Mechatronic Data Models in Production Engineering

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Abstract: In automotive industry, to manage the market-driven challenges in the form of soaring product variants and decreasing model cycles successfully, new methods and IT solutions are required, especially in the field of production engineering. In this context, mechatronics as a key technology will play a decisive role in the future. This mechatronic issue refers not only to the increased use of mechatronic components in real production systems but also to the use of mechatronic data models in production engineering phases. Apart from their main characteristics, this contribution highlights different application scenarios of developing, using and processing these cross-domain data models.

Keywords: Mechatronics, Production Engineering, AutomationML, Virtual Commissioning

1. INTRODUCTION

After years of rising profits, companies in the automotive industry are currently confronted with stagnant or even diminishing markets. Due to the resulting competition for key market shares, car manufacturers (OEM) are engaged in an innovation race characterized by the following core demands:

- Soaring number of product variants with many product derivates
- Decreasing innovation and model cycles
- "Green technologies" in the field of future powertrain systems

These market-driven challenges inevitably affect all phases of the overall product lifecycle, especially the production-related project phases both of production engineering and ramp-up. On the one hand, the considered processes become increasingly more complex and, in consequence, more error-prone. On the other hand, in order to gain important market shares, the time for production engineering and ramp-ups has to be cut to the bone. Last but not least, these challenges also lead to extensive changes of the production systems themselves. The production facilities will become more and more flexible (as base for the production of more than one product), the lifecycles are getting longer and longer and the number of production ramp-ups will be constantly rising – especially during running production.

In order to manage these crucial production-related challenges, mechatronics as a key technology will play a significant role in the future. In this context, the following topic fields are presented both from a scientific- and user-oriented point of view taking the example of the engineering process of highly flexible production systems in the automotive industry. The considered mechatronic-oriented engineering applications are:

- **Functional engineering**
  Functional engineering describes a methodology for improving the production-related electrical and control engineering process. Base of this new methodology is the definition and use of mechatronic objects. The most important characteristics of these mechatronic objects as well as the functional engineering workflow are illustrated.
- **Data exchange via AutomationML**
  AutomationML focuses on the data exchange in production engineering. In this contribution the motivation and goals of AutomationML as well as the use for virtual commissioning are described.
- **Virtual commissioning**
  Apart from the illustration of the goals and concept of this hybrid simulation technology, the most important characteristics as well as the development process of the required mechatronic plant model as base for virtual commissioning is presented.

2. FUNCTIONAL ENGINEERING

Traditionally the process of production engineering is divided into mechanical design, robotics/simulation, electrical design and control design. Methods and tools of the digital factory primarily support the mechanical design as well as the simulation/robotics processes based on interdisciplinary workflows and an integrated data management. In the field of automation engineering (electrical/ control design), the situation is different. Innovative and integrated methods and technologies are still missing or they are currently developed by different companies. For example, Daimler pushes the mechatronic-oriented approach of „functional engineering" to improve and standardize the processes of control engineering, robotics and drive engineering (Hirzle, 2008).

2.1 Concept

The basic idea of functional engineering is the use of a „mechatronic engineering kit". Therefore, it is required to standardize all production-related resources used in the considered company (e.g. robots, conveyors). Such resources are described by their mechatronic characteristics illustrated in Figure 2. Once defined, these mechatronic objects can be used along the whole production engineering process. Related to the different engineering phases, the relevant aspects including a short description of these objects are:

- *Identification*
  Most important aspect of a mechatronic object; is uniquely defined in the standardization process (object identifier); at the first use the instance identifier is defined
- *Geometry/ Kinematics*
  Used in mechanical design to develop and simulate the mechanical 3D plant model (e.g. use for DMU/ accessibility checks, robot simulation)
- *Electrics*
  Contains all necessary information and templates both for wiring diagrams and the connection to the used controls (e.g. PLC: Programmable Logic Controller) and power supply
- *Behavior*
  Description of the function-specific behavior of the mechatronic object in relation to a control (e.g. PLC, RC: Robot Controller); essential base for virtual commissioning (chapter 4)
- *Communication/ Control/ Visualization*
  Definition and use of templates for PLC function blocks, human machine interface (HMI) and for the communication between controls and the mechatronic object

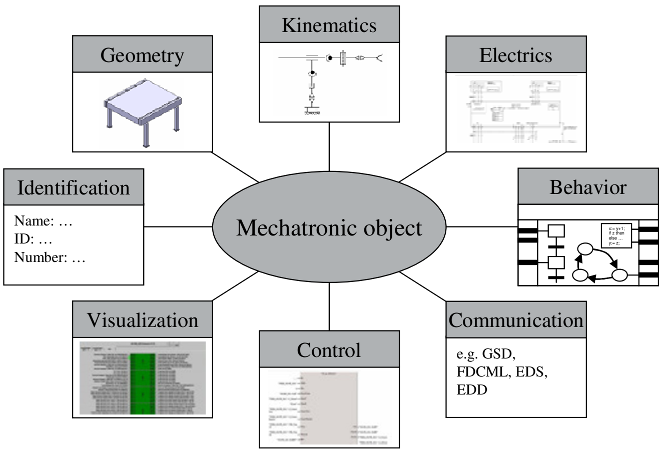

Figure 2: Aspects of a mechatronic object in production engineering

2.2 Engineering workflow

The main inputs for functional engineering are results from the concept planning and the mechanical design. As illustrated in Figure 3, one base is the 2D plant layout including the planned resources (e.g. number of robots) and already defined PLC and protection areas. From the mechanical design more detailed information about the planned resources are necessary as for example which robots are used or how the clamps are connected to the valves (pneumatic plan). Based on pre-defined standardized configuration rules (e.g. concrete linkage between motor type and conveyor) and the needed mechatronic object library, the input data are enriched with electrical information. Thus, it is possible to generate all required types of wiring diagrams, PLC programs (incl. resource-specific function blocks) and the plant-specific behavior model as base for virtual commissioning (chapter 4) automatically. In chapter 3 exemplary the process of behavior model generation based on AutomationML is described in detail.

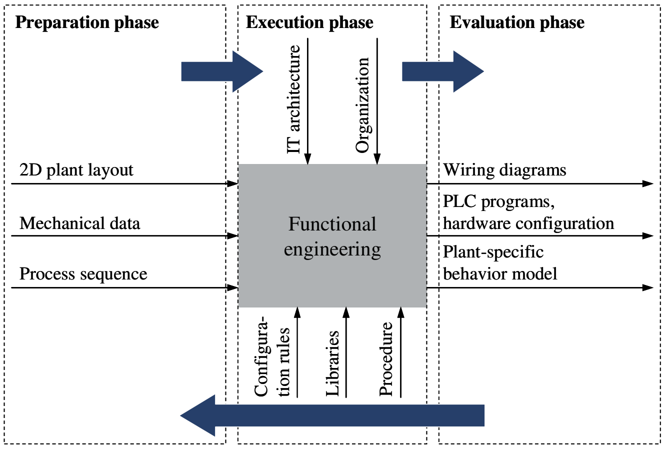

Figure 3: Functional engineering – Phases, data flows and inputs/ outputs

Apart from the resource-specific issues, functional engineering is also intended for improving the data consistency for process planning. On the one hand, the process sequence defined in the digital factory is enriched with control-specific information in order to generate the PLC Sequence Function Charts (SFC). Thus, the whole PLC program can be automatically generated. On the other hand, so far it is possible today, the motion planning for robots of the digital factory (OLP: Offline Programming) is enhanced with the necessary signal information for communication to the PLC. Based on this, the whole manufacturer-specific robot program code (e.g. KUKA, ABB) is generated.

3 DATA EXCHANGE VIA AutomationML

3.1 Motivation

To achieve all goals of functional engineering in a most efficient way, it is essential to exchange the different heterogeneous planning and design data between the different software tools without loss of information. That means, respective interfaces between all relevant engineering tools are required. In order to avoid many proprietary interfaces, it is recommended to use an integrative data exchange format.