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Modular Inspection Equipment Design for Modular Structured Mechatronic Products – Model Based Systems Engineering Approach for an Integrative Product and Production System Development

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Abstract

Quality control is an essential part of the production of modular mechatronic systems. Especially the quality inspection of the overall system at the end of the production is of extraordinary importance. The associated inspection equipment can also be a mechatronic system, which is often explicitly designed and manufactured for one product with a large expenditure of time. In order to have the needed inspection equipment ready by the start of production (SoP) and to consider additional requirements to the product, which are produced by the inspection equipment concept, an integrative mechatronic product and inspection equipment development procedure is needed. Furthermore, the inspection system has to consider the modularity of the system and often has to be designed in a modular way. Nowadays, the development of complex mechatronic systems is often carried out with the help of model-based systems engineering (MBSE) methods. Consequently, the inspection equipment should also be designed with the help of MBSE. This paper describes an integrative product and inspection equipment procedure for modular mechatronic systems with the help of MBSE. Especially the peculiarity of the modularity is described and validated with the help of an application example.

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1. Introduction

Nowadays, most of the modern technical products are mechatronic systems. Mechatronic systems can be described by the close interaction of mechanics, electrics / electronics, control engineering and software engineering. Therefore, the interdisciplinary collaboration in the design and the development of such systems becomes more and more important [1]. Currently, the global competition can be characterized by the high speed of innovation, shortened product life cycle as well as increasing customer expectations for performance, quality and price of products [2], [3]. Furthermore, a global distribution of the production of mechatronic systems becomes more and more common [4], [3]. Consequently, the product complexity increases due to the increase of the product functionality.
In order to meet customers' requirements, these mechatronic systems are often built in different variants [5], [6], [7] and/or in a modular way. This modular structure of the product additionally increases the complexity of the development.

As a result of an increase in product quality, the quality inspection is becoming increasingly important during the production of mechatronic systems. In particular, the quality examination of the overall system at the end of production is extremely important. The increasing complexity of mechatronic systems leads to an increasing complexity of their inspection equipment. Most of this inspection equipment is also complex mechatronic systems.

When the product is a modular mechatronic system, the inspection equipment itself has to consider this modularity. Furthermore, there can be additional reasons for the modularization of the inspection equipment, e.g. for the expendability. This allows companies to adapt the inspection equipment to different sales numbers of the product or to inspect the product in different countries. Another reason can be that different varieties of products have to be inspected in different countries.

Due to the complexity of the modern mechatronic systems, the product and the production system must be designed and developed integratively, in order to match optimally with each other [8], [1]. Especially the development of the product inspection equipment – because of the numerous existing interfaces and interactions between it and the mechatronic product – has to be considered.

Regarding the shortened product life cycle, simultaneous engineering approaches are typically used. The production system and its quality examination components – mainly the inspection equipment – have to be designed and developed simultaneously with the product development. The development of inspection equipment has to be started at an early development phase of product development, in order to be ready by the start of the production time. Moreover, the development of inspection equipment typically results in additional product requirements, which have to be communicated back to product development. These requirements can only be considered if the inspection equipment development starts in an early phase of the product development.

This paper shows a systematic considering the modular structure of a modular mechatronic system during the development of an inspection system. It is shown how to modularize an inspection system with the support of MBSE-methods. Additionally, an integrative product and inspection development process is shown. The systematic will be applied and described by an application example, which is the innovative modular inverter system (IMIS) of the company KEB [9].

2. State of the Art and Need for Action

This chapter describes the related state of the art. It starts with a description of general trends in the product development and production. An introduction to the integrative product and production system development to the mechatronic design with the help of MBSE is given. Furthermore, the state of the art for different types of inspection planning is presented. At last the need for action is illustrated.