SME with information and knowledge in different phases during production system planning with digital tools. Goals of the WiES-Pro environment are to improve planning quality, shorten the planning duration and reduce the costs of production system planning in SMEs. The WiES-Pro approach consists of an expandable suite of several SME-tailored digital factory tools with a central data hub forming the WiES-Pro planning environment. Main functions of WiES-Pro data hub are to store and provide synchronized product data, work plans or extracted work orders to the different applications, see Figure 1.

The key advantage of WiES-Pro is the reduced number of functions in the single connected applications. During a planning activity several connected applications are applied. This approach leads to different advantages for SMEs. Due to the small number of functions per application, the training for the employees is non time-consuming training and easy for the employees. Also the factory specific instantiation of the WiES-Pro environment is simplified.

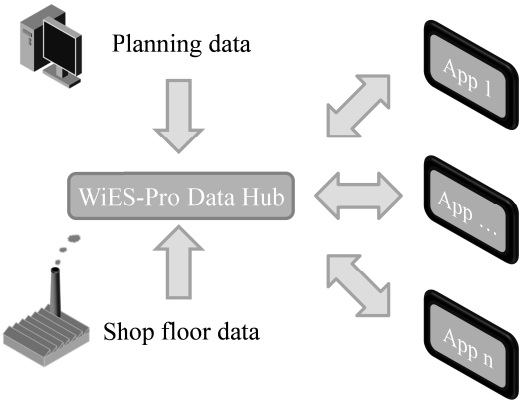

Figure 1 WiES-Pro Approach

5. Implementation

Premise for the implementation of the WiES-Pro approach is to use SME capable, non-expensive, standard software. In the following sections, implemented components are presented.

5.1. WiES-Pro Data hub

In order to provide synchronized information for the different planning applications, a data hub is required. With the focus on SME, the major criteria for the implementation are an easy setup, configuration and customization to the specific factory. Therefore, as foundation for the implementation, the idea is to use a document management system, capable to manage list data and documents. List data are in this case the factory structure, machine master data or bill of materials of the products or production orders. Documents in this case comprise CAD files or simulation model files or NC programs. For the implementation of the WiES-Pro data hub Microsoft SharePoint® has been chosen due to good SME capability. Main advantages are low requirements of capital and know-how. Additionally it offers high security standards. It disposes of a Microsoft SQL Server®, which is a relational database management system. Figure 2 shows the WiES-Pro data hub and four exemplary tools which are presented in the following.

The Microsoft SharePoint provides the foundation for data management, user administration as well simple work flow management, project management and collaboration functions. On top the WiES-Pro data model as well as application specific websites are instantiated, providing the applications, the application specific synchronized information and knowledge. The planner then can transfer the know-how of finished projects, identify similarities to earlier projects or analyze the status at the shop floor. The connected applications are executed out from the portal either locally as a client or directly as a web application.

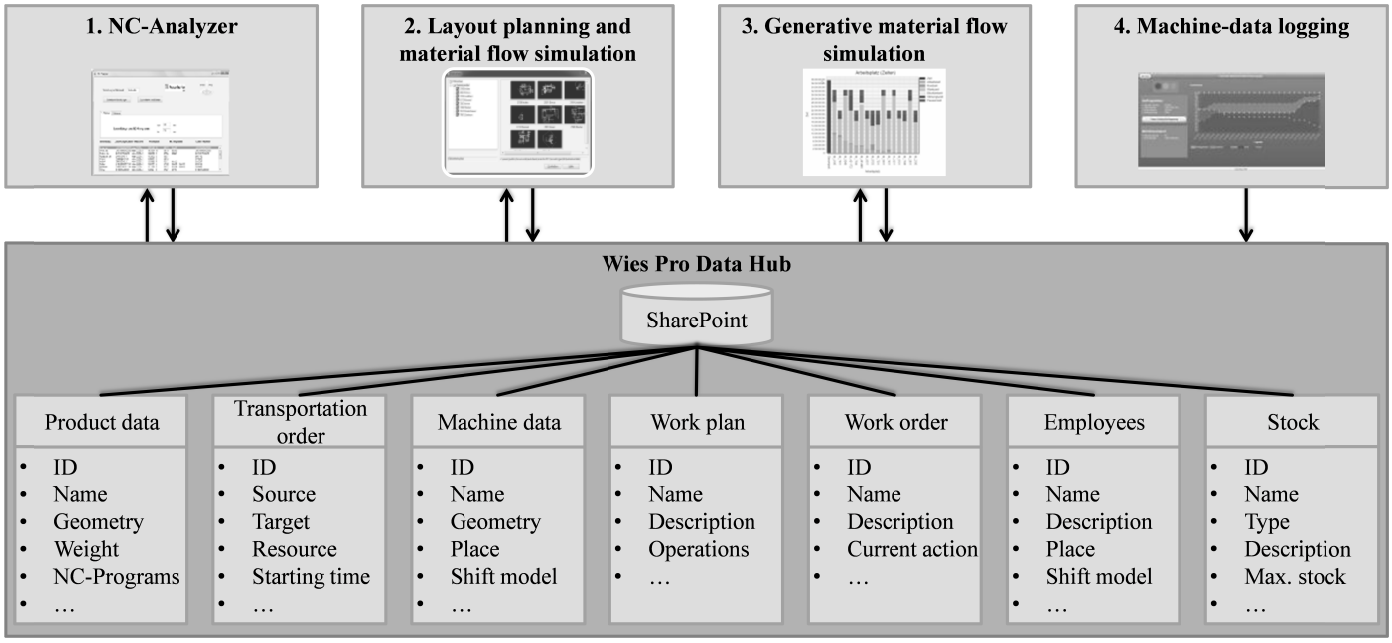

Figure 2 Structure of WiES-Pro

5.2. NC-Analyzer

The idea of the NC-analyzer is to help the process planners of SMEs to find similar parts compared to the part which needs to be planned. This is done by analyzing NC-files of previous parts and calculates attributes out of the re-enacted tool movement. These attributes are then compared to the current part. Afterwards, the similarity search algorithm is used to identify the part with the best match. This approach will help to develop the field of Computer-Aided Process Planning (CAPP). The implementation is done with MATLAB and was validated using current production data by a German SME with a turning process. As a conclusion, the NC-analyzer prototype tool was used successfully to demonstrate the feasibility of the developed method. Future activities are expanding to other G-Code-based production processes.

5.3. Layout planning and material flow simulation model editor

One of the main targets of the WiES-Pro environment is to improve the quality of factory planning. The layout planning is highly influenced by the material flow of the products. Therefore, the idea is to support the planner during layout planning activities with easy to generate material flow simulation models. The modelling of material flow models usually requires high skills. Therefore, the simulation model is graphically created and edited as part of the layout planning activities. The modelling is based on the value stream visualization for machines and storages. In addition to the shape of each machine and storage in the layout a corresponding value stream object can be added. It consists of graphic representation and attributes. It is implemented as an AutoCAD-add-on (Figure 3).

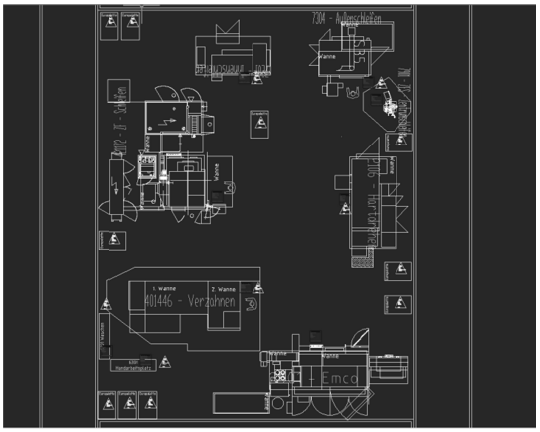

Figure 3 Layout planning and material flow simulation model editor

The data inside the objects are synchronized with the WiES-Pro data hub. The object data of the model are implemented as machine and storage master data lists in the WiES-Pro data hub. The CAD-model is also able to import data from and export data to the SharePoint. Thus, it is possible to create rough layouts and to specify them afterwards.
Additionally, the tool is the interconnecting link between the wide spread factory layouts in AutoCAD and the WiES-Pro data hub. It provides positioning data of stock and technical resources on the shop floor for the simulation.

5.4. Generative material flow simulation

The aim of the generative material flow simulation is to realize a fast validation of the previous layout planning without any modelling know-how. Therefore, the WiES-Pro environment uses an automated simulation on basis of standard models which is directly connected to the WiES-Pro data hub. The planner performs various experiments through

adapting the initial values of the simulation. This can be realized either by using the different applications of the WiES-Pro environment such as the layout planning or by manual adaptions in the WiES-Pro data hub. To further simplify the validation process the in- and output parameters of the simulation were reduced to the most important indicators. As a result, the number of possible settings and thus the preparation time is reduced.

5.5. Machine-Data logging

The operating and machine data logging is an application which is especially designed for SME. Through its web-based design which is shown in Figure 4 it is compatible to miscellaneous hardware devices. Main idea is the application on a tablet or a smartphone which is placed near the machine. The operator logs his actions with the help of the touch screen. He can register for example the status of orders, breakdowns, quality failures or shortage of material. The operating and machine data logging helps the enterprises to verify the results of the simulation in the real production.

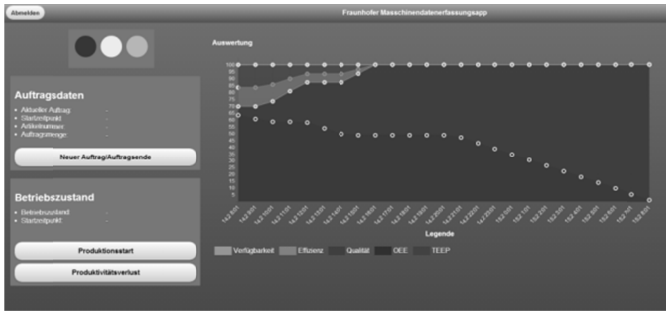

Figure 4 Machine data logging

With the application the operator is enabled to log different condition of the machine with the help of a user interface. It is possible to relate the data to different machines or operators. During the logging process, the operator permanently gets information about the current order and the development of the overall equipment effectiveness of the machine. (OEE)

6. Conclusion and Outlook

The presented WiES-Pro environment for production system planning supports the planner in a SME with information and knowledge in different phases during production system planning. Goals of the WiES-Pro environment are to improve planning quality, shorten the planning duration and the costs of production system planning in SMEs. With the focus on the application on SMEs a suite of digital factory tools with a reduced number of functions interlinked through a data hub has been developed.

The implementation of additional planning applications evolving the WiES-Pro environment represents the main topic of our future work.

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