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## Decoupling of product and production development in flexible production environments

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### Abstract

The integration of production development in product development methodologies is one of the most promising current research topics for shortening time-to-market of development projects. In flexible production environments new products shall be produced by the adaption of the existing production system. The characteristics of production system adaption differs substantially from a new development of a production system. This paper analyzes effects of flexible production environments on integrative development methodologies and how to match inconsistencies in a united approach. The focus was placed on simplifications of established methodologies and a new approach considering these simplifications is presented.

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### 1. Introduction

To meet the demand of a steadily decreasing time to market, a reduction of development time is required. The simultaneous development of product and production system is a promising approach to enhance already optimized development procedures. Additionally parallel design of product and production system enables a close coordination to prevent extensive changes due to neglected production restrictions. For simultaneous development approaches, a strong interconnection between the development of product and production is required. Therefore procedure models already try to integrate the production into the product generation process [1]. This paper deals with the impact of flexible production environments, mainly caused by the implementation of Cyber Physical Production Systems (CPPS), on the linkage of product with production development. The paper describes an approach that takes into account the market changes as well as the new range of possibilities of CPPS. Nowadays much effort is used in order to connect production and product development and create a production, which is tailored for future products. The implementation of CPPS enables possibilities to automate the

interface between production and product development and therefore redesign the mutual development. The changes in cooperation between development and production and the effects on target products are explained in detail.

### 2. Interconnection between product and production development in product engineering methodologies

Established product engineering methodologies usually include procedures for production system development or at least the specification of the production process. Common engineering procedures like Pahl et al. [2] and the VDI guideline 2221 (Systematic approach to the development and design of technical systems and products) [3] do not emphasize explicit phases of production system development. These approaches consider the product development procedure as a concluded iterative sequence. Neither the integration nor the consideration of restrictions or feedback of the assigned production system in an early phase of the product development are explicitly emphasized. Considerations regarding the envisioned manufacturing process however are included. The procedure shown in the VDI 2221 for example

ends with the elaboration of production and utilization information. This includes the description of the production process by working plans, bill of materials and operating instructions. The production system development, respectively the adaption of manufacturing means are regarded as downstream processes, which are executed by the production planning department. In section 4 it is shown, that this kind of procedure is still a common approach in industrial practice.

The VDI 2206, “Development methodology for mechatronic systems” [4] and the 3-cycle-model of Product Design [5] are considering restrictions of the production system at an early phase of the product development and also integrate elements of production system development into the product development procedure in a simultaneous manner. The VDI 2206 [4] outlines the parallel design of product and production. Models of product and production shall support this integrative approach. Following the V-cycles, product and production systems are specified and lead to in series producible products with affiliated production systems. Summarized the VDI 2206 concludes that the integration of different product development domains must also include the integration of their production systems. The described iterative character of VDI 2206’s development approach for the production of mechatronic systems is shown in figure 1.

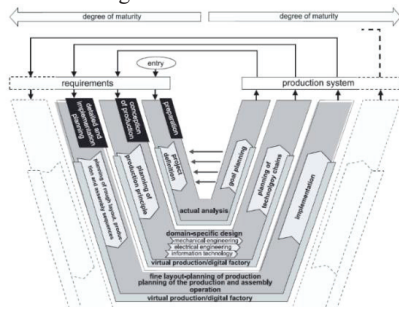


Fig. 1. . Iterative procedure of an integrated development approach for mechatronic systems [4].

Several production development methodologies [6,7,8,9] describe the product development from the production perspective. The interconnection between product and production development in these procedures are characterized as "integrated", "parallelized" and "simultaneous". Observed more closely, the interconnection is limited to the final phase of product development, where simultaneously the product development is completed and a concept for the production is derived. In figure 2 the process model of the VDI 4499 (Digital Factory) is shown. This figure also illustrates the consecutive elements of this approach. The conceptual design of production is started before the product development process is finished.

Another interconnection between product development and production is presented in figure 3. The production system development cycle is based on Westkämper [10], the product development cycle on the VDI 2221 [3]. Product and production development follow independent procedures and are not necessarily interconnected.

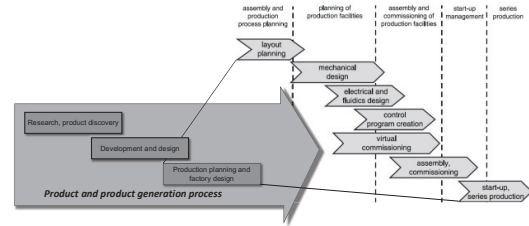


Fig. 2. Production development process of [6]

Based on consultations and agreements with and assumptions of the other domain, development of both is realized. This procedure originates from the functional division of product and production development into two separate departments. This kind of procedure can lead to a deficient interconnection between production and product development. It is possible to create a product, which cannot be produced, respectively a production which cannot produce the developed products.

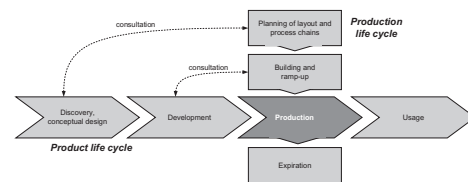


Fig. 3. Common interconnection between product and production life cycle

Most established product development/engineering procedures, like [11, 12, 13, 14, 15] do not consider the integration of production in detail or see it as downstream processes. The state of the art of integrative development is described in the following subsections. Two characteristic approaches for the interconnection between product and production are introduced as examples.

### 2.1. Simultaneous development

As already mentioned, many product and production engineering methodologies include simultaneous development elements of product and production. The VDI 2206 for example describes a parallelization between product and production development, but does not present a precise procedure model. A detailed elaboration is shown by Vielhaber [16], who compares the interconnection of different procedures and develops an integrated product and production development process model. This integrated process model is an enhancement of the procedure shown figure 3. Whereas the connections between product and production planning in figure 3 are loose and not structurally defined, Vielhaber creates fixed bonds. Vielhaber proposes a synchronization between the product and production process. The synchronization is not seen as a model-based joint development, but more as links through harmonized milestones and joint analysis activities. This synchronization shall improve the cooperation between

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