

# Selective measuring of freeform surfaces for quality control and selective maintenance of bending tools

T. Pfeifer<sup>\*</sup>, D. Imkamp, M. Glombitza

*Laboratory for Machine Tools and Production Engineering (WZL), Aachen University of Technology, Aachen, Germany*

## Abstract

Bending tools are frequently used to manufacture freeform surfaces. In such cases, the geometry of the workpiece is determined wholly or in part by that of the tool (e.g. die forming). The quality of the finished product depends largely, therefore, on the geometry of the tools. Tool geometry is changed in the course of the manufacturing process by wear and optimisation. When the time comes for repairs or the manufacture of new tools, there is no record of the geometrical modifications which have been carried out. A model in the form of a quality control loop to feed back geometrical modifications to CAD and CAM systems is presented in this contribution. A means of creating the individual components in the quality control loop is described. Particular care has been taken to ensure that both the measurement and the feedback are limited to selected areas in order to minimise the cost and time involved. © 2001 Elsevier Science B.V. All rights reserved.

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## 1. Introduction

Freeform surfaces of many of the sheet metal products in our daily lives are important to us for both functional and aesthetic reasons. Their uses range from that of a soap dish, formed so as to be aesthetically pleasing to the shell of an aircraft, designed from an aerodynamic point of view. As a result of technical advances in the techniques used to manufacture such surfaces (e.g. hydroforming [1], 3D-laser forming [2]) and ever higher customer expectations in terms of product design, such parts will become increasingly important. Requirements relating to the quality of the surfaces, in particular, will become more exacting.

The quality of bend parts depends largely on process control and on the quality of the tools used. Research conducted in this field concentrates on these two areas. In this context, digitisation and geometric reconstruction (reverse engineering) are among the subject areas relevant to metrologists. In contrast, the techniques applied in the quality assurance and implementation of quality control loops assume a subordinate role. However, this is the area in which improvements stand to be made, particularly in

view of the rising expectations in terms of the quality of bend parts. The concept and the technical tools presented here illustrate how a quality control loop for the production of bend parts can be developed, taking into account the changes of tool geometry during the use of the tools.

## 2. Changes of tool geometry during use

Steel bending tools with freeform surfaces for use in metal forming operations are currently manufactured in milling or eroding operations. The development of new technologies such as HSC has made it possible to mill even materials which are notoriously difficult to cut and which were previously always eroded [3]. Indeed, the levels of form accuracy and surface quality achieved in milling operations are particularly high [4,5]. The specifications regarding tool accuracy for a metal forming operation are thus usually met with ease.

Before using the tool in a manufacturing environment, there is often an extensive tryout phase, despite the use of computer-assisted simulation. At this stage, the tool geometry is modified in order to optimise the forming process. Material is frequently removed manually with the aid of grinding tools. Deposition welding is used to add material to selected areas which are then ground until they fit into the surrounding geometry. The geometrical alterations are very rarely documented or fed back to the design department.

<sup>\*</sup> Corresponding author. Present address: Werkzeugmaschinenlabor, RWTH Aachen, Lehrstuhl für Fertigungsme Btechnik und Qualitätsmanagement, 52056 Aachen, Germany. Tel.: +49-241-807412; fax: +49-241-8888193.  
*E-mail address:* t.pfeifer@wzl.rwth-aachen.de (T. Pfeifer).

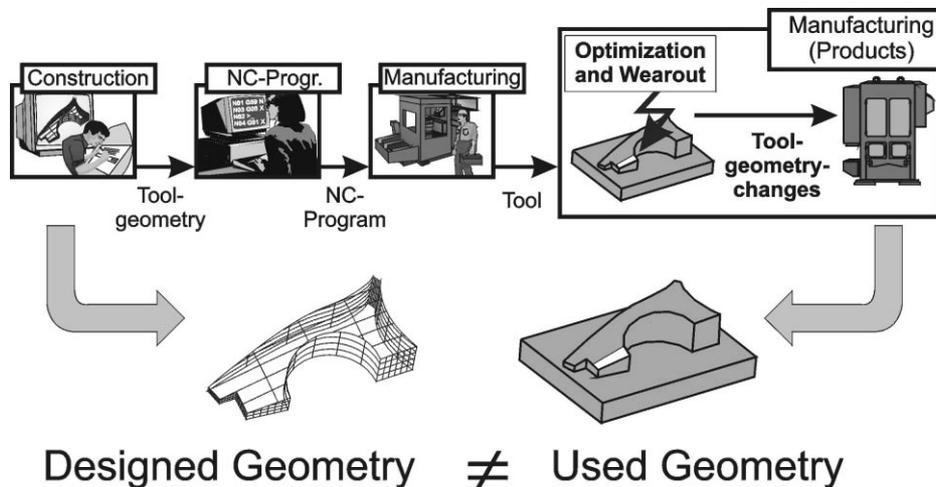


Fig. 1. Manufacturing of bending tools.

In addition to these deliberate geometrical modifications, unintentional changes to the geometry also occur as a result of wear when the tool is in use. The effects of this are particularly noticeable when the tool is subjected to high levels of mechanical and tribological load [6].

As a result of these mechanisms, the tool geometry used in the manufacturing process is not the same as the geometry designed using the CAD system (Fig. 1).

This is verified by the chromatic diagram showing deviations between measured data and CAD data relating to a bending tool for a metal chassis in Fig. 2.

### 3. Manufacturing and quality testing bending tools

At present, bending tools are designed in a CAD system on the basis of the CAD data of the part to be manufactured. The CAD data of the tool are the input information for the CAM system in which the NC programs for the milling operation are written. The required geometry is filed in geometrical terms in the CAD data and in the NC programs.

The demands imposed on quality testing of bending tools are wide-ranging. Material characteristics and geometry almost always have to be tested. Gauges or special test

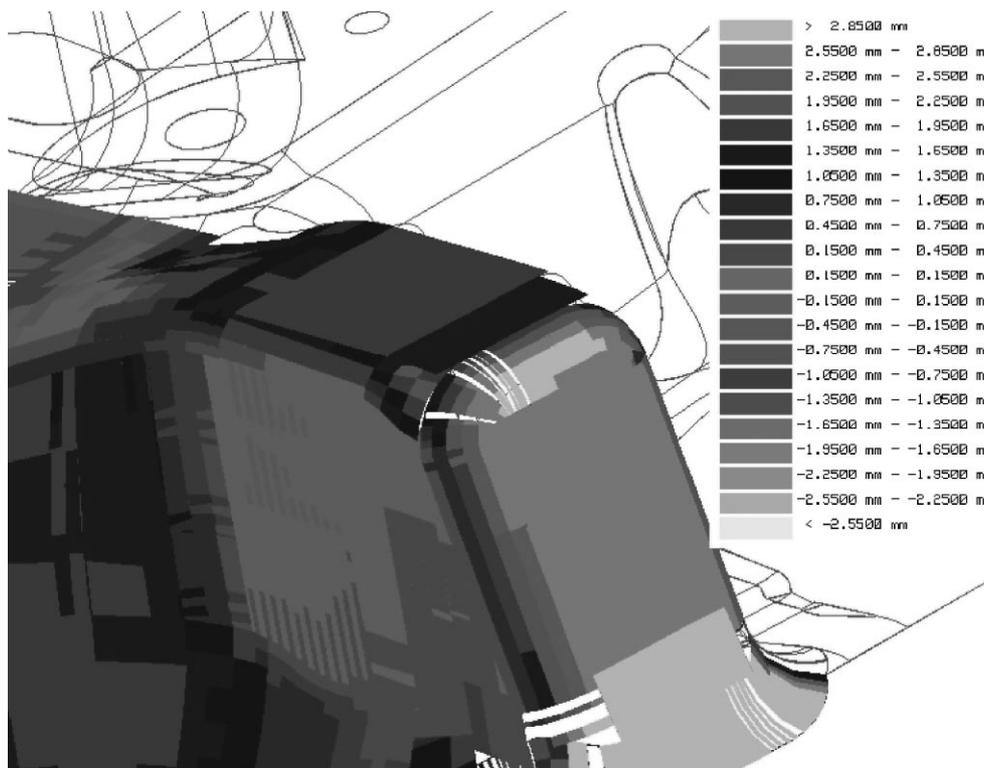


Fig. 2. Deviation areas of a bending tool.

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