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Automatic adjustment of car body fixtures using artificial intelligence

Dipl.-Ing. R. Fritzsche[a]*, Dipl.-Math. oec. A. Richter[b], Prof. Dr.-Ing. M. Putz

[a]*Head of group assembly systems at Fraunhofer Institute for Machine Tools and Forming Technology IWU, Reichenhainer Straße 88, Chemnitz 09126, Germany*
[b]*Scientific employee at Fraunhofer Institute for Machine Tools and Forming Technology IWU Reichenhainer Straße 88, Chemnitz 09126, Germany*

* Corresponding author. Tel.: +49-371-5397-1359; fax: +49-371-5397-61359. *E-mail address:* rayk.fritzsche@iwu.fraunhofer.de

Abstract

In car-body production, the fixtures used for fixing the car-body panels during the joining pro-cesses predominantly consist of rigid constructions that require a time-consuming manual set-up process. To automate the adjustment process and reduce ramp up times, different adjustment modules have been developed at the Fraunhofer IWU in order to meet specific requirements. Because of high quality requirements, produced components will be checked against an adjustment database. The exactly positioning for each clamping point will be derived, with the aid of mathematical algorithms and modern methods of artificial intelligence, based on measured values and the knowledge of the template technicians.

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Keywords: Quality management; Body in white; Ramp up; Artificial intelligence; Neuronal network; Database

1. Introduction

1.1. Motivation

The current trend in the automotive industry is towards an ever increasing number of vehicle model variants. From small to medium-sized cars and limousines to sport coupés and SUVs, well-known vehicle manufacturers provide several model variants of their vehicles for almost every target group. Shorter development phases in the product creation process promote shortened model cycles as well as the introduction of new derivatives. As shown in Figure 1, this leads to increased segmentation of the model range with a simultaneous decrease in the number of units produced. The modern materials and technologies that enable technical innovations also enable design-specific changes that companies aim to offer customers as quickly as possible in order to ensure a market advantage. These trends and developments increasingly require a significant reduction in plant start-up times, an increase in plant flexibility and an increase in the degree of automation in the overall production process. [1;2]

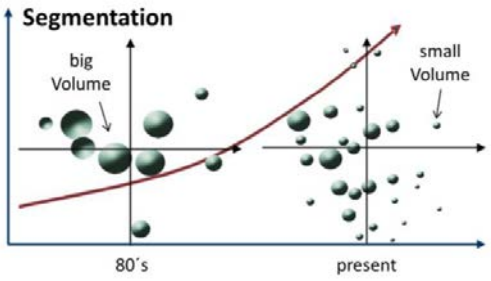

Fig. 1. Rising segmentation and reduced volume [3].

1.2. Need for automated solutions

For an efficient and sustainable production process against the backdrop of the increasing number of variants and decreasing in model model cycle times, mechanised and automated fixture components and control processes are necessary. In order to use kinematic systems for automated

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adjustment and an increase in production flexibility, strict requirements must be fulfilled. In addition to absorbing strong process forces, these requirements include the adjustment times relevant to short cycle times and, in particular, the reproducible accuracy of the adjustment systems for static and dynamic process forces during the clamping and joining processes of the components.

1.3. Current workflow for fixture adjustment

The body shop fixtures currently used to position and fix the car-body sheets to be joined are mainly rigid constructions that are adapted based on the component to be produced and the manufacturing technology being used. These fixtures mainly consist of positioning and fixing elements firmly mounted on a substructure or base plate.

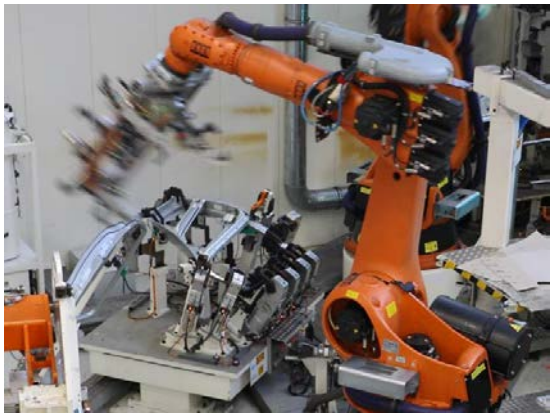

Fig. 2. Body shop fixture with rigidly arranged clamps and positioning elements [3]

In order to meet the demanding quality requirements, the fixture components must be set and adjusted to within a tenth of a millimetre. In a process known as shimming, the fixing screws for the fixture components are loosened at the shim positions, and shims of varying thicknesses are inserted or removed by hand between the consoles and the positioning or fixing elements. Then, the screws are re-tightened. This requires an interruption of production and intervention in the system safety circuit. In the course of these very time-consuming manual processes, the fixture components can be adjusted in up to three directions. This manual procedure can only be reproduced to a limited extent, because the tolerances of several shim plates accumulate. Furthermore, manual fixing implies an additional process uncertainty. The adjustment procedures that are carried out are also not documented in full, and this documentation can only be used to a limited extent due to the manual handling of data. These types of body shop fixtures are set up during the plant start-up, whereby the fixture components are repeatedly adjusted and the manufactured components continually measured and examined in a quality control loop. Due to the complexity of the production lines and processes, this plant start-up process takes several months. In order to comply with the specified manufacturing tolerances, there is also a need for repeated re-adjustment during production, i.e. following the start of production (SoP), owing to geometric fluctuations of individual parts from previous primary shaping and forming processes. As part of this process, components or assembly groups are removed from the production line at random while the plant is in operation, and the relevant quality features are recorded. If deviations from the tolerance specifications or corresponding tendencies are detected when taking these measurements, then the fixtures must be adjusted. This control process, from the removal of components through to the necessary adjustment of the corresponding fixture, takes up to one hour or even longer.

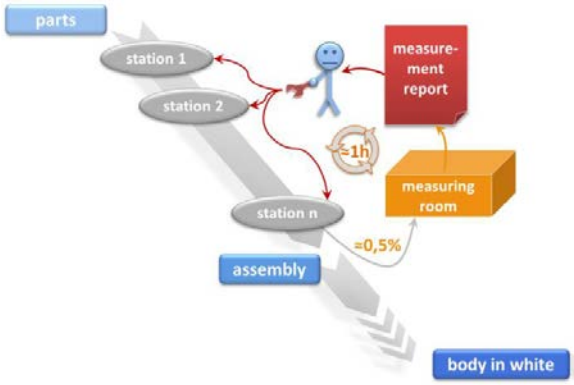

Fig. 3 Current quality control loop with random-sample measurements and manual fixture adjustment [Fraunhofer IWU]

For a cycle time of 60 seconds, this means that 60 further components are produced with the geometric deviation, which must then be either reworked or scrapped. The basis for the adjustments is the measuring report of each of the manufactured components. The decision to adjust which clamping point and by how much is for the plant operator to make due to his extensive experience. Owing to the complexity of the deep-drawn sheet metal parts, several measuring points are always subject to an adjustment. Furthermore, adjustments affect each other in that a second or third adjustment offsets the first, for example. A plant operator develops his know-how over many years, primarily through trial and error. Thus adjustments from two plant operators can be quite different despite having identical component measurement data.