AUTOMATIC MODEL GENERATION FOR VIRTUAL COMMISSIONING OF SPECIALIZED PRODUCTION MACHINES

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1. INTRODUCTION

Actual challenges in production are individualization and short product lifecycles. To achieve this, the product development and the production planning must be accelerated. In some cases specialized production machines are engineered for automating production processes for a single product. Regarding the engineering of specialized production machines, there is often a sequential process starting with the mechanics, proceeding with the electrics and ending with the automation design. To accelerate this engineering process the different domains have to be parallelized as far as possible (Schlögl, 2008). Thereby the different domains start detailing in parallel after the definition of a common concept. The system integration follows the detailing with the objective to verify the system including the PLC-code. Regarding production machines, the system integration is done either by commissioning of the real machine or by validating the PLC- code against a model of the machine, so called virtual commissioning.

2. CURRENT SITUATION WITHIN VIRTUAL COMMISSIONING

The goal of virtual commissioning is to verify the developed PLC-code by checking the sequence of actions of the machine. To enable this verification, the PLC-code is tested against a virtual model. This virtual model consists of two main behavior models, the electrical and the mechanical part. The setup of the models is a time consuming manual process today. To save modeling effort, often the electrical components, like contactors, motor protection, switches or door locking devices, are not modeled today. This leads to a gap between the signals used within the PLC program and the signals implemented in the model. An analysis of a typical virtual commissioning model showed that for only about 50% of all PLC-signals have direct impact on simulating the actions of the mechanics. All other signals are communication signals with the electrical components, for instance switching a contactor, controlling clearances or getting status information. This means for the setup of the virtual commissioning model, that either the original PLC-code has to be adapted for virtual commissioning or the virtual plant has to be a very detailed. The first case would fail the goal of virtual commissioning by testing the original PLC-code. Further on, it is difficult to keep the virtual commissioning model and the artefacts of the engineering process synchronized. Therefore the second case is pursued here. The problem of the second case is, that a detailed model including all signals is needed, which leads currently to high manual effort. To reduce this manual effort, there are currently two main approaches known; the "library focused"- and the "modeling in parallel within the engineering process"-approach. The library approach is based on modeling components including 3D-models, kinematics, collision-objects and logical behavior and to store them within libraries. Additionally these library elements could be provided by suppliers (Kiefer, 2009). This leads to the need of open data formats for exchanging the behavior-models. This is suggested by Drath through using AutomationML (Drath, 2010). The second way is suggested either by Lindworsky or the Aquimo-project (Litto, 2010). Lindworsky starts with a functional description of a machine, which is used as a layer between the different domains on an abstract level. Within every state of the engineering project, the functional description could be enriched with information out of different disciplines, especially from MCAD-systems, to generate a virtual commissioning model (Lindworsky, 2008). The Aquimo project captures this idea, but uses a commissioning model between the disciplines instead of the functional description (Litto, 2010). Regarding specialized production machines the library approach as it is, cannot be used regarding geometries and kinematics, which are designed from scratch within the different engineering projects. The second approach also leads to a high effort, because the enrichment over the engineering process must be done by all concerned disciplines.

3. CONCEPT OF AUTOMATIC MODEL GENERATION FOR VIRTUAL COMMISSIONING

Regarding the requirements on virtual commissioning of specialized production machines the effort of modeling has to be minimized by providing the flexibility on the mechanical side at the same time. The mechanical engineers focus on the geometrical parts and the kinematics between them. This is special to each machine. Actuators, sensors and other electrical components, like contactors, are bought-in parts from suppliers. These standard components are used in different engineering projects. This could be supported by libraries. Additionally all of these components are contained within the wiring diagrams, connected to each other and to all used signals within the PLC program. This is shown on the left side in Figure 1.

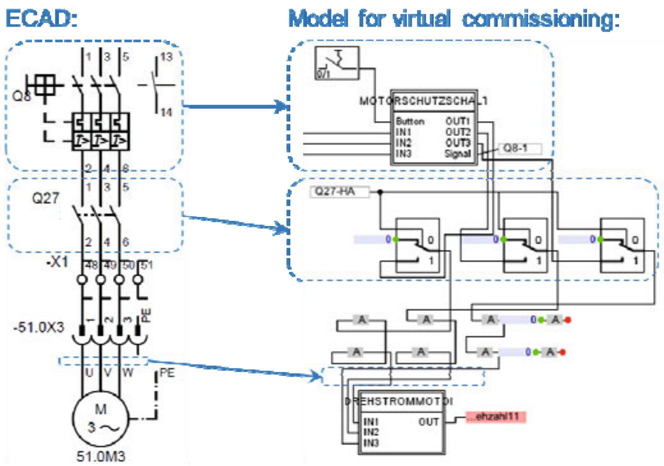

Fig. 1: On the left, wiring diagram and on the right, equivalent objects for components and connections within virtual commissioning model.

This leads to the possibility to generate the behavior model for virtual commissioning based on the wiring diagrams and on behavior models for the components stored within a library. Therefor a logical behavior model of each component within the wiring diagram has to be defined in the library of the virtual commissioning tool. This model must contain all electric and fluidic ports and the logical behavior of the component. As pictured in Figure 1, the Contactor Q27of the wiring diagram has a corresponding behavior model consisting of three switches triggered by the signal Q27-HA. If the user has defined the mapping between the ECAD component and the logical behavior model once, it is possible to generate the appropriate high detailed logical behavior model directly. To do so, the components on the wiring diagram are replaced by the simulation components. The information about the connection between components is also extracted out of the wiring diagram. The geometries and the kinematics could be reused from the data of the 3D-CAD model, which is designed during the detailed mechanical engineering. The interface between the generated behavior model and the mechanics is exactly defined. For actuators the current position in runtime is written to the mechanical model by this interface. The sensor-signals, calculated by collision within the mechanical model are written to the generated model. So the PLC is only directly connected to the Generated behavior model. This approach leads to high flexibility on geometries and kinematics by minimizing additional effort for modeling the mechanics of the virtual commissioning model. Additionally an automatic generation of the behavior models for all components used within the electrical view is realized.

4. IMPLEMENTATION OF THE CONCEPT FOR AUTOMATIC MODEL GENERATION

The automatic model generation described in chapter 3 was realized with SIMATIC Automation Designer, especially with its ECAD-functionality and SIMIT. The object oriented model of SIMATIC Automation Designer was used to get the information on the setup of the wiring-diagrams. The mapping between the objects of the wiring-diagrams and the simulation objects in SIMIT was done based on the library of the SIMATIC Automation Designer. Further on, an application was developed to convert the static wiring-diagrams into the simulation model in SIMIT. SIMIT provides the realtime environment with direct connection to the PLC via Profibus DP and Profinet. The geometries, kinematics and collisions are modeled in Tecnomatix Process Simulate Commissioning. To minimize the modeling effort of the mechanical model, especially the behavior of the actuators, only the nominal position of each actuator and the sensor signals are exchanged through an OPC-interface between Tecnomatix Process Simulate Commissioning and SIMIT. The behavior model of the actuators is part of the electrical components.

5. CONCLUSION AND OUTLOOK

The automatic model generation of a virtual commissioning model accelerates the phase of system integration by minimizing the modeling effort for the setup of the virtual commissioning model. The method allows the mechanics to be very flexible in modeling. Because of the detailed simulation model, further analyses can be performed, like definition of test use cases for the whole system. The behavior models of the components are on a logical level. Because of this abstraction, in comparison to physical models of the components, suppliers could deliver these models without giving too much data to customers. This leads directly to the ability to provide the logical behavior models within public libraries.

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