Monitoring of Micro Machining Operations

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Abstract

Today micro machining operations are not adequately provided with suitable setting parameters and the process is not perfectly controlled as the process parameters cannot be detected due to the extremely small working zone and the high spindle speed. In this contribution a new inprocess-sensor and -method will be introduced which admit the monitoring of micro machining operations.

1 Functional principle

At LaFT (Laboratory of Production Engineering of the Helmut-Schmidt-University) a newly developed sensor [1, 2] detects the electrical transition resistance between the rotating tool and workpiece and allows herewith the monitoring of micro machining operations. The new sensor is called “Transition Resistance Sensor” and is shown together with its functional principle in Figure 1.

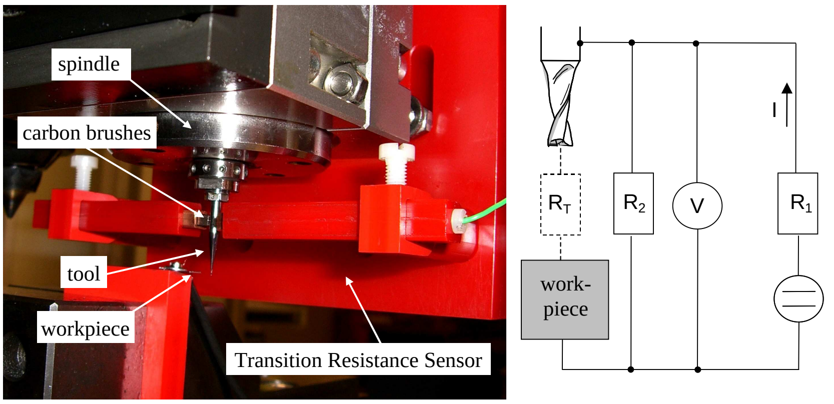

Figure 1: Transition Resistance Sensor and its functional principle

The detection of the transition resistance R_T between cutting edge of the rotating tool and workpiece is accomplished by direct current analysis. The electrical current is located in the range of a few mA. In order to limit the current the resistance R_1 is placed before the parallel circuit. For prevention of spark discharge and electric arc one to the transition resistance proportional resistance R_2 is placed in the electrical circuit.

The electrical contact from the voltage generator to the rotating tool, which makes the current flow possible, is realized direct at the tool shaft by carbon brushes. The workpiece is connected electrically to the voltage generator, so that the electrical circuit is closed. Compared to the rotating tool the workpiece connection is easier, because the workpiece is clamped only and it does not rotate.

The voltage U is measured, which is proportional to the transition resistance R_T. Figure 2 shows the expected signal. The voltage U_{nc} results, if there is no contact between cutting edge and workpiece. The level of this voltage in the range of a few V is the implication of the input voltage and the used resistances. While cutting the voltage U_c is measured.

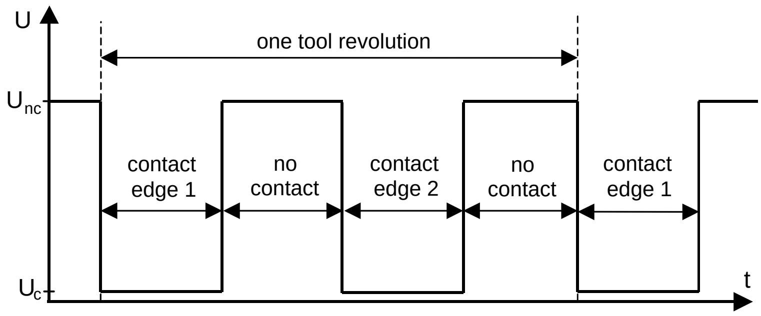

Figure 2: Expected signal

2 Applications

The interpretation of the voltage U, which is proportional to the transition resistance R_T, allows various applications of the new sensor and accordingly the monitoring of micro machining operations with high number of revolutions up to 160.000min^{-1}. The signal of a “perfect” micro milling process with isochronous cutting edge actions (new tool with two cutting edges without wear) is presented in Figure 3a. Deviations of this signal shows different applications (monitoring options):

- Number of revolutions using calculation of all edge contacts (Figure 3a)
- Out-of-roundness (Figure 3b)
- First cut detections during machining, e.g. during determination of the zero points (Figure 3c)
- Analysis of the micro machining operations, e.g. only one cutting edge in action (Figure 3d)
- Control of the micro machining operations, e.g. inprocess adjustment of setting parameters (target: micro machining operations like in Figure 3a)
- Tool breakage, tool wear (Figure 4) and tool deflection

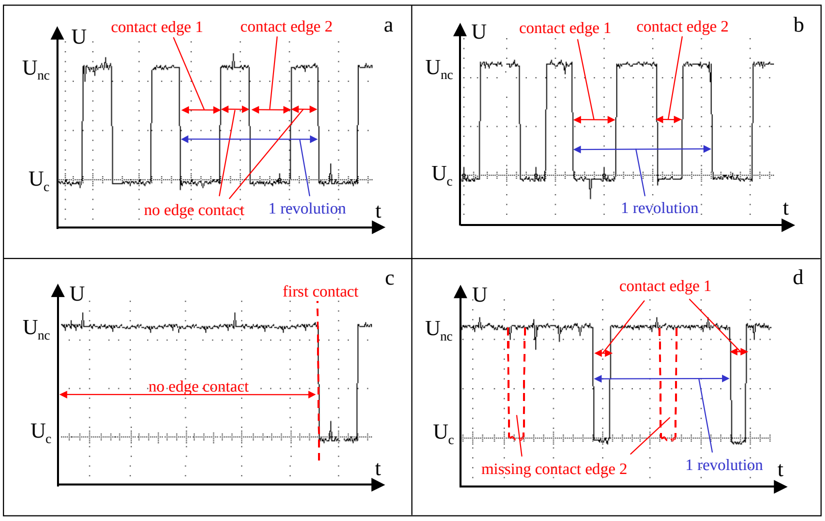

Figure 3: Possible monitoring options of the new Transition Resistance Sensor

Particularly the tool wear can excellently be detected with the new sensor. This inprocess detection is divided into the following steps:

1. Cutting edge action times become longer
2. Disturbances arise during cutting edge action identifying an increased transition resistance between cutting edge and workpiece
3. Clearance surface of the cutting edge in contact with workpiece (Figure 4)

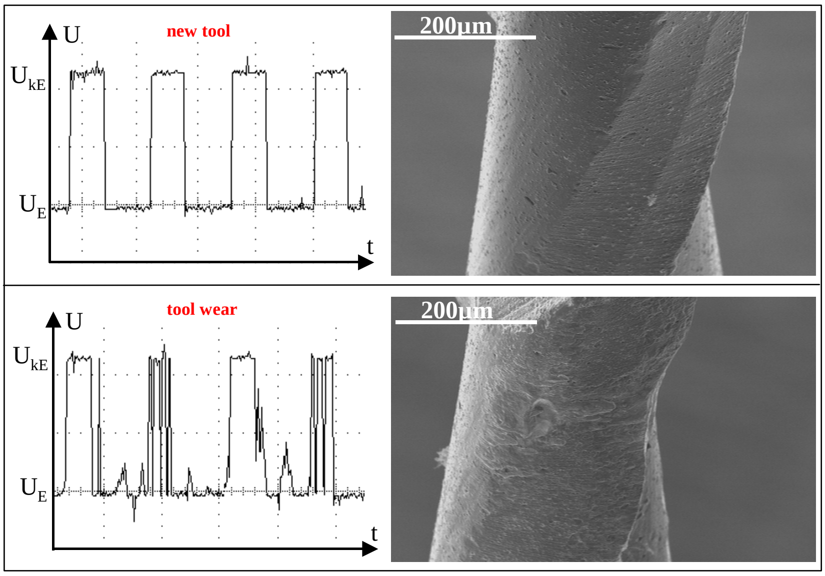

Figure 4: Inprocess detection of tool wear with Transition Resistance Sensor

3 Conclussions

In this contribution a new “Transition Resistance Sensor” for monitoring of micro machining operations with high number of revolutions up to 160.000min^{-1} is presented. The new sensor was developed completely at the LaFT and its suitability was proven. Various applications like inprocess detection of tool wear were introduced. The main focus of further improvements of this sensor is the automatic control of the micro cutting processes.

References:

[1] Wulfsberg, J. P.; Brudek, G.; Bruhns, F.: Verfahren zur Visualisierung, Überwachung und Regelung der Prozess-Maschine-Interaktion beim Zerspanen im unterbrochenen Schnitt. Patentanmeldung, Aktenzeichen: 10 2005 059 945.1

[2] Brudek, G.; Wulfsberg, J. P.: Werkzeugschneiden mit Tastsinn - Visualisierung der Prozess-Maschine-Interaktion beim Mikrozerspanen. Mikroproduktion 3/2006, Hanser Verlag, p.19-23