On-machine Measurement for the Micro-EDM-milling Process Using a Confocal White-light Sensor

V. Schulze, C. Ruhs
wbk Institute of Production Science, Karlsruhe Institute of Technology (KIT), Kaiserstraße 12, 76131 Karlsruhe, Germany

ruhs@wbk.uka.de

Abstract

This paper deals with the integration of an on-machine measurement device and its application during the micro-EDM-milling process. By using a confocal white-light sensor with a resolution of 25 nm directly on the EDM-machine the depth of a cavity can be detected without unclamping the work piece. This helps to avoid inaccuracies caused by reclamping the work piece between the manufacturing, the measurement and the reconditioning process. Due to the high resolution of the confocal white-light sensor it is also possible to measure the surface roughness on the ground of the cavity. This feature also provides the characterisation of the surface quality after the EDM-process.

1 Challanges

Micro system technology is still a fast growing market with a huge demand for microstructured parts and systems. This leads to new challenges optimizing the manufacturing processes to supply the needs of the industrial users. Normally micro parts are manufactured by moulding processes, like powder injection moulding (PIM), to produce large units at the lowest cost. For these manufacturing processes moulds with high accuracy are made, using wear-resistant materials. To fabricate these filigree and definite cavities micro electrical discharge machining (micro-EDM) is a suitable solution. Especially the micro-EDM-milling process is a flexible way to machine very hard materials because there is no need to structure the tool electrode before the EDM process like in traditional die sinking. Unfortunately there is always a tool wear during the EDM process [1]. In micro-EDM-milling there are several parameters that influence the electrode wear: parameters like work piece-electrode-material combination, diameter of the electrode, machining parameters (voltage, current, frequency, etc.) and machining depth. This causes a geometrical deviation of the manufactured depth of a cavity. For each material-parameter-combination some preliminary experiments have to be performed to get information about the tool wear. This information must be supplied to the CAM-system and finally to the NC-code to realize wear compensation during the process [2]. This value is normally integrated in modern micro-EDM-milling machines and leads to a very small deviation between the specified value and the actual value of the erosion depth of the manufactured structure. The difference is normally in the range of a few micrometers. To enhance the accuracy an optical device can be used.

2 Sensor integration

In this case a confocal white-light sensor is used. The integration of the sensor in the Sarix SX100 micro-EDM-milling machine was a cooperative work between the wbk Institute for Production Science and Sarix, the manufacturer of the micro-EDM-milling machine. A confocal white-light sensor is based on the principle of chromatic distance measurement (Figure 1 (right)). The wavelength spectrum of 400 nm – 800 nm (white light) is focused on the work piece surface by a measuring head with a strongly wavelength-dependent focal length. Thus the different wavelengths are focused to different distances. Depending on which wavelength is reflected from the work piece surface the spectrometer detects a peak. The wavelength of this peak is used to determine the distance in a certain measurement range. The sensor works on transparent, highly reflective or even matt black surfaces.

The sensor was adapted on the Z-axis of the machine to afford the movement with high accuracy during the measuring process. To move the sensor in the right position very close to the surface of the work piece a device including a pneumatic cylinder and a linear bearing was constructed and built (Figure 1(left)). To protect the optical parts from the dielectric fluid during the erosion process the sensor was integrated in a body with a flap gate at the bottom (not shown in Figure 1).

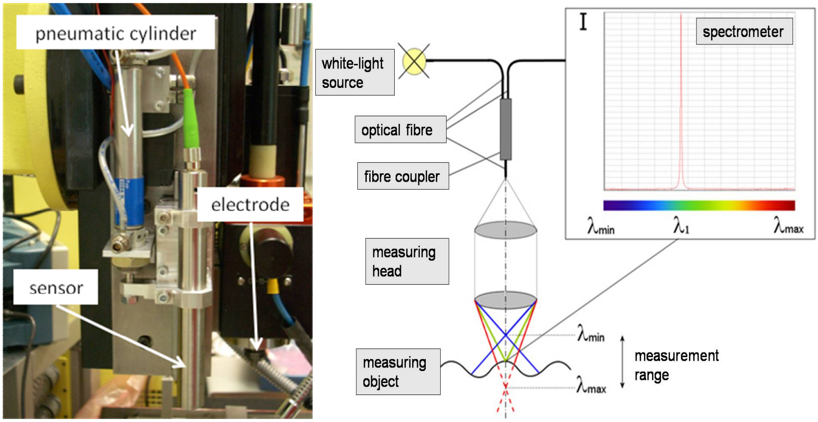

Figure 1: Confocal white-light sensor on the micro-EDM-milling machine (left), measurement principle (right)

3 On-machine measurement of surface roughness and depth of a manufactured structure

The integrated measurement system provides the opportunity to observe the manufacturing result directly on the EDM machine. The main advantage of this strategy is that the whole process takes place without unclamping the work piece. Inaccuracies that are caused by reclamping the work piece could be eliminated with the aid of this on-machine device. This feature enables a reconditioning process of the manufactured structure.

To guarantee a precise EDM-milling work the actual depth of a cavity has to be observed. Figure 2 (left) shows that there are some irregularities on the ground of a mould for a gearwheel made of 30CrMo6 according to the path of the cylindrical tool electrode made of WC-6Co. Possible reasons for that are inhomogeneities of the work piece, an inconsistent flushing of the working gap and an inconsistent tool wear during the manufacturing process. By measuring the structure and reconditioning the work piece a more homogeneous surface could be achieved (Figure 2 (right)). Based on this measuring and reconditioning process an improvement of the ripple of 7 µm could be reached. Figure 2 (right) shows a maximum ripple of about 2 µm.

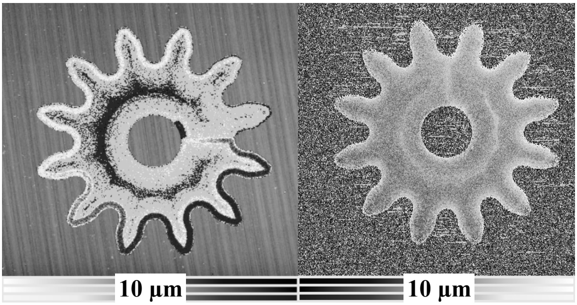

Figure 2: Mould for a gearwheel before (left) and after the reconditioning process (right)

Furthermore the surface roughness can be detected directly on the machine tool. In the next steps these manual and separate processes have to be combined to provide a system including the measuring of the actual depth and the surface roughness working automatically.

4 Summary

It has been shown that the EDM machining process conditions become more accurate and repeatable due to the aid of an optical measurement and control device. By measuring the machined depth and reconditioning the work piece directly on the machine tool a maximum ripple of 2 µm could be achieved.

In the future an automatic reconditioning process will be developed and new applications like automatic parameter detection will be evaluated and implemented into the machine tool.

References:

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