A pressure-die-casting process moulds bulky work pieces, in which abrasion after some production cycles requires a manual, labour intensive overhaul of tool parts. Robotic automation of the tool gauging and welding process provides a means to reduce maintenance time and costs. The tools current shape is reconstructed from photometric depth measurements based on stripe projections. Based on the deviation of the current from the nominal tools geometry regions of interests that require electro-surfacing are identified. During the electro-surfacing new material is applied to the worn-out tool areas. Because of the large dimensions of the tool and the required measurement accuracy a measurement of the tool as a whole is not possible. Therefore it is required to perform several small single measurements with high measurement resolution, which are merged afterwards using the position information of the robot. The overall accuracy of the measurement result is based on the single measurement accuracy and the accuracy of the measured robot position information.

This paper illustrates the development of a high accuracy automatic measurement system based on a standard industrial robot and a fringe projection system. First of all a fringe projection system is built up, which allows measuring the shape of a tool-part with an accuracy of a few micro meters. In conjunction with an additionally constructed calibration object the calibration of the measurement system is carried out automatically. The standard industrial robot is appliquéd with the fringe projection system, depicted in figure 1.
In addition to that an automatic calibration procedure is developed to identify the unknown transformation $\text{Cam}^{-1}\text{TCP}$ between the sensor frame and the robot’s coordinate frame, illustrated in figure 1b. By measuring the position and orientation of the calibration object $\text{CalCam}$ from different robot positions the transformation $\text{Cam}^{-1}\text{TCP}$ is identified. The usual way is to describe this transformation by means of homogeneous transformation matrices. Instead of using the standard approach, in these contributions different approaches based on quaternions, dual quaternions and a method based on Lie theory are compared with respect to the overall accuracy. Based on the chosen method an automatic optimal pose generation and selection scheme is realized to guarantee comparable identification results, regardless where the calibration object is placed in the robot workspace. To start the automatic calibration procedure the operator places the robot, appliquéd with the fringe projection system, just above the calibration object. Through three small initial movements the position of the calibration object in the robot workspace is roughly estimated. A “virtual” sphere, depicted in figure 2b, with a grid is placed around the calibration object and the grid points are considered as possible measurement poses. On the one hand these approaches guarantee an optimal measurement distance for the fringe projection system on the other hand this assures the visibility of the calibration object. Then all possible robot poses are calculated and checked if they are reachable. For the reachable subset of poses all possible pairs are calculated and selected based on criteria like the maximum relative rotation angle as well as good distribution overall possible relative rotation axis. For this purpose a pre selection based on the relative rotation angle and a standard clustering algorithm on the set of relative rotation axis is carried out to generate a subset of measurement poses. The robot joint configurations are chosen in a way that the overall translational movement is minimized.
Simulation results as well as experimental results with an appliqué fringe projection system are presented. In addition to that an automatic measurement procedure is developed to realize an automatic measurement of a complete tool. The single measurement positions are calculated automatically out of a single overhead position. From these single measurements the tool shape is reconstructed as depicted in figure 3. To complete the gauging procedure of a tool a 3D comparison is realized and an identification of worn out tool areas is exemplarily shown.

Figure 3: Tool part measurement and reconstruction