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Product-Service Systems for Functional Offering of Automotive Fixtures: Using Design Automation as Enabler

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Abstract

In production of automotive components, control-measuring is an important activity to assure that geometries meet expected tolerances. This is done via randomly taking parts out of production for control-measuring in a fixture. This fixture is both a tedious and repetitive product to design and configure. The aim of this paper is therefore to present an approach to adopt a design automation strategy towards supporting the configuration of fixtures and to discuss opportunities for moving towards a Product-Service System-paradigm in this domain. This paper reports on a development of a design automation demonstrator to configure fixtures for control-measuring. The demonstrator has been developed in a commercial CAD-environment and will be deployed through a web-based interface. The paper concludes with a discussion on PSS-opportunities and how to drive this with a Knowledge-Based Engineering-modelling approach.

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Keywords: Knowledge Based Engineering; Design Automation; Mass Customization; Product-Service Systems

1. Introduction

Moving from providing traditional hardware products to product-service systems (PSS), means that manufacturers' mind-sets shift from primarily doing cost reduction to taking on a greater relationship focus, together with customers – being providers of value. Similarly, suppliers move from being providers of components to taking on responsibility in the value-creation cluster, providing proactive value-creation for their customers. At the same time, they take on added levels of risk and costs, in exchange for a, potentially, steadier revenue stream further ahead in the relationship. This, coupled with the continuous change towards a globalized marketplace, where companies can no longer rely on regional proximity for sustaining their business, there is a need to develop their capabilities for this scenario.

In production of automotive body components, fixtures are an important part of the ongoing work on geometrical assurance. They are used to control that the manufactured part, often formed through a stamping, adhere to the expected form, within given tolerances. A fixture setup is built-up by a number of holders connected to a frame (see figure 1). The positioning of the holders is relative to readily defined reference points on the automotive body component, which are positioned so it is possible to quickly measure at a set of defined control points. By using these fixture setups, it is possible to accelerate the number of measures that can be made.

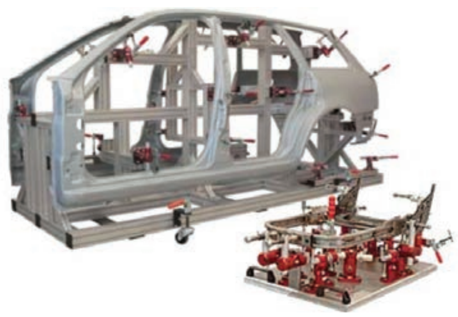

Fig 1. A fixture setup for control measuring.

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The fixture setups are configured in a Computer Aided Design (CAD)-environment, where design experts model the fixtures, by reference to each automotive body component. This includes manually positioning each holder relative to reference points on the component, and fine-tuning their orientation and positioning on the base-frame.

A major challenge with this is that it is repetitive, albeit it requires the attention of expert configurators to put this fixture setup together in a way that is structurally stable and also efficient from a process and measuring perspective.

With this in mind, design automation seems to be an interesting approach to explore. Is it possible to capture the skills of the experts in some best practices, rules or other knowledge elements that then allows it to be supported with a design tool for automating, at least parts of the tedious and repetitive design tasks?

From here on out, the idea is then to further virtualize and globalize the capability, by putting it in the hands of the customers through virtual channels. Customers, often engineers at partner companies in the automotive industry, can then do more of the configuration work on their own, at their own desktops. They can then configure the fixture in parallel as they make their design choices and decisions on their parts.

The aim of this paper is therefore to present an approach to adopt a design automation strategy towards supporting the configuration of fixtures and to discuss opportunities for moving towards a PSS paradigm in this domain.

In essence, the paper is also exploring what capabilities would be needed for a small firm, here being a support firm in the value chain that is producing automotive fixtures, to be able to add value in a large and global business-to-business (B2B) consortia context.

2. Theory

The design process paradox [1], see expanded version in figure 2, captures, albeit coarsely, the notion of a catch-22 in design process-terms.

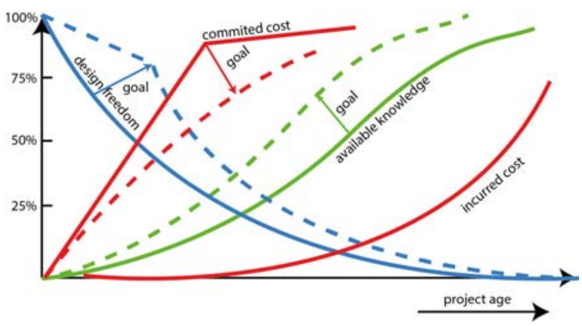

Fig 2. Expanded version of design process paradox, adapted from Ullman [1] and Verhagen et al. [2].

In the beginning of the design project, when the possibility to affect the design and thus also the committed costs is at its greatest, the knowledge is also at its lowest. Many strands of research into supporting and improving product development focuses on moving the curves in a positive direction (see dashed curves in figure 2). So also in the field of knowledge enabled engineering, where various knowledge-oriented tools and methods are applied to move downstream knowledge more upstream – or to say, to utilize various previous experiences and learnings from before in the current project.

2.1. Design Automation

Design automation deals with automating design tasks which are normally carried out in manual fashion by engineers and designers. Moving to Knowledge-based engineering (KBE), it is defined by La Rocca ([3]) as:

"… a technology based on the use of dedicated software tools called KBE systems, which are able to capture and systematically reuse product and process engineering knowledge, with the final goal of reducing time and costs of product development by means of […] automation of repetitive and non-creative design tasks [and] support of multidisciplinary design optimization in all the phases of the design process."

Verhagen et al. [2] (2012) sees KBE as a way of working, achieving design automation and knowledge retention.

For a generative KBE-application, a set of inputs are used to redesign and analyze a generative product model in order to generate an output design [3], see figure 3.

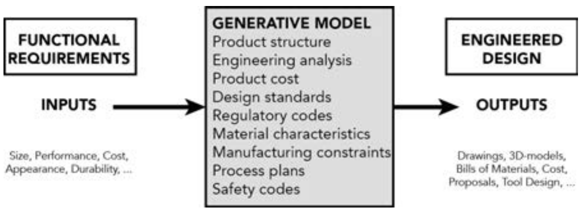

Fig 3. Generative KBE Application, adapted from [3].

A KBE-system is closely related to CAD, often being implemented as modules inside CAD-systems, where the developer writes code to manipulate a CAD-representation of a product in the KBE-application.

From a knowledge perspective, KBE is motivated and supported by the application of a knowledge lifecycle [4], see figure 4. The knowledge lifecycle is devised to support the identification, justification, capture, formalization, packaging and activation of knowledge-support solutions on specific design activities or entities.

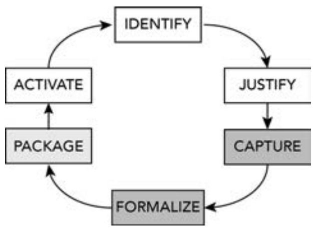

Fig 4. KBE lifecycle, adapted from [4]– accentuating its focus on primarily knowledge capture and formalization.