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A Conceptual Model for Knowledge Integration in Process Planning

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Abstract

In the machining process planning there is a need to develop technical solutions that facilitate and support the automation of operations, aimed at time-and cost-effectiveness. One of the key challenges is the ability to create an environment where information can be shared efficiently and securely. This paper introduces a conceptual model for sharing and integration of knowledge in process planning. The model includes e.g., an adaptation of the MOKA method extended with learning capabilities combined with process related data and information. In this context also a software for cutting tool data management and tool selection in the CAM system is presented and discussed.

Keywords: Knowledge Sharing; Collaboration; Machining Process Planning

1. Introduction

Recent introduced business scenarios, i.e. Product Service Systems to meet higher customer value satisfaction level in a business to business situation places greater demands on the industry regarding flexibility and availability. New strategies, tools and methods must be developed to better support product innovation process in a global competition with respect to creation of cutting edge innovations with adequate quality, optimal cost saving and profitability, and availability of products and services. Today, there are not many manufacturing industries which alone can take responsibility for running the entire product development. Product and service development occurs more often in collaboration with partners with complementary skills. The efficient and lean collaboration between various stakeholders internally and externally, e.g., distributed teams, suppliers, customers, and partners requires higher level of standardization and automation, and an efficient integration of information and knowledge, technology platforms and common practices and policies[1]. Different approaches have been proposed to support efficient cooperation, e.g., Wang proposed a web-based approach for production process planning and process control [2].

Furthermore, complex *IT* environments as well as increased level of collaboration within and between companies set demands on proper utilization of models in the industrial processes[3], as well as efficient procedures and mechanisms for exchange of data and information. Here the use of international standards will play an important role. Several researchers have dealt with these issues. Rosén [4] addressed the use of *ISO10303* application protocols as base for an enterprise product data and information sharing environment. Nyqvist [5] presented requirements and resulting information model with related reference data library, basis for *ISO 13399*, the international standard for representation and exchange of cutting tool information. Johansson [6] addressed the need of using standardized information models for design of products, processes and manufacturing systems. *ISO10303-214* was studied and changes of the standard have been proposed. Nielsen [7] identified information requirements related to process planning in concurrent engineering environment and used *Express* for the information modeling.

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Furthermore, since manufacturing process has a significant influence on flexibility, availability and profitability of product and services, it is crucial to analyze the manufacturability in an early stage of development process to avoid unnecessary loops and to shorten time to operation [8-13]. However, a considerable part of the manufacturing process consists of machining process. Among the key elements of production planning preparation is the selection of appropriate cutting tool assemblies for specific machines and components. A careful performed tool selection for the various features is essential to avoid collisions, achieve shorter operation time, setup time and quality, e.g., dimensional accuracy. Here, it is important to be able to re-use knowledge and information through digital models without the long search times in the catalogues and databases. In other words, automating the flow of knowledge is desirable in a way that allows access to the cutting tool providers' solutions with appropriate tools, cutting process parameters and application expertise. This can save substantial time required for process planning to achieve higher quality and lower cost.

In the present study different aspects and needs concerning re-use of data, information, knowledge sharing and exchange of digital models arising during production process planning are discussed. A conceptual model for knowledge integration in a process planning environment is also described. Furthermore, obstacles and needs with respect to exchange of information in process planning stage including aspects on availability of cutting tool information have been highlighted by an industrial case study. Finally, a software tool for efficient handling of cutting tools and information exchange based on international standard is presented.

2. Knowledge development and integration strategies

In order to promote efficient knowledge re-use and collaboration between various internal and external actors in a process planning stage, the flow of data, information and knowledge must be improved. Re-use of established knowledge in the form of technical platforms, handbooks, *IT* tools, digital models, etc. require proper methodologies (e.g. *MOKA)* as well as a harmonized *IT* environment where they can be shared safely, quickly and satisfactorily without the many hands-on.

2.1. MOKA

MOKA is an acronym for Methodology and software tools Oriented to Knowledge based engineering Applications. This methodology has been developed by a consortium of participants from industry and academia [16]. To distinguish the term "knowledge" from "data" and "information", the consortium expresses that: *"knowledge is information in context"* and they describe the term *KBE* (*Knowledge Based Engineering*) as: *"The use of advanced software techniques to capture and re-use product and process knowledge in an integrated way"* [16]. The kernel of *MOKA* is the so called "*MOKA* life cycle" and contains the activities [16]; identify, justify, capture, formalize, package, and activate. A typical application of *MOKA* is e.g. a *KBE* tool to support engineering design work.

2.2. Digital environment

Digital manufacturing and use of digital models in all stages of product development process becomes increasingly important [14-15]. This implies that multiple domains of engineering knowledge and its associated *IT* tools need to interact with each other simultaneously. Fig 1. highlights some important activities related to the product development process. These are here grouped into the categories pre-process, in-process and post-process, with machining process as base line. Below these categories are further discussed.

Pre – Process activities include here design, process planning and digital verification. In this stage of the product development process, many important decisions are made, for example regarding, suitable manufacturing processes and methods, clamping strategy, machining strategies, cutting tools and cutting data.

Then, generation of tool paths in the *CAM* environment, post processing or *CNC* programming directly in the controller will be done. Simulation in early stages, e.g. to validate alternative solutions, verification of collision free tool paths etc. will play an important role to avoid costly late changes. Examples of data, information and knowledge to be handled are:

- Knowledge about needs and requirements from stakeholders, e.g. customers and internal production.
- Information about the product to be machined incl. geometry representation, features, tolerances, material, material conditions etc. (product model).
- Information related to process planning including; manufacturing methods, clamping strategy, machining strategies, cutting data, tool paths etc.
- Information about the resources needed for machining incl. cutting tools, machine tools, clamping equipment etc. (resource models).
- Process knowledge, e.g., represented as process models describing the machining process (e.g. analytical, numerical, mechanistic models) as well as process models describing a work flow, e.g. *IDEF0* models.