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Engineering innovation factory

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Abstract

The complexity of product realization has increased significantly due to the requirements on ecological and social as well as economical sustainability. This has led to an increased demand on innovations concerning new materials and product- and process technologies, as well as on new business models for a better utilization of products and materials.
Most innovations occur through a learning process where various actors, individuals as well as organizations, take part. Breakthroughs do not necessarily occur within the research or development departments, they are equally likely to occur during production or utilization. The challenge thus lies in providing platforms and tools for cross-divisional, collaborative innovation and for sharing Best Practices.
This paper describes an initiative at KTH Royal Institute of Technology for supporting the integration of various company disciplines and external expertise through a collaborative framework where industry and academy can collaborate, supported by modeling, simulation and visualization during the innovation process. The approach combines theories and methods concerning innovation and digital factories and emphasizes aspects concerning learning, communication and collaboration.

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1. Introduction

The complexity of product realization has changed due to the requirements on environmental and social as well as economical sustainability. This has led to an increased demand on innovations concerning new materials and product and production process technologies, as well as on new business models for a better utilization of products and materials. Most innovations occur through a learning process where various actors, individuals as well as organizations, take part. Breakthroughs do not necessarily occur within the research or development departments, they are equally likely to occur during production or utilization. This calls for platforms and tools for cross-divisional, collaborative innovation and for sharing best practices.

Further, innovation in terms of new components, processes and materials is encouraged with a quick, virtual evaluation of alternatives. Today, digital product modeling, digital factories, and tools for analysis and simulation are used in industry when developing complex products and production systems. By efficient modeling and simulation, development times can be reduced significantly and resources (time, energy and material) be optimized. While many large companies use simulation, their tools and information concerning product design, production planning and maintenance are often spread out and not integrated. This makes it harder to interconnect different competence areas and to achieve a coherent basis for cross-divisional decisions. In addition, smaller companies do often not utilize the potential of simulation since they lack the resources to operate or invest in expensive IT tools – or even selecting the right tool for the purpose.

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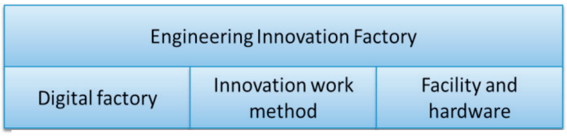

Fig. 1 Main components of Engineering Innovation Factory

The purpose of the Engineering Innovation Factory (EIF) is to enable innovation by supporting both cross-divisional collaboration and virtual analysis. The goal is to establish an environment in which industry and academy can collaborate, supported by tools for modeling, simulation and visualization.

The approach combines theories and methods concerning innovation with those of digital engineering and visualization, leaning on a model for collaborative innovation [1, 2], which emphasizes aspects concerning learning, communication and collaboration.

The EIF, with a virtual (digital) and real (physical) environment, is comprised of three parts (Fig.1): 1) A Digital factory [3] portfolio with IT tools for visualization, digital engineering and manufacturing in an architecture which integrate the IT-tools and manage information. 2) Methods for utilizing and adapting tools and devices to support collaborative innovation. 3) Physical environment for workshops with advanced visualization devices that encourage creativity.

Two aspects permeate the EIF: collaboration and changeability. The goal is not primarily to develop or optimize analysis tools, but rather to use and combine these tools for the purpose of visualizing, communicating and managing perspectives and changes to technologies, products and manufacturing systems. There are other environments for collaboration based on modeling and simulation [4, 5, 6]. [6] provides a physical environment to inspire the users to think outside the box, but does not focus on the digital factory as a supporting framework. [4] and [5] provides Digital factories and address similar issues as the EIF. The difference is that the scope of EIF is to support disruptive changes in technologies and materials. It is built entirely on COTS for process and layout design, supporting industrial needs in engineering change management. Further, EIF will contribute methods for choosing and utilizing the tools depending on the task at hand. These methods are documented as work process models [7] based on industrial studies.

2. Collaborative innovation based on simulation and visualization

The innovation method includes principles and methods for innovation suited for the manufacturing industry. It leans on a collaborative innovation model [1, 2] emphasizing aspects concerning learning, communication and collaboration [8, 9, 10]. Further, based on principles for model based development of production systems [7, 11], a structured use of digital models and simulations will be suggested, where the selection of IT-tools is adapted to the needs in the various phases of the innovation process. One reason that changes are impeded in practice is the fear of what they would entail and the belief that the changes are impossible or at least require an insurmountable amount of resources to realize. Thus the goal with visualizations and simulations is to support the ability to envision what the change would entail in practice and how these changes could be managed.

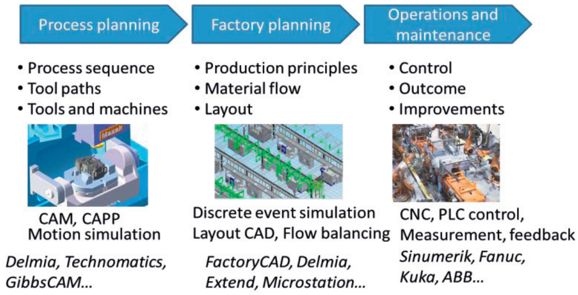

Fig. 2 Issues and production engineering tools during production life cycle

Simulation and visualization of the whole value chain, from ideation to manufacturing, will be used for the purpose of learning and establishing a common view of interdependencies in the early ideation stage. In the research and verification stages, digital product and production engineering (CAX) tools are used to test various new ideas by exploiting various production issues through applications such as CAM, discrete event simulation or 3D motion simulation (Fig. 2).

Visualization is an important tool to support the understanding and communication between different disciplines. Visualizations are thus effective tools when it comes to illustrate and portray appearances and relationships and also helps to create a common perception of future products and processes [12]. Using visualization in project teams during the development of new production systems, processes or products, facilitates the possibility of creating a common mental image of a future product or process [13]. As visualization relieves working memory, capacity is freed for problem solving [14]. With a work process continuously visualized in the form of eg. sketches and graphs, effective work is facilitated over an extended period of time [15].

The work method will describe how and when modeling and visualization is used in product realization, and guide the selection of models and applications depending on purpose and specific requirements from the use cases.

To summarize, there are requirements both in relation to needs in the innovation process and related to the configuration and development of the information framework as such. Related to innovation, it should provide the ability to visualize and simulate whole value chains. Aspects concerning the product, production processes, factory and production equipment are combined. Further it should support the managing of change and tracking of dependencies between information in various sources such that the tools that are relevant for each task could be used. The Digital factory is to be used in various settings and will depend on the needs and supplied models of the participants. Thus the applications should be possible to select and configure according to each use case, and the IT framework developed accordingly. In the long run, participants should be able to bring their own tools and integrate these with other tools in the Digital factory.

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