Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 67 (2018) 458 – 463

www.elsevier.com/locate/procedia

11th CIRP Conference on Intelligent Computation in Manufacturing Engineering - CIRP ICME '17

Digital real-time feedback of quality-related information to inspection and installation areas of vehicle assembly

Marco Gewohn*[,a], Thomas Usländer[a], Jürgen Beyerer[a], Gerhard Sutschet[a]

[a]*Fraunhofer Institute of Optronics, System Technologies and Image Exploitation, Fraunhoferstraße 1, 76131 Karlsruhe, Germany*

* Corresponding author. Tel.: +49-176-30934252. *E-mail address*: marco.gewohn@iosb.fraunhofer.de

Abstract

The article presents an information technology model for the transparent feedback of quality-related information on the vehicle assembly production process in real time. This system integrates huge amounts of heterogeneous data sets, gathered through quality gates in the assembly line, to provide new user-focused information for controlling production quality. All information is prepared to cater to the specific needs of three different types of users and then reported back via four levels of quality feedback to the recipients as a defect occurrence in quality. This ensures that quality-related process information is provided immediately as essential to make progress towards achieving first-time quality and improving production quality.

Peer-review under responsibility of the scientific committee of the 11th CIRP Conference on Intelligent Computation in Manufacturing Engineering

Keywords: Quality assurance; Feedback; Production quality; Smart factory; Internet of things; Vehicle assembly

1. Introduction

A manufacturing company faces various challenges which decisively influence production. In addition to the increasing complexity and variance of assembly through a wide range of customer requirements and the change from mass production to mass customization [1-6], the high flexibility demands through the dynamic, crisis-prone environment [7-9], coupled with the increasing challenge of data, information and process transparency [1, 9, 10] due to JIS production, the compatibility with cost targets in particular poses a major challenge for businesses [11].

Quality, differentiated between product quality and production quality, is thus a decisive factor in market competitiveness. In addition to production at competitive costs and delivery within a reasonable time, a company needs to offer products with flawless quality – to maximize the product quality. An enterprise endeavors to manufacture the products from the outset with zero defects under the challenging conditions in accordance with the zero-defect principle [12] – to maximize production quality. In automotive production, the assembly step is characterized by various manual activities[1] which entails an increased defect risk along with the associated rework costs [1]. Maximization of product and production quality and minimization of the quality costs for necessary rework requires digital feedback of quality information in real time to the responsible individuals and locations within the context of "Quality 4.0" [13].

1.1. Challenges of quality feedback

The compatibility between cost minimization, especially of rework costs, and quality maximization poses a major challenge for manufacturing companies [8, 14].[2] One measure is to implement a *Quality Feedback Model* (QFM) in order to report information as quickly as possible back to all the relevant actors and locations to augment quality awareness and knowledge.

[1] Assembly accounts for approx. 20-70% of direct labor costs [2, 14]
[2] Cf. magic triangle: compatibility of time, costs and quality

Peer-review under responsibility of the scientific committee of the 11th CIRP Conference on Intelligent Computation in Manufacturing Engineering
doi:10.1016/j.procir.2017.12.242

Nonetheless, the implementation of a targeted QFM proves just as challenging as ensuring the compatibility of cost and quality targets. A consistent closed-loop must be developed to control quality information by fully recording necessary data and thus generating reliable information – extracting smart data out of big data [15]. Moreover, data processing must be defined such that the defect prevention process can be initiated at the end of the process. Such control requires technologies of the emerging Industrial Internet of Things (IIoT) [16] such that the necessary information frequency and accuracy can be ensured – right information in the right place at the right time.

While many approaches to quality feedback focus on technical aspects of innovation, one important factor is often overlooked [8]: the individual who is responsible for delivering high-quality products in the value chain. Hence, a *QFM* needs to involve all those individuals taking part in the process in order to respond rapidly to dynamic changes in the human-system collaboration [2, 17].

1.2. Current status of quality feedback in vehicle assembly

The level of intensity and usability of quality feedback varies widely among automotive manufacturers [18-20]. Certain manufacturers have completely automated quality feedback in real-time embedded in the production line, while others only manually digitize defect recording, but continue to implement the reporting without any digitization, automation or real-time constraints. In particular, various system and media incompatibilities as well as a lack of user orientation through non-standardized information hamper optimum quality feedback. Consequently, the information chain of the quality feedback process is impeded, slowed down and its quality impaired at this point. [21]

These kinds of manual and analog quality feedback processes make the system highly prone to errors and potentially delay reporting. This causes a variation in quality in the corresponding quality section inspections, delays defect prevention and gives rise to other defects at the source and generates quality costs. The delay in feedback causes fluctuations in the system and creates inertia. For this reason, the creation of consistent quality feedback processes in real time with high user orientation is a basic prerequisite for moving toward first-time quality and maximizing production quality.

1.3. Aims of the QFM

The introduction of a QFM should primarily help an enterprise to achieve its defined quality targets, but also reduce the costs of quality production and assurance. Likewise, the objectives of improving production systems and added-value chains [22] also coincide with the perspectives of Industry 4.0. It meets the demand of Industry 4.0 application scenarios to access relevant information at the suitable production points across the entire added-value process on the assembly line [23]. Following objectives are met in addition:

- Laying the foundations for robust processes [24, 25]
- Creating a tool for consistent reporting [8]
- Ensuring quality is delivered by minimizing quality slip
- Reducing repeat defects by identifying systematic defects
- Provisioning rapid quality feedback loops by involving workers in the quality production process (awareness) [8]
- Maximizing product and production quality
- Minimizing quality costs
- Implementing a learning hybrid quality system[3]

2. Requirements

2.1. Quality requirements

For a common understanding, the term quality has to be defined and specified by its individual attributes. Quality is standardized by the ISO as the degree to which a set of inherent characteristics of an object fulfils requirements [26]. It is evaluated through the conformity to the desired condition of its (inherent) quality characteristics. Thus, quality characteristics are distinguishing features [26] of a specific object which represent the quality categorized by Table 1:

Table 1. Categorization of Quality Characteristics

	Qualitative Characteristic		Quantitative Characteristic	
Type	nominal	ordinal	discrete	continuous
Scalability	naming	evaluating	counting	measuring

The *measurability of quality* is important to evaluate quality through its individual *quantifiable and measurable characteristics*. These characteristics with its degree of consistency between target and actual state shall be reported back to the concerned persons which results in the requirement for *visualization of quality* through quality characteristics. Only by this way, the degree of fulfillment of the object requirements and the quality achievement can be determined which leads to the ability for quality production.

In order to achieve these requirements, the quality characteristics shall be represented in a user- and process-oriented manner through a *quantifiable quality model*. Moreover, it is necessary to *transform these information* about the degree of consistency between target and actual state *into a minimization of inconsistency* – in general to transform into quality information. Through the quantifiable quality model and the scalable quality features, it is possible to achieve that:

- the degree of consistency between target and actual quality can be precisely controlled,
- the deficiencies of the quality characteristics can be minimized, and
- the desired scalable quality by the quality characteristics can be produced.

2.2. System requirements

The QFM system shall provide users with *information on quality* as a prerequisite for the user requirement regarding the

[3] Hybrid system means a collaboration of human and (IT) system