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Collaborative Process Optimization – An Approach to Individual Packaging Hollows

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Abstract

The increasing number of variants in the plastic packaging market is a big challenge especially for small enterprises (SEs). With increasing customer needs, like individualized products, small lot sizes and short product life cycles, it becomes necessary to work more efficient and effective, especially across enterprise borders to fulfill market needs. Here the Product Lifecycle Management (PLM) approach enables specific company solutions to handle the growing complexity and number of variants to be managed at product development and production processes. However, state of the art PLM approaches focus mainly on optimization of mass production and big sized enterprises. Therefore, the PLM-approach is extended in its usage for SEs and established as an operational platform between specialized companies, so called “works-flow”. In a prevalent approach, expert enterprises for each part of the value chain for plastic packaging hollows have established and worked at new products separately. Results of this traditional way are delays, high costs and low efficiency. This interrupted value chain is closed and the processes of the expert enterprises are brought together to realize an integrated work flow. This is the goal of "works-flow", a disruptive approach for an integrated and digital value chain network. To solve the leading problems there are four main issues. Reducing the interface problems by using an integrated and digital product model for the whole value chain network. Establishing the base knowledge for the processdesign, construction and production to build individual packaging hollows. Developing a modularized systematic for the product and its tool-set based upon a pre-designed parametric CAD model. Reducing the ramp up time of the production by handling process data knowledge and automatic processes for the construction of tool-sets. Therefore, connecting and enabling the separated SEs for the design, tooling and production to an integrated operational process chain leads to cost reduction in the whole process chain, a shorter time-to-market and an earlier start-of-production. Furthermore, it enables a non-before achieved process quality and process stability. The initial usage of the “works-flow”-approach leaded to a reduction in the time-to-market up to 60% and a higher product quality.

Keywords: Collaboration, Digital Workflow, Individualization, Product Lifecycle Management, Tooling.

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Introduction

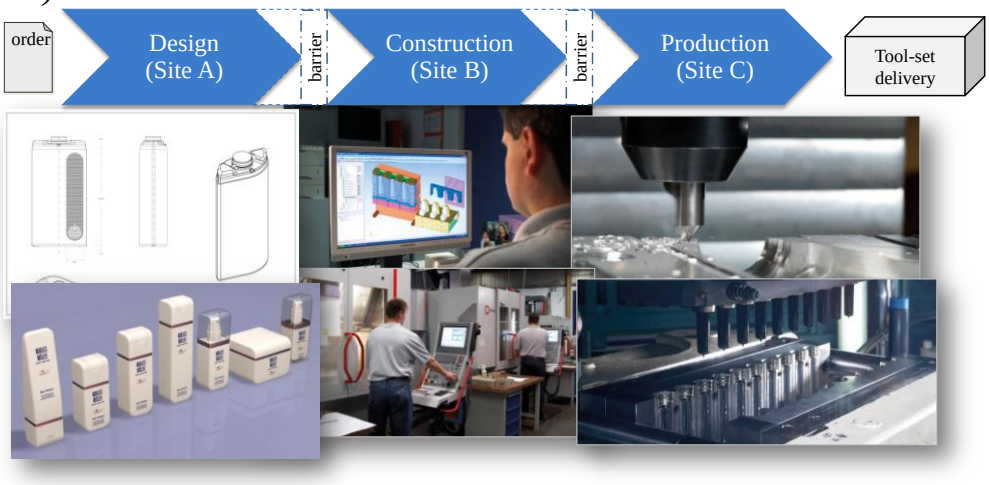
The market for plastic packaging grows worldwide. Especially in the areas of food packaging, packaging of cleaning supplies and cosmetic packaging (VDM, 2014). Along with this growing demand for packaging products the diversification of the product itself becomes evident. Only by using product-specific packaging, the customer recognizes the product as unique and special.

The bottling of liquid products happens usually in packaging hollows made up of glass, plastic or composite material. Due to the gravity of glass and the non-transparency of composite material, especially plastic packaging material is selected for new product packaging designs. The manufacturing of these packaging hollows demands specific production tools.

In the traditional way, expert enterprises along the whole value chain for the production of plastic packaging hollows have been established (

Figure **1**). The new product design is done by packaging designers. The construction of the production tools is done by specialized construction enterprises, then produced by tool-building enterprises and the production of packaging hollows is done by plastic manufacturing enterprises. These small enterprises are usually separated from each other, working separately at the new product. This way of product development leads to problems along the whole value chain. Interfaces between the enterprises lead to loss of information required later in the value chain. Problems with the design may occur during production first. Deficits in communication between the members of the value chain cause loops in the processes design, construction and production.

Figure 1. *Current Situation in the Plastic Packaging Industry (Rosemann, 2014)*



That is the reason, that a tool was required to help the organization of handling data, information and knowledge between separated enterprises. Because the involved enterprises are small, the platform has to be operated independently with less expense of man power.

To meet the requirements, the established PLM approach is adjusted for small and separated enterprises.

Existing Approach

Product Lifecycle Management

Product Lifecycle Management (PLM) is a concept of integration all necessary data, information and knowledge for the whole lifecycle of a product (Corallo et al., 2013). Thus methods, processes and organizational structures were developed. The use of these integrated data usually needs an extensive IT-programme. The integration of business processes from product design, construction, and production to product services is a task which within an enterprise is challenging, especially mapping the creative processes to a distinct, predictive business process. PLM is so far a business concept model which has to be set up specifically for a single enterprise (Saaksvouri and Immonen, 2008).

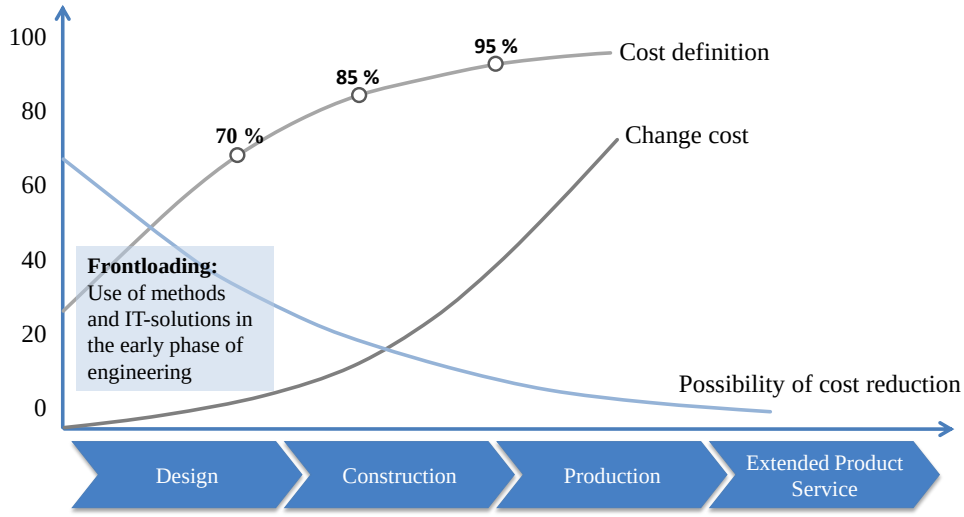
The origin of PLM is handling complexity in the product development process (Sendler, 2009). With upcoming computer aided design and therefore easy accessible engineering changes, the product development process accelerated and produced amounts of rapidly increasing data (Sendler, Saaksvouri). Managing these data and their validity is necessary. PLM cores the central management of all product data in a central database for all related documents and grants easy access for the persons involved.

PLM is a common view and language that an enterprise has to agree with his partners and suppliers (Sendler, 2009). The PLM strategy concerns all areas and processes of an enterprise. Its successful implementation affects the performance of the products, the market position and the company's success (Sendler, 2009; Eigner and Stelzer, 2009).

Currently the use of PLM is limited to business areas of development and construction and simultaneously PLM is mainly used by larger enterprises. The use of PLM in small and medium enterprises is low (Abramovici et al., 2004).

The chance of PLM is coping with complexity and engineering challenges (Saaksvouri and Immonen, 2008). Furthermore, it is a business strategy helping to save costs in the whole product development process (Figure 2).

Figure 2. *Cost Efficiency by using IT-Tools and Frontloading [acc. to Eigner and Stelzer, 2009].*



Lack of Existing Approach

The existing PLM approach focuses on the product development process inside single enterprises. As the complexity in production increases enterprises become more and more specialists in their main field of operation. The need for operational value chain networks rises, including the problems shown above. Focus should be given in the data management within enterprises and not the exchange of data and their coordination or the conflict salvation between value chain members, as these problems are not solved by an existing PLM approach.

Furthermore, the PLM's objective is the digital product development process. The subsequent manufacturing process is not targeted. By integrating the requirements of the manufacturing process into the development process valuable information and knowledge helps with the avoidance of upcoming problems in the late (and expensive) phase of production.

State of the art PLM approaches are not satisfying the specific demands of SEs. Due to the size of these enterprises, usually there is no PLM specialist working at the optimization of the business processes. The efforts of implementing a PLM strategy have to turn into business benefits for the enterprise rapidly and its employees have to benefit obviously. Otherwise, the PLM strategy is doomed to fail.

Collaborative Process Optimization

Definition

To understand the explanations in this paper it is necessary to define the term "collaborative process optimization" in detail.

In case of the presented approach the view "collaborative" focuses on the collaboration of different enterprises and their employees. "Process optimization" has to be understood on one hand as an optimal process of developing new products. On the other hand it is an optimal process of producing these products.

The following explanations refer to an industrial implementation in a value chain network for the production of plastic packaging hollows. A transfer to other branches and products is achievable.

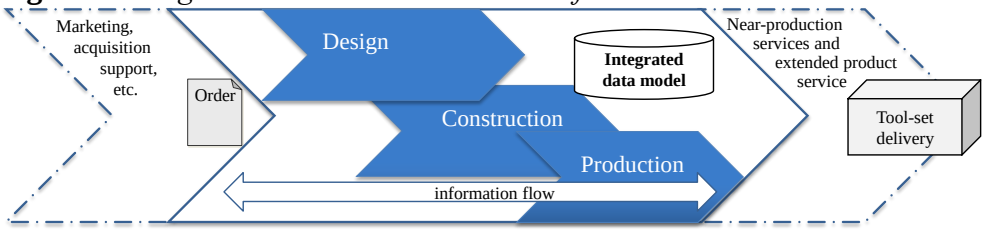
Scope of Use

As the value chain network is locally distributed and organizationally separated, it was necessary to build up an integrated, IT-based process chain for the efficient and flexible production of customized packaging hollows. The IT itself is operated independently as an operational platform for the connected small enterprises. This "PLM-as-a-service" enables the SEs to set up first the basics PLM collaboration to generate quick benefits for themselves and the whole value chain network. Further on it was the basic step for fully integrating PLM as a business strategy at the next step.

These integrated process chain is referred to as "works-flow", shown in Figure 3. With the possibility to enlarge "works-flow" to a fully integrated PLM e.g. using customized services for production and the product.

The integrated data model for the base development process (design, construction, production) qualifies continuity in the information flow from incoming order to tool-set delivery.

Figure 3. *Integrated Process Chain "Works-flow"*



Concept of "Works-flow"

The concept of "works-flow" is based upon four main issues. Establishing a digital product model, basic process knowledge, modularized systematics and process data knowledge. Therefore, the holistic PLM approach focuses on the relevant processes for the product development process in small enterprises, still expandable to a full PLM business programme in each enterprise.

Integrating the whole value chain network to an operational platform realizes advantages in costs, time and quality. Along the entire product development process a closed process optimization is achieved.

Digital Product Model

The aim of developing a digital product model is reducing the interface problems between members of the value chain network. By using one common model, information that initially influences the product can easily be made available for later processes. The digital product model provides the properties from process beginning, required in further process proceeding. Thus, it serves as an information and knowledge carrier throughout the process.

Basic Process Knowledge

Due to the separation of single process steps in separated enterprises, the focus of each employee lays on his process step. Therefore, establishing base knowledge for the whole process - design, construction, production - to build individual packaging hollows was necessary. Knowing the requirements and restrictions of other process chain members helped to avoid the developing products that are not possible to manufacture in this process chain. Gaining knowledge of the process chain qualifies the chain members to an early intervention if possible problems occur.

Modularized Systematics

In order to cope with upcoming complexity in the product development process, reducing this complexity is possible by setting up a systematic of the product and its production tools. This systematic, using geometric features of the product for differentiation, enables all members of the process chain to set realistic limits to the product geometry. With parametric modelling these features are used to generate automatic processes for further product development. By this, the saving of the construction time is achieved.

Process Data Knowledge

As parameters of the production process for packaging hollows have to be set up specific for the individual product, it is essential to handle the existing knowledge. Starting from the existing process parameters of a similar product these new process parameters are achieved sooner by using a standardized experimental set-up than by previously prevailing the procedure of “try and error” (Schuh). Using this process knowledge, the ramp up time for the production is reduced.

Benefits of the Proposed Approach

Using the “works-flow” realizes benefits for the enterprises. The integrated process optimization affects the magic triangle of time, cost and quality positively. The development of new products is faster, with lower loops in the development process and at a higher quality level. This integration of the value chain network enables continuous quality assurance

for the development process and especially for the production process as related information is available from the beginning. Measuring the expenses and value shares, these can be distributed in relation to the total process chain. Process assurance in the early design phase helps to reduce or avoid failure costs. Realization of the time, cost and quality advantage enables higher market shares.

Realization in Industrial Environment

Based upon the considerations of the "works-flow" is implemented in a value-chain network for the production of injection stretch blow molded plastic packaging hollows. The network consists of three independent enterprises.

At a first step, dependencies between bottle design, tool restrictions and production requirements are discussed and by this, a common view upon the whole process chain is established.

Building the digital product model consists in this case of two models, one for the bottle (design process) and one for the tool-set (construction process). These are built up as parametric models. Connecting these two models enables an automated construction process. Only specific changes to the tool-set have to be done manually.

With basic geometry features a modularity of bottles and preforms is developed (

Figure **4**). Easily changing parameters in the base model enables the bottle designer to build customized packaging products nearly without restricting the design process. Simultaneously requirements of construction and production are taken into account.

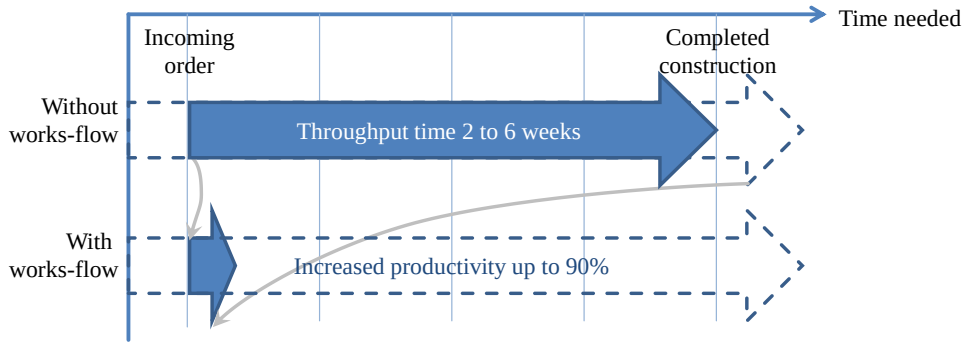
Using previous production data sets, the production ramp up time is reduced.

Figure 4. *Basic Geometries for Developed Bottle Modularity*

Results

Using the "works-flow", the reduction of the throughput time from incoming order to production start of tool-set is significant. In the presented case study the throughput time is reduced from two to six weeks to two to three days (Figure 5).

Figure 5. *Reduction of Throughput Time from Order to Production Start of Tool-set*



As a common view on the process chain is established, insufficiencies in the production process are apparent. Their elimination result in higher process reliability and a shorter ramp up time for the production.

Conclusions and Outlook

In this paper the extension of the PLM-approach towards a across enterprise network approach for small enterprises was presented. This so-called "works-flow" enables small enterprises to work together more efficiently, at lower costs and on time. A concrete application showed the cooperation of SEs for the collaborative development of new products and therefore required production tools for the production of packaging hollows in a single-stage injection stretch blow molding process.

The subject of process integration and process innovation is part of current research at Bayreuth University and the Fraunhofer Project Group Process Innovation. In the future, the approach should be evaluated for branches with similar separation of their product development e.g. paper packaging.

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