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A holistic product lifecycle management approach to support design by machine data

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Abstract

This paper is based on an experimental environment with various systems (CAD, CAM, ERP, PDM, MES, TMS) and a coupled milling machine. Based on a holistic view of the process chain and a methodical approach it is possible to ensure a smart bidirectional flow of information between the systems from order and design to manufacturing. As a result technical and economic advantages can be achieved in the early stages of the product life cycle. Especially in design phase plan costs, routing, machinability and processing time can be already considered.

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1. Introduction

In order to withstand international competition it is necessary to reduce production costs and to keep a high product quality. Especially high-wage countries has to produce more efficiently in order to stay competitiveness [1]. Another challenge is that there is a rapid change of knowledge and technology in many fields, such as software engineering, nowadays. This requires already networking and communication of knowledge in the early phases of a product [2]. In particular the product development process is important to reduce the overall costs. That means that between 60 and 80 percent of the entire costs are defined between the concept and preliminary design phase. The later the problems takes place the higher are the costs. The rule-of-ten states the costs to fix a problem in the next process step is ten times higher than before [2]. For that reason the improvement of the design process has a high saving potential.

Product lifecycle management (PLM) is a method to improve the information management in companies. The focus of product lifecycle management systems has long been in the area of planning, design and engineering functions. Nowadays the PLM-systems try to cover more and more of the whole product lifecycle from ‘cradle to grave’ [3]. To enhance the information flow three domains (people, process, information) needs to be carried out [4]. To implement a PLM-system across the entire product lifecycle there is a huge need for smoothly functioning, carefully designed product lifecycle management processes (Support processes, integrate systems, information conversion and preserving information over years) [5]. One problem is that often information are missed or have a bad quality. Especially in the design process, which is in an early phase of the product lifecycle, the information are incomplete and imprecise [7]. Usually the information feedback from low-level manufacturing activities to high-level design is handled by human interactions [8]. As a basic for improvement the machine data is transmitted and visualized in a Manufacturing Execution system (MES) [9]. Through diagrams/graphs and key performance indicators like Overall Equipment Effectiveness (OEE) production manager detect problems and initiate a change process [10]. A media disruption is so taking place in the information flow. This fact shows that there is improvement potential for automatization.

The more information are available in the design phase the less complications and expenses are in the later phases of the product lifecycle especially in the phase of production. A big

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benefit is to know already during construction which machine and which tools with which technology parameters are available. As a result the work piece of this framework is designed properly. Based on a good data quality the machinability can be ensured without major revisions. Another factor that already can be considered during design is to avoid if possible cost intensive features of the workpiece. For this assistance a software-tool with high quality data is necessary.

A complexity is to keep the individual system databases on a current state. Often an enormous effort is necessary to maintain all databases. For the supply of information with good quality data, the IT system environment and production must be smart linked. The interfaces of the individual systems often have to be adapted to the individual environment of the enterprises.

The aim is to establish a smart information cycle in the whole lifecycle. Internet of things is the approach which it is based on. “Internet of Things (IoT) is an integrated part of Future Internet including existing and evolving Internet and network developments and could be conceptually defined as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable, communication protocols where physical and virtual ‘things’ have identities, physical attributes, and virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network” [11]. Through the return of data from the production relevant databases can be filled which can support the designer. The importance of information at the right time with the right quality at the right place is worth a lot in the sophisticated corporate world. With appropriate software tools, lined with information, the designer can prepare already during the design process the workpiece optimally for the next steps.

2. Data management systems for design and manufacturing

IT-Systems become more and more importance for the industry. A very competitive factor is the information flow time. An effective information flow shortens the processes [12]. Another advantage of the computerization in manufacturing industries are new possibilities for the enterprises to try new methods like data mining and process virtualization for improving the overall performance [13].

The main IT-Systems in enterprises are the following:

- ERP: Enterprise Resource Planning
- PDM: Product Data Management
- MES: Manufacturing Execution System
- SCM: Supply Chain Management
- CRM: Customer Relationship Management

The constellation of the IT-systems depends on the different characteristics and size of the companies.

For simulation and demonstration aspects the Institute for Information Management at the Karlsruhe Institute of Technology in cooperation with cooperation partners from the industry established an IT-Systems environment oriented by a cutting enterprise. The landscape includes the following systems: Enterprise Resource Planning, Product Data Management, Manufacturing Execution System, Tool Management System (TMS), Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), CAD-Analysis-Tool. To implement the interfaces between the systems the institute works hand in hand with the cooperation partners. The IT-Systems are coupled with a milling machine. The IT-Systems are based on a server farm coupled with databases (Figure 1). Most of the IT-systems are based on a client-server model.

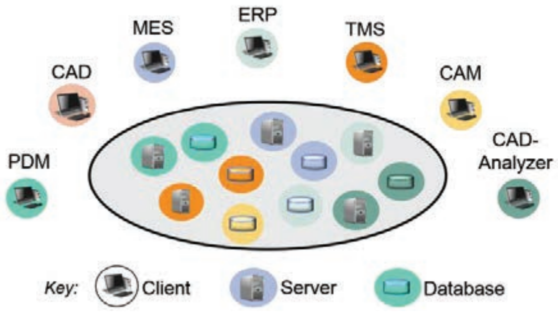

Fig. 1. IT-park

The system landscape is linked according to the principles of product lifecycle management and seeks to ensure a continuous bidirectional information flow without media disruption (Figure 2). Particularly critical is the repatriation of information from the manufacturing to the design process.

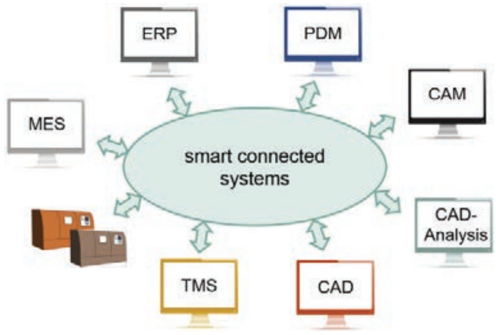

Fig. 2. Smart connected IT-system environment at IMI

To set up a demonstration environment it was necessary to define a simplified process from product development to production. This defined information flow affects the interfaces between the systems. The connection between the systems depending on the individual processes of the enterprises. By adding or exchanging a new system in a company there is this first big decision if the system adapts the existing processes or the processes adapt to the IT-system. The different implementation scenarios have to be evaluated. A successful implemented information system adoption involves the adaption process and a full absorption in the organization [14].

To optimize a process it was first necessary to define a demonstration scenario orientated on machining small and medium-sized businesses (SME). In the following paragraph a part of the scenario is described. The example attempts to show the information flow from product creation to production with the involved IT-systems.