Fluidtronic – Development environment for fluid technical mechatronic systems

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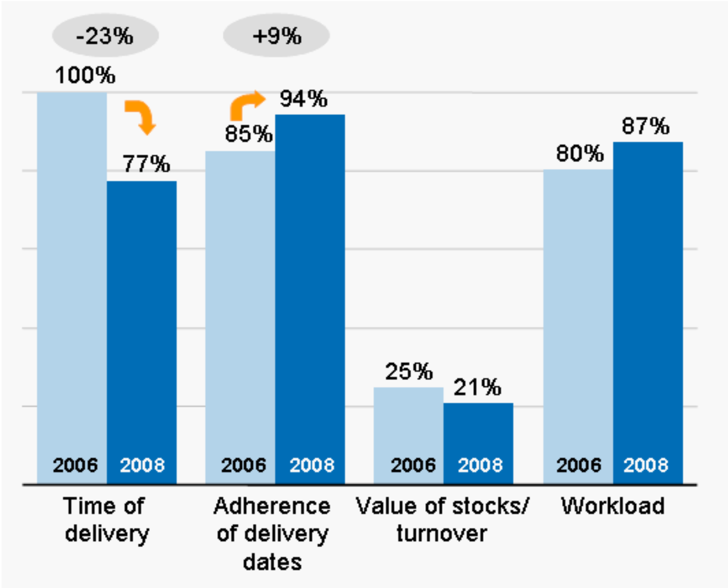
1 Introduction

In the German machine and plant engineering the fluid technical industry is an important manufacturing branch. In 2004 the total sales turnover was 4,6 billion Euro counting 27.000 employees/1/. With an international trade share of 33% fluid power technology is already the major branch in German machine and plant engineering and keeps growing above average. In 2004 the sales volume increased 11% upon last year. The industry sector of fluid technology is divided in a small number of major enterprises with a large product range and a wide field of small and medium sized companies which provide special fluid technical components or system specific solutions. In the present cooperative project a hydraulic press is selected as an example for a fluid technical mechatronic system. The increase of electronical components within manufacturing technology is a determining factor for the ongoing mechatronisation . In this case the automation on production line - and product level.

A spatial integration of components results on the level of system components like sensors and controls. Intelligent sensors and actor tools as well as monitoring concepts of preventive maintenance are the future booster for continuing mechatronisation/2/, /3/. Other trends in machine and plant engineering are reduction of delivery time and a general improvement of in-time delivery (picture 1). The high volatility concerning demands complicates production- and capacity planning within production. This leads to a trade-off between service- and production offer. The growing individuality and dynamic of markets is contrary to fast, efficient and reliable service- and production offers.



Picture 1: Trends within machine and plant engineering

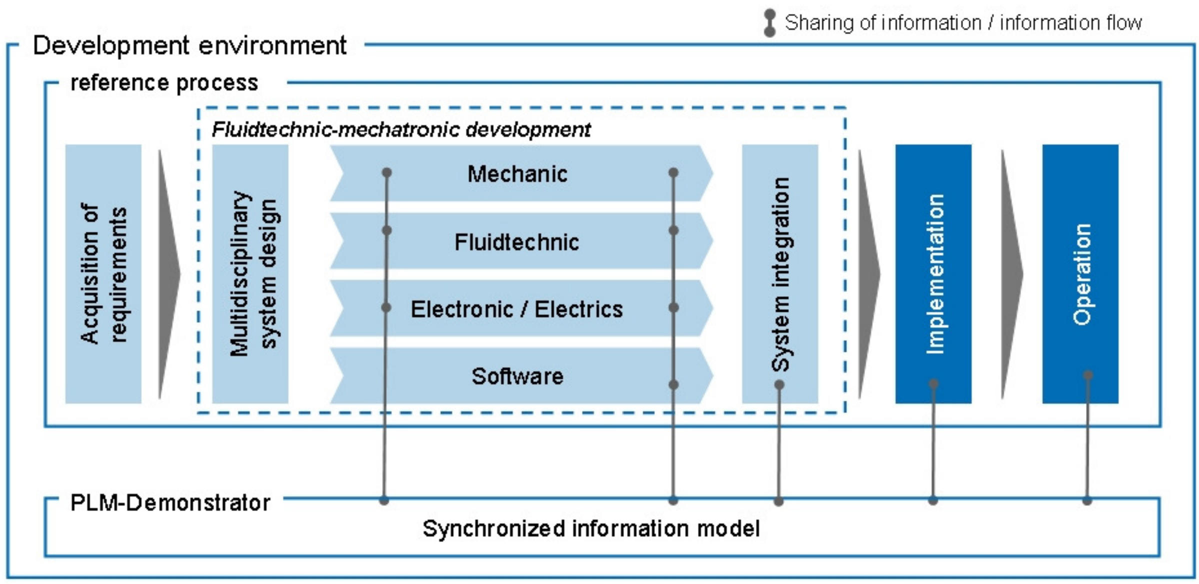
2 Target of the research project

The target of this research project is to reach a higher reliability of fluid technical mechatronic products. The focus lies upon the optimization of the research and development phase of small and medium size companies within the highly specialized fluid technical business. Therefore configurable reference processes for technical mechatronic research are defined and implemented in a PLM-demonstrator with in the framework of a development environment by example.

The configurable reference processes include the activity of development support as well as the necessary methods and tools. The description of the development process results in process templates. A specific template is an element of a development process and contains the respective process step, the step name, the operating organisation, the required activities, the system functionality, the methods and relevant categories to measure efficiency as well as input and output information. A reference Process for instance explains the systematic approach needed in order to realize product requirements for an overall product concept faster with other methods.

The reference process is exemplarily pictured with the help of an PLM-demonstrator in a development environment. The demonstrator is built on the basis of the Windchill-Plattform and existing integration standards (e.g. STEP, PLM services and results of the simPDM initiative of ProSTEP iViP Association). In order to realize the demonstrator it is necessary to adjust and instantiate the platform neutral reference- and information models, developed within the research project, for Windchill.

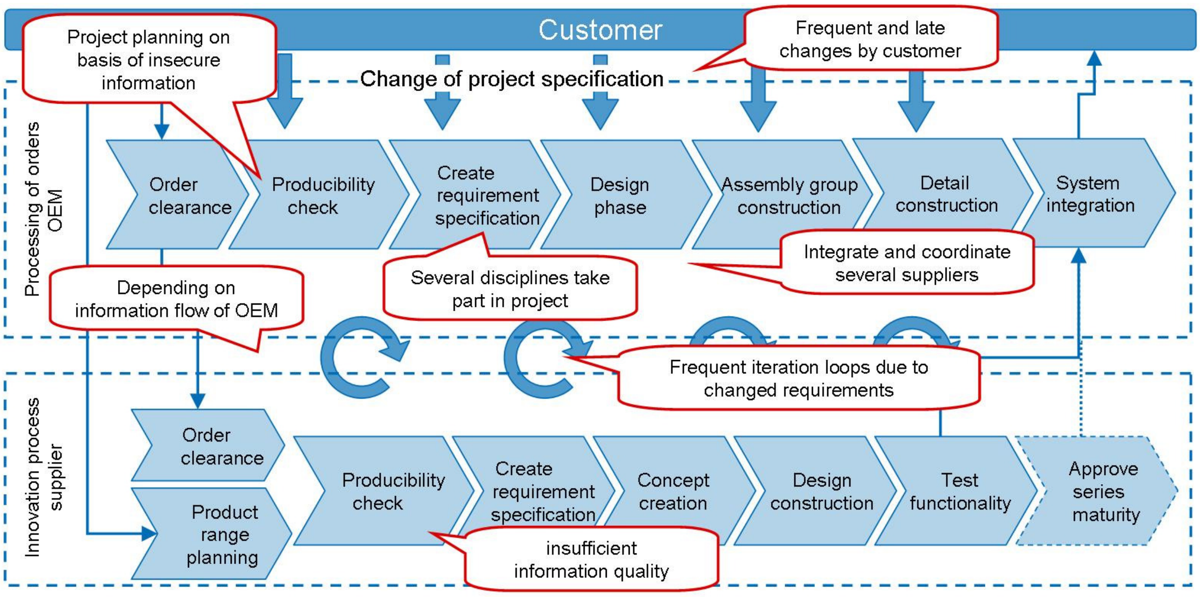
The relation and the connections between the focused project elements in an integrated development environment of a fluid technical mechatronic system are shown in Picture 2.



Picture 2: Environment for the fluid technical mechatronic research and development

3 Deficits in the development of fluid technical mechatronic systems

Fluidtechnical mechatronic systems are characterized by a high level of close interactions for all participants and complex interactions between OEM and supplier. Picture 3 shows exemplarily the interaction of companies at the development of a hydraulic press, whereas the major bottle necks of the development process can be seen. Due to the high level of interactions and complex network structures a safeguard system for product reliability and for an integrated development environment for fluid technical mechatronic products is significant.



Picture 3: Deficits in development process

Inside the companies an overall product system within the product development in order to cope with the complex interactions, caused by integrating mechanics, electrics, software and fluid technology does not exist, this. The cooperation of different disciplines in product development is characterized by isolated terminologies, process models, methods and tools. These deficits lead to misunderstandings due to different meanings for the same terms. The insufficient documentation of requirements, an incomplete documentation along the development, a missing consistency in the development process and an unstructured approach are additional weaknesses. These weak spots lead to an incomplete realization of the customer requirements. The resulting problems are solved in additional iteration loops in the product development, where single subsystems are brought together to a consistent and functioning overall system.

When software is used to improve the development process, almost only discipline based tools are in use. The different discipline based tools have the disadvantage that the information exchange between certain applications does not work properly. Information gaps, which require a manual product data exchange, exist between the used software tools.

The development process in the industrial fluid technology is still strongly characterized by the mechanical discipline, the chronological integration of other disciplines takes place far later. For this reason the interactions between the disciplines within the product development are considered insufficient. The appearing interactions between diverse fluid technical disciplines are becoming more complex, due to the increasing spatial integration of the components. Ignoring the interactions will lead to delays in product development and initial operation.

The product development in companies is characterized by a sequential processing, which is caused by grown structures. The sequential organized developing processes delays the information exchange between the involved experts and the teamwork between disciples.

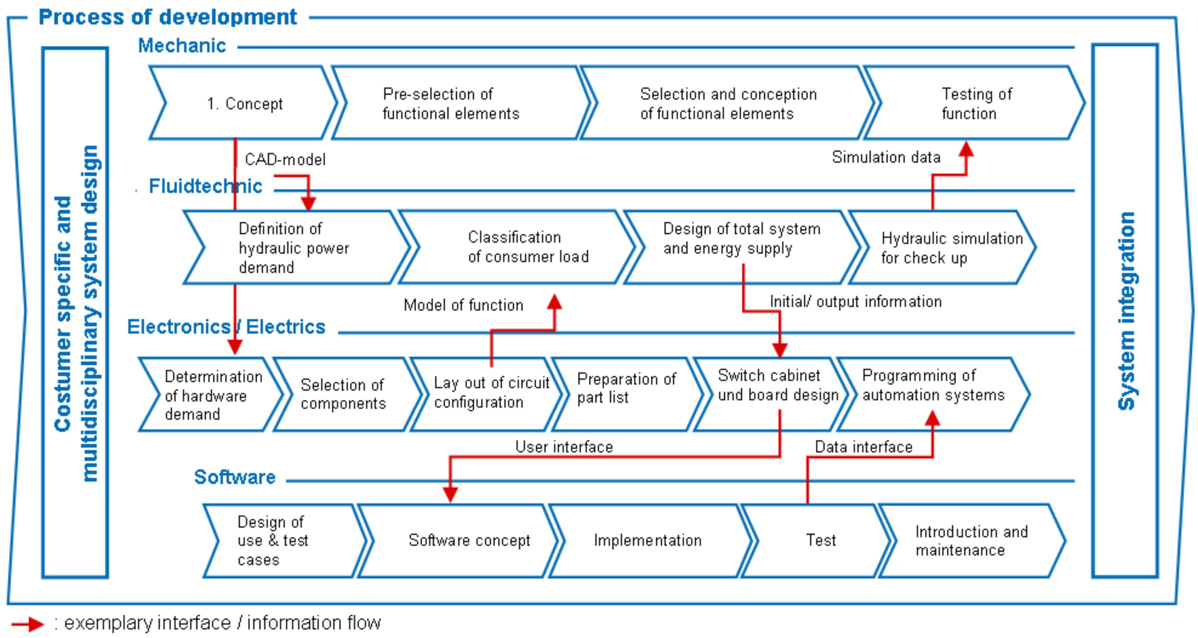
4 Approaches in fluid technology

The causes for the mentioned weaknesses in the development of fluid technical mechatronic products are mainly located in the development process and in the existing development tools. Based on these weaknesses approaches have been identified to increase the process efficiency and the product reliability. These approaches are described in the following paragraphs.

As a result of the multidisciplinarity of the fluid technical mechatronic development the product functions can only be realized by integration of the different disciplines. Therefore the requirements of all involved units (customer, disciplines, suppliers) have to be collected at first and then be valuated and prioritized by the involved disciplines (mechanics, electrics, software and fluid technology). Based on the product requirements an overall coordinated concept should be generated, which contains product drawings and a structuring on a conceptual base (e.g. function structure). The overall product concept and the conceptual product structure serve as a bridge between the early requirement definition phase and the construction phase and therefore define the basis for the disciple-specific concept /4/.

During the development and use of fluid technical mechatronic machines a large amount of documents and information is generated, which have to be available for the involved disciplines and partners (suppliers and customers) in order to maintain an optimal cooperation. The integrated administration and organization of information about products and their development processes along the entire product life cycle is provided through holistic PLM solutions. Product data from different sources can be saved within the PLM solution and can be integrated in the product structure. For this reason the PLM forms a superior information model, which synchronizes the discipline-specific information models. Furthermore the implementation of PLM based on standards (STEP, XML, etc.) enables the integration of IT systems (CAD, E-CAD, simulation tools) to a coherent IT platform. This platform provides the entire life cycle of fluid technical mechatronic products.

An appropriate development process for fluid technical mechatronic products synchronizes all discipline-specific flows with clear, predefined information flows, starting of with the gathering of requirements, the providing of an overall system concept up to the entire system integration. The process in picture 4 is formed according to the detail level of the V-model, which is introduced in VDI-2206. In addition it shows the development process including a time dimension. Based on an overall concept, discipline-specific proceeding models, methods and tools are used to create product information. Afterwards the discipline-specific results can be integrated in an overall system and the system attributes can be balanced /5/.



Picture 4: Connections between development processes

Through the changeover from sequential to parallel processes mistakes due to lacking communication and rework by reason of untuned changes, that reduce the development time, are being avoided. The continuous interaction between the involved departments and the high availability of information are two of the main elements of Simultaneous-Engineering (cp. /6/, /7/) that can be deduced for fluid technical mechatronic development.

5 State of Science

In Terms of IT, standards for data exchange and integrative software solutions became accepted over the past years. In this context the standards STEP (Standard for the Exchange of Product Data), XML (eXtensible Markup Language) and PLM (Product Lifecycle Management) form an essential contribution. STEP is an international standard (ISO 10303) for describing physical and functional attributes of product data. The standard STEP can be understood as a "construction kit" you can use to write on custom-designed product data models (application logs) under the use of basic modules (base models) according to defined rules and standardized methods (language of date modeling EXPRESS). Based on a standardized description it is manageable to exchange product data like CAD-models between different CAD-systems. XML is an expandable markup language that allows to bring structured information (e.g. product data) into a standardized format. Arnold defines PLM as an integrating concept for IT-supported organisation of all information about products and their development processes throughout the whole product life cycle so that the information are always up to date and available at the relevant positions in the company /8/. According to Peak and Hartmann the complementary use of these three concepts and technologies contributes to cross-company integration of information models of different mechatronic disciplines /9/, /10/. For the focus of this research project in particular, the project initiative SimPDM (integration of simulation and calculation into a PDM-environment) forms an essential basis within the ProSTEP iViP association. The SimPDM-project team develops concepts, structures and reference processes in order to enable the targeted saving of simulation models and calculation results in PDM-systems. In addition solutions for the parametrisation of simulation and calculation models are automatically being developed using the available product information (e.g. geometric data) from the PDM-system /11/, /12/.

The challenge of the cooperation of companies and disciplines inside of networks lies upon the process level whereas the use of process models makes an important contribution to the composition of the cooperation.

According to Kalpic process models serve as an efficient tool for the development and cross-department use of process- and product information /13/. The waterfall model is an idealistic procedure model with defined phases. At the end of each phase follows a validation of the results. In return the spiral model is a cyclical, risk orientated procedure model for the iterative specification of the requirements and the layout. The V-model stands for a comprehensive system understanding of hardware and software and contains an integrated quality, configuration and project management. The Rational Unified Process that already contains an integrated configuration, modification, project and environment management is an object-oriented development methodology that distinguishes itself through an iterative, incremental model orientated and application driven approach. For the development and description of a process model different modeling languages can be used. The use of UML (Unified Modeling Language) is widely spread because this method has establish itself as the modeling standard for object-oriented software development and is also used for object-oriented modeling of business processes (e.g. by means of application models and activity models for the description of the process templates) /14/, /10/, /15/, /16/. The use of this modeling language can assure the consistency of the modelized objects within the information model.

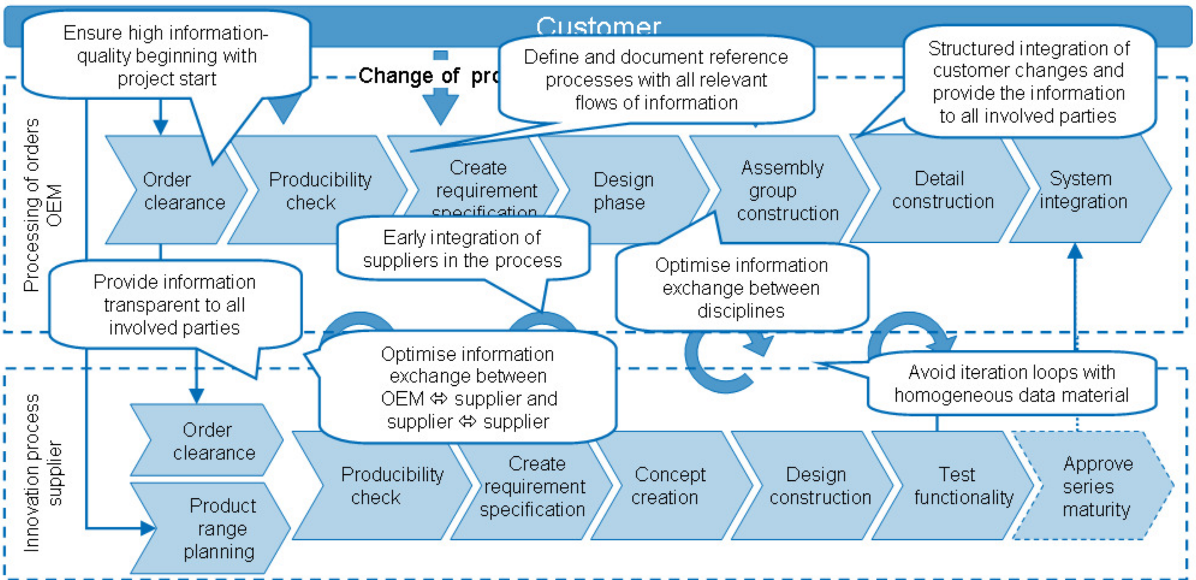
6 Approach to the creation of ideal reference development processes

The reference processes are developed inductive by consolidation of know-how from the practical experience as well as deductive from theoretical cognitions. The applied methodology for the creation of reference processes /17/ enables the optimal adaptation of established sequences and Best-Practices to the specific requirements of fluid technical mechatronic development.

An optimal desired process depends on several influencing factors. Via the coordination of reference processes and surrounding conditions a company-specific optimal “fit” ought to be achieved in consideration of the current state and IT-situation. Additionally the reference processes have to be adaptable to the needs of different companies. In doing so the aim is a clean borderline of the object area as a basis of clear defined requirements. The listed specification sheet forms the basis for the definition of the reference process because only the sections of the object system that conform to the modeling aim should be mapped. By a high degree of generic it is possible to derive a rough reference process on the highest detailing level so that it is applicable cross-sector and cross-system. For this it is necessary to define the “lowest common denominator” as the common reference process for the object area. The so-called high-level process displays dissolution during validity for the whole object area, normally on the basis of a few steps. The generic high-level reference process serves as a “regulation framework” for the structuring of the further approach. To this it is necessary that all concerned persons are able to agree on a basic alignment of the process.

The identification and allocation of Successful Practice elements forms the starting point to further detailing of the process. The objective is the consideration and securing of the realisation of the “state-of-the-art” in the reference process. In this connection the high-level process is also used as a regulation framework. A specific approach to the identification of Successful Practice elements is necessary for every case. Existing dependences between the configurable elements have to be identified in the form of configuration rules and documented. ”In this context process configuration means composition of processing steps or system elements on the basis of standardised process elements and on the knowledge base of stored configuration rules according to the characteristic of company-specific requirements”. The configuration rules describe the solution space. Commandments represent configuration necessities (“use of method A also requires processing step C”) while prohibitions represent restrictions of the solution space (“use of method A excludes processing step E”). Afterwards the unified mapping of the configuration processes via flow charts takes place. Via process types for several types of companies reference processes for different types of companies become realisable. The configuration items inside of the process types form the basis of the company-specific configuration of the reference process.

The results are configurable process modules (process templates) that regard the specific requirements of mechatronic fluid technical system development. The demands on the reference development process are described in picture 5.



Picture 5: Reference development process requirements

7 Conclusion and perspective

The universal designed reference processes and data structures have to be instantiated within a next step of implementation of a PLM-demonstrator for Windchill. To make the development process more efficient the objective is to provide project respective data automatically. This finally results in a PLM solution which maintains that every Partner and discipline has access to project relevant data and therefore is up to date. The transferability of solutions on platform independent systems is provided in the implementation of interfaces.

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