

INNOVATION AT THE DIGITAL PRODUCT - THE USE OF THE VIRTUAL REALITY IN PRODUCT DEVELOPMENT PROCESSES

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1 Abstract

The technique of virtual reality has been developed so far that it isn't a privilege of large industries anymore but also smaller enterprises can take advantage of it. In this case the main item is the Digital Product which is used for visualization tasks. The scope of this paper is to demonstrate how the Digital Product and its visualization is used in different enterprise processes and which benefits arise from that.

2 Introduction

Starting with the market investigation up to the market entry the product development process has to be carried out in an increasingly shorter time. Nowadays the time-to-market of a product is critical, only a few weeks delay can decide considerably about success or failure of a new product. In order to solve these problems the method of concurrent engineering is used. However, this is not done completely. Many processes still are serially or are removed from the product development process. The reason for this is that the contemporary product development process is still based on a paper-based method which has been slightly modified in order to use it in a team.

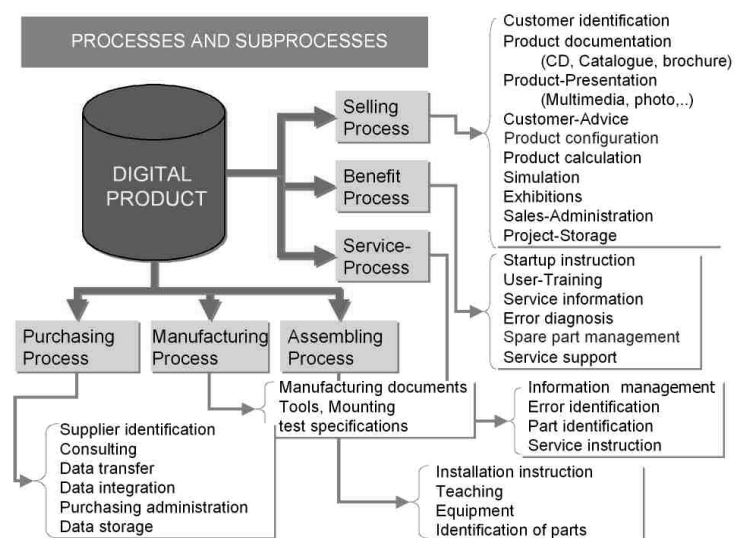


Figure 1. The Digital Product - the "entirety of all product data"

Every part of the product development process has its own data world (Fig. 2), clear boundaries exist and only a document exchange is done. The responsibility of the technical department is limited to the preparation of perfect production data sheets. The sales department generates catalogues (on paper or CD) without basing them authoritatively upon the data of the Digital Product. Faced with this current problems the future way is drawn: The next step will be to use state-of-the-art means and tools to overcome these boundaries. The product data and thus the digital product become the integral and strategic turntable of the whole enterprise.

3 Motivation

Information and/or data arise from the entire development stage and the entire profit stage of a product. The entirety of all relevant product data, that are generated and administrated consistently, represent the real product and are named "Digital Product". Product development processes use the data of the digital product, add new data or modify data of the Digital Product.

Dissecting these processes it becomes clear that in most cases a person is the producer or the receiver of these data. He uses specific services which allow him to carry out these processes based the digital product. Such services are for example:

visualize: The content of the Digital Product and/or parts of it is made accessible to the customer. In this case it is not distinguished between a graphical and a textual edition. In the case of visualizing functional aspects are in the center of interest.

simulate: The Digital Product or parts of it are used to simulate unknown properties. The simulation can be used to find out functionalities of the product or of the processes.

archiving: Data of products or processes and data coming from the customers feed the Digital Product. The archiving of these data allows an instantaneous access to them.

documenting: The content of the Digital Product is used for a textual or graphical documentation of the product or the processes.

transferring: The content of the Digital Product or parts of it are accessible over a network in order to be used by other services or processes.

presenting: Parts of the Digital Product are extracted, processed in textual or graphical form and represented in a comprehensible way. Optical aspects are in the center of interest.

integrating: Parts of the digital product are integrated into the databases of other Digital Products in order be used by foreign processes and services.

	visualize	simulate	archive	document	transfer	present	integrate
Selling process	◐	○	◐	○	◐	◐	◐
Benefit process	◐	○	○	◐	◐	◐	○
Service process	◐	○	○	○	◐	○	○
Assembly process	◐	◐	○	○	◐	○	◐
Manufacturing process	◐	○	○	○	◐	○	◐
Purchasing process	◐	○	○	○	◐	○	○
Design process	◐	◐	◐	◐	◐	○	◐

Figure 2. Assignment of the services to the enterprise processes

Not all enterprise processes have to use all services (Fig.2). The services guarantee the connection of the processes and sub-processes to the Digital Product. In particular the services "Visualization" and "Data transfer" are of central importance. The task of virtual reality will be to represent complex data structures to the persons in an acceptable form. Furthermore virtual reality must enable the persons to interact with the Digital Product in an effective and ergonomic way. In this manner all enterprise-processes will be enabled to use the data of the Digital Product in order to achieve the desired shortening of time-to-market.

4 Contributions

Virtual reality and with that the Digital Product gain more and more importance within industrial enterprises. In future an essential task of virtual reality will be the replacement of the physical preproduction model in the primary development phase. The physical preproduction model must be distinguished into the following functional types:

Design-Prototype: It is used for the inspection of the design draft concerning aesthetic, optical and ergonomic aspects; mechanical qualities are not of any importance; mostly a functionality is not integrated (Fig. 3).

Geometrical Prototype: It is used for the inspection of the form accuracy and the accuracy of fit. Only the geometry is in the center of interest but not the material itself.

Functional-Prototype: The functionality of components is tested with this prototype. This inquires an identical material as the one for the series production.

Technical Prototype: All functional aspects of the system are checked.

The scope of this paper is to give some examples how the digital prototype and the Digital Product is currently used in enterprises and which efforts arise from this. A discussion is given whether the Digital Product is able to replace the physical prototype.

The essential task of virtual reality in the product development process is the visualization of objects and functionalities. Today geometry and design questions of new products already can be completely solved with the geometry visualization of the Digital Product without the need

to create a design preproduction model (Fig.3). In accordance with the tasks in a product development process (Fig.1) the services of visualization and communication can be essentially supported by this digital preproduction models.

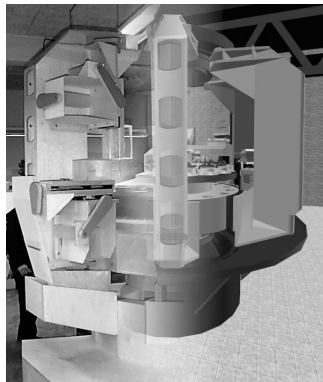


Figure 3. Virtual reality replaces the geometrical preproduction model

The advantage of digital geometrical preproduction models for the companies is obvious: the costs for the preparation of a real preproduction model drop in the same way as its manufacturing time. Thus it is possible to achieve a higher product quality considerably earlier and to influence the time-to-market significantly (Fig. 4).

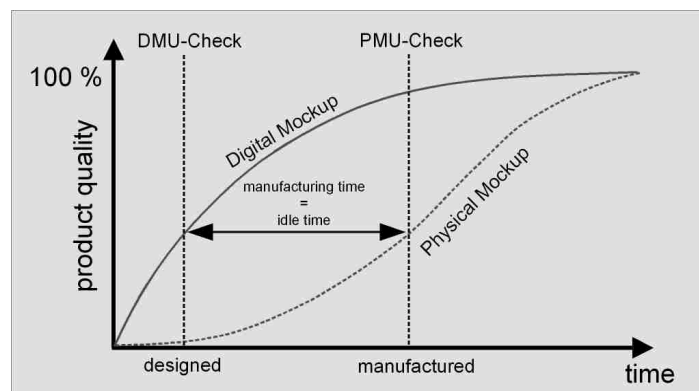


Figure 4. Shortening of the time-to-market with the digital preproduction model

The advantages of digital preproduction models become clear in particular if constructive changes must be made and visualized afterwards. Making changes in physical preproduction models is very time consuming because of the additional manufacturing time. In this case the digital preproduction model allows it to represent the changes tridimensionally after a very short time.

Another example of the promising usage of virtual reality in the product development process is given by the FMEA, the failure mode and effect analysis. FMEA is a means to recognize potential design and construction mistakes within an early phase of the design process. The FMEA is made in order to prevent faulty constructions from being manufactured or from being sold. Thus this method is useful to save high costs that are caused by faulty products on the market. In cooperation with a large power tool manufacturer the existing FMEA-method was basically analyzed. One of the main advantages of this method is the systematic scrutinizing of the design. Thus it will be possible to consciously integrate participants from other fields of an enterprise. However this is also one of the most problematic points because

of the underlying two-dimensional drawings. Only persons with practice in reading these drawings have a contiguous illustration of the part on which the discussion is about.

Based on the data of the Digital Product an additional visualization of the geometry was integrated into the FMEA (Fig. 5). This allows to carry out the methodical analysis considerably more efficiently and thus also less expensive. Using VRML (virtual reality modeling language) as a description language for the objects guarantees a low-cost usage of these visualization possibilities on standard computer systems. The geometrical data as a component of the Digital Product are visualized simultaneously during the FMEA in addition to the form to be filled. All participants synchronously obtain the same visual information and thus a moderation of the session is facilitated. A standard personal computer is used in order to realize a low-cost solution for small and medium enterprises. Since it is necessary for the realization of the FMEA to visualize simultaneously both the form and the object, two projectors are used. They are connected to a personal computer by two separate graphics channels.

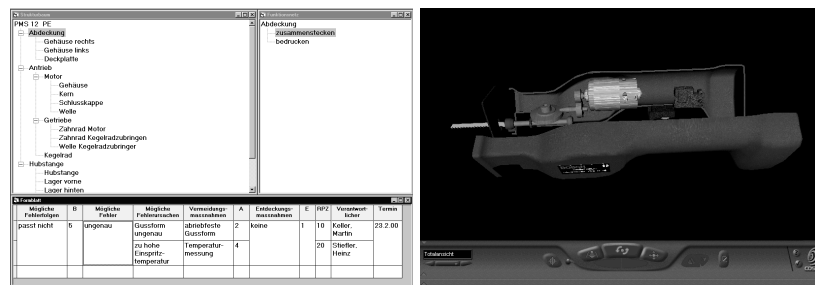


Figure 5. Product visualization within the FMEA

A simple navigation and visualization tool is used during the FMEA. The moderator can carry out a simple navigation, i.e. swiveling, displacement and so forth. Thus the relevant part can be investigated in detail. The Digital Product is used in order to allow the services visualization, engineering and communication.

In the case of very complex objects that have to be designed, as for example during the planning of bigger plants or machines, it is desirable to integrate the customer into the product development process more closely. In order to realize this demand a new interaction system was developed. Some persons can use this system for a simultaneous planning of complex objects. The involvement of the customers requires an easy use of the system without any training phase (Fig. 6).



Figure 6. Working at the Buildit-System

"Sit down and collaborate" - could be the motto because everybody can become operable in a few seconds without prior knowledge of this system. The positioning of machines, the navigation in the room as well as adding new elements is done by the displacement of an interaction brick. The results of the interaction are immediately visible both in the outline and in a tridimensional view. With the aid of this system and thus the Digital Product the team elaborates the solution of a planning problem.

A further important area of application for virtual reality is the representation of functional relations. In a very early stage of the product development process instructional materials and assembling instructions can be performed with the use of the Digital Product (Fig. 7).



Figure 7. Virtual assembly instruction

The representation allows it to train the assembling of a product interactively. Next to the geometrical representation textual complements supply additional information. The units to be examined are not static, but they can be turned, rotated or zoomed by the user. Thus it becomes possible to examine geometrical limiting conditions and functional properties and to learn about the product before it is manufactured.

Large products as for example plants are unsuitable for exhibitions since they usually have very high transportation and build-up costs. The only way to show these products to the customers consists in the use of virtual reality. In order to check whether an exhibition can be done only by the use of a digital mockup a complete asphalt factory was modeled (Fig. 8).



Figure 8. Modeled asphalt factory

The practical test of such big VR-models showed that the computer performance is yet not sufficient enough for a fluid visualization. Additional problems came up with the projection of these models during the visualization on booths. Within the bright environment of a booth the projectors must be very bright and therefore very expensive in order to realize an appealing representation of the new product. In addition the clientele in mechanical engineering does not show acceptance for a complete digital exhibition of products at the present time.

5 Conclusions

The examples from the above show that virtual reality and thus the Digital Product becomes increasingly important for the industry. New low-cost technologies will allow to use the data of the Digital Product intensively in the different enterprise processes. In future the product data won't be used only for manufacturing but also for other enterprise processes:

- Increase of the product quality: The visualization of the geometry with the data of the digital product allows to recognize potential sources of errors early and to achieve a higher quality in a shorter time. Further efforts in this field will allow a step-by-step approximation to the digital functional preproduction model. Next to the geometry visualization this prototype has to simulate also physical qualities in order to enable an initiation of a machine on a virtual basis. Also extreme test runs at a machine become possible that up to now led to a destruction of the physical functional preproduction models. The digital product already includes the necessary data sets but up to now an effective linking is still missing. If this succeeds satisfactorily a machine or plant including their control and their physical behavior can be simulated. The amount of time from the idea up to the finished product can be significantly shortened.
- Involving the customer during the product development process: Future products are not branded articles anymore but they are manufactured especially to the orders and needs of the customer. This can be done best by involving the customer very early into the product development process. The customer specifies "his" product without deeper knowledge into its manufacturing. He participates in the generation of the Digital Product; "his" product can be visualized early and possible changes can be done without additional costs.
- Improvement of the internal communication: If the common data set of the Digital Product is consistently used it is guaranteed that the data keep up-to-date. Already existing visualization also can be used in the manufacturing process.
- Employee and customer education: The techniques of virtual reality will allow to explore the products interactively, to inspect them and to gain first experiences before the first specimens of this product go into production. Thus it will be possible to train persons on complex products in a very early stage. Before a new product comes onto the market experienced personnel is available (Fig. 9). Also the customer can gain experience with his future product so that he is operationally immediately after the delivery of the product.



Figure 9. Education with the virtual model

- Marketing: Exhibitions and product presentations are one of the most expensive parts within the life-cycle of a product. The companies are endeavored to represent an

comprehensive product range to the customer on big booths and in extensive product catalogs. Printing costs, postal charges, exhibition costs and haulage are very high. If only a small part of the product presentation could be done with the use of virtual reality there will be the possibility to save a large amount of money. In addition it will be possible to present in the same booth size a considerably larger product palette. Since the represented geometries originate from the digital product these can be made available to the customers. This will allow to generate a brochure that fits especially onto the questions of the prospective customer.

- Service: Especially in the case of custom-built products an individual service is necessary. The digital product and its visualization will help to prepare service tasks in order to carry out a maximally effective maintenance on the customers products.

6 Future work

Future work will handle the use of the virtual reality in medium and small enterprises. This will be an optimization of the data access of the Digital Product by the means of virtual reality, for example a simplified generation of the virtual illustrations from the existing CAD-drawings. In addition new areas of application are supposed to be opened for the visualization, for example in the product configuration or in the preparation of virtual assembly or operating instructions.

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