Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 33 (2015) 47 – 52

www.elsevier.com/locate/procedia

9th CIRP Conference on Intelligent Computation in Manufacturing Engineering

Efficient validation during product development using a self-optimizing inspection system

Schmitt, Robert[a], Falk, Björn[a], Frank, Daniel[a]*

[a]*Chair for Metrology and Quality Management, Laboratory for Machine Tools and Production Engineering WZL of the RWTH Aachen University*

* Corresponding author. Tel. +49 241 80-26977; fax: +49 241 80-22 193; *E-mail address*: d.frank@wzl.rwth-aachen.de

Abstract

In order to be competitive and to offer distinguishable products which delight customers, companies have to tailor their products to the exact needs and specifications of their customers. At the same time, companies have less time to develop new products or make changes to existing products, due to an overall shortening of product lifecycles and increasing market related cost pressure. Because of this lack of resources in product development, products are often not validated against the real customer impression until they reach the market. In consequence, companies risk non-acceptance of their products by the customer. Additional changes in product specifications might come too late and not make up for the lost trust of the customers in the company's products.
To overcome this challenge, companies have to improve the product validation process, i.e. validate more quickly and earlier. A self-optimizing validation system could present a possible improvement in this regard. Using this efficient system, the validation could take place before the product is delivered to the market. In addition, the information from product validations would automatically be prepared and directed to the product development or the production process, to enable changes within the product specifications, without necessary interpretations of the validation.
The paper gives answer to the question, how validation can be improved regarding efficiency and objectivity. To do so, the concept of a self-optimizing validation system using tactile sensors is presented, which can be used to validate the haptic product perception of customers. To display the relevant functions of this system and the necessary interfaces to the linked processes, a Viable Systems Model of the technical system is used to demonstrate this concept. The results implicate the applicability of the Viable Systems Model on technical systems and represent a contribution to the research towards a self-optimizing production system.

Selection and peer-review under responsibility of the International Scientific Committee of "9th CIRP ICME Conference"
Keywords: Evaluation, Inspection Optimization; Product, Development, Quality, Conceptual design

1. Introduction

1.1. Dimensions of product quality

Nowadays manufacturing companies from high-wage countries are facing different challenges when trying to maintain their market shares and profitability in consumer driven markets such as automotive and consumer electronics [1]. The high functional quality of their products has long been a unique selling point which justified higher prices. As technology and process know-how rises in companies from low-wage countries, customers are offered low priced product alternatives similar in terms of their functional quality. Instead of just comparing elements of functional quality of different products, customers are increasingly looking for alternative, emotional quality cues when choosing [2]. A major element within this emotional quality is its Perceived Quality [3]. In order to continually distinguish

Selection and peer-review under responsibility of the International Scientific Committee of "9th CIRP ICME Conference"
doi:10.1016/j.procir.2015.06.010

their products, OEMs (original equipment manufacturers) from high-wage countries have to develop highly individualized products meeting not only the requirements regarding functional, but also emotional, and the before mentioned *Perceived Quality* [4], [5], whereas only Perceived *Haptic* Quality will be considered within this paper.

In addition to fulfilling the requirements mentioned above, the product development process has to be highly efficient, as product costs still have to be nearly equal to those coming from mass-production, due to the high availability of goods and volatility of customer requirements [6]. In the following section, the paper will show that validation of products is an aspect which has to be optimized, to make sure conformance of products with the customer can be assured even when available resources for product development are declining.

2. Validation as a major task within the product development process

2.1. Current approaches at validation in product development

In order to develop successful products, customer requirements have to be identified and quantified, correctly transformed into product specifications and the conformance of the product to the customer requirements has to be evaluated within the process of product development [7]. Literature holds different product development approaches which specify the execution of these tasks and seek to solve the trilemma of costs, quality and time (see e.g. [8], [9]).

However one similarity between these approaches is, that the development process advances iteratively. These iterations consist of the development of a solution, the analysis of the solution and the deduction of new targets for the next iteration. Within every iteration, decisions have to be made on how to proceed, often with incomplete information. Important decisions are especially those about which concept of the product or parts of the product are followed and which are discarded. The desired result of each decision is to choose the concept, which most effectively and efficiently fulfills the customers' requirements. [9]

To make this choice, ideally, the concepts are compared and *validated* using the future customer's impression. The term validation origins in social sciences, where it means testing whether a certain method delivers the results it was intended to. Transferred to technical products, *validation* means seeking the answer to the question "Is the *right* product being developed". [8]

Thus, validation comprises an evaluation of the degree, to which customer requirements are met within a concept. Ulrich states that evaluation of concepts should involve the customer. According to Ulrich, procedures for validation include phone, mail, internet or face to face surveys, where the concept as a virtual or physical model is presented to representative customers and they are asked to evaluate it. [7] To demonstrate the currently used approach to validate on the example of Perceived Quality in product development, the process is visualized as a control loop in Fig 1.

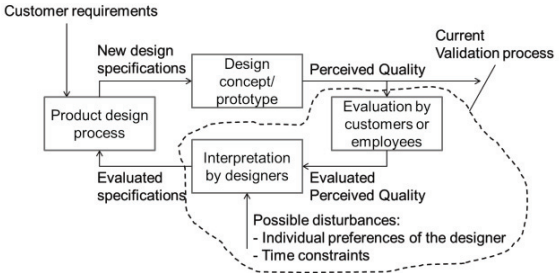

Fig 1: Generic design iteration loop using studies and surveys to validate design concepts or prototypes

2.2. Challenges arising from current approaches of validation in product development

Due to the high costs related to surveys or extensive interviews and the problematic interpretation of the results, testing of concepts using customers, i.e. validation is often not performed adequately, or not performed at all [9]. However, by not validating their concepts within product development, companies risk non-conformance of the finished product with the customer's requirements and thus, non-acceptance by the customer [10].

Instead of validating the product using the customer impression, it is common to leave validation to a team of company employees [7]. This procedure carries a high risk, as the evaluation of the employees can be biased [11]. However, even if validation is performed by the customer using methods such as survey or studies, the effectiveness of the validation depends on the designer's ability to derive targets for the product specification from the subjective evaluations of the customers.

To enable companies to use regular validations regarding the Perceived Haptic Quality of their products throughout development in order to ensure conformance of the developed product, a more time- and cost-efficient validation procedure has to be elaborated. At the same time, this new procedure has to produce results which reflect the actual Perceived Haptic Quality and allow an objective conclusion regarding optimized specification of the product concept/design. Consequently, the underlying research question guiding this paper is:

How can validation of Perceived Haptic Quality within product development be made more efficient and objective?