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Workflow and information centered support of design processes—the IMPROVE perspective

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Abstract

Design process excellence is considered a major differentiating factor between competing enterprises since it determines the constraints within which plant operation and supply chain management are confined. The most important prerequisite to establish such design process excellence is a proper management of all the design process activities and the associated information. Starting from an analysis of the characteristics of chemical engineering design processes, some important open research issues are identified. They include the development of an integrated information model of the design process, a number of innovative functionalities to support collaborative design, and the a-posteriori integration of existing software tools to an integrated design support environment. Some of the results obtained and experiences gained in the last years in the collaborative research center IMPROVE at RWTH Aachen University are presented.

Keywords: Computer-aided design; Information modeling; Software engineering; Tool integration; Business processes; Workflow; Work process

1. Manufacturing and design in the 21st century

The markets and hence the requirements on manufacturing in the process industries have been changing tremendously in the last decades. Growing market volume and limited, often largely local competition have been dominating manufacturing in the seventies and eighties. Today, the process industry is facing largely saturated markets in many geographical regions of the world. Internet technology has been successfully used in e-commerce solutions to achieve almost complete market transparency. Engineering and manufacturing skills are available globally. At the same time, transportation cost have been decreasing significantly. Hence, every manufacturer is facing truly global competition. Economic success is only possible, if new ideas can be quickly transformed into new marketable products or if the production cost of established products can be diminished substantially to counteract decreasing profit margins. Product innovation, process design as well as manufacturing processes have to be continuously improved to reduce time to market of a new product, to minimize manufacturing cost and to establish a high level of customer satisfaction by offering the right product at the right time and location.

1.1. Two business processes

The *value chain* in any manufacturing oriented industry comprises *two major business processes*—manufacturing and design—which are highly interrelated (Schuler, 1998). These business processes are constrained by the socio-economic environment, in particular, the market, the legislation and the available process technologies (Fig. 1).

Value creation happens in the *manufacturing process* (Fig. 1, top), which is part of a supply chain including warehouses, distribution and procurement in addition to the production plants. Excellence in manufacturing is not possible without explicit consideration of the constraints

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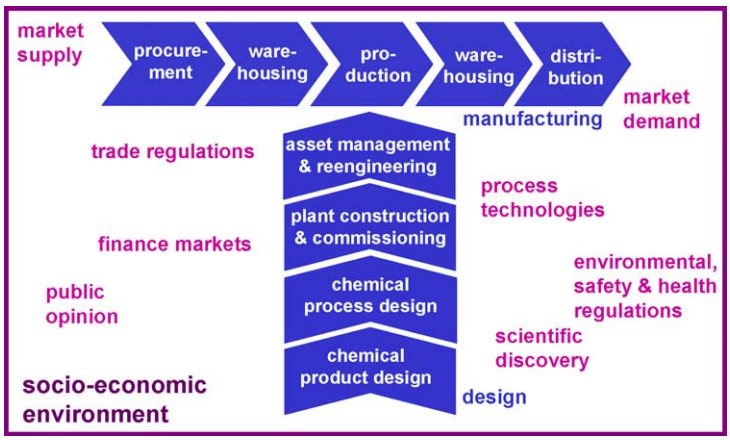

Fig. 1. The two major business processes in the process industries: manufacturing and design.

and potentials resulting from interaction between the plant and the supply chain it is embedded into. The influencing factors from the supply chain on plant operation have to be exploited rather than rejected by model-based plant management considering all the manufacturing business processes across the whole supply chain (Backx, Bosgra, & Marquardt, 1998). The changing business environment can be addressed on a short time scale by adapting supply chain management and plant operation strategies for a fixed design.

The manufacturing process is largely determined by the second business process, the *design process*, which comprises all the activities related to the design of a new product and the associated production plant including the process and control equipment as well as all operation and management support systems (Fig. 1, bottom). This business process starts with an idea on a new product and subsequent product design. Conceptual design, basic and detail engineering of the production plant are the major activities which follow, before the plant can be built and commissioned. Excellence in design requires consideration of the complete design lifecycle (Marquardt, Wedel, & Bayer, 2000). In particular, the interactions between different design lifecycle phases focusing on different aspects such as the chemical product, the process concept, equipment design, plant layout, or control structure selection need to be exploited. Only an integrated consideration facilitates the realization of synergies and the achievement of the true economical potential. The plant and the supply chain have to be continuously reengineered during their lifetime in order to adjust manufacturing to major changes in the market conditions and legislation, to adopt new process technologies and to profit from accumulated operational experience. Asset management is increasingly established to make best use of existing facilities and to support preventive maintenance and benchmarking activities. Plant reengineering is only possible on a longer time scale as compared to an adaptation of the manufacturing process for a given plant and supply chain design.

1.2. Value creation

The economic performance of an enterprise heavily relies on the quality of the products of these two business processes. Typically, the *major focus* is on the product of the *manufacturing process*, namely the chemicals, which are sold to customers and therefore are considered to generate the revenue to the enterprise. The manufacturing process and its associated supply chain, however, are considered as the cost generators. Profit can be increased on the short time scale with limited investment, if the manufacturing cost can be reduced by optimized strategies for plant operation and supply chain management. It is therefore not surprising, that the current industrial focus is on the reduction of manufacturing cost in order to counteract decreasing profit margins.

This strategy does not seem to be sustainable in the long run, since cost reduction by means of better supply chain management and plant operation using existing assets is largely independent of a certain product portfolio and does not contribute to a fundamental understanding of the processing technology and its impact on chemical product characteristics. The employed operations research techniques apply to many businesses and may therefore evolve in a technological commodity. After a transition period during which these technologies are adopted, the differentiation between competitors with respect to manufacturing excellence vanishes.

Hence, at least at this point in time, there is no adequate appreciation of the contribution of design excellence to the overall success of an enterprise. It is the design *process* which *determines* the design of a *manufacturing* plant. This design is largely responsible for the achievable quality of the chemical product and for the order of magnitude of the production cost. The design also constrains the operational envelope and hence the flexibility to react to changing market conditions. Ideally, an integrated consideration of plant and supply chain design on the one and supply chain and plant management on the other hand should be addressed (Backx et al., 1998). However, such an approach would have to generalize and extend