Data Acquisition and Optimization of Setting and Processing Parameters in Micro Machining Operations

G. Brudek[1], J.P. Wulfsberg[1]
[1] *Helmut-Schmidt-University / University of the Federal Armed Forces Hamburg, Laboratory of Production Engineering, Holstenhofweg 85, D-22043 Hamburg, Germany*

gregor.brudek@hsu-hh.de; jens.wulfsberg@hsu-hh.de

Abstract

Today micro machining operations are not adequately provided with suitable setting parameters and the process is not perfectly controlled because the processing parameters cannot be detected due to the extremely small working zone. In this contribution various new developed experimental setups are shown with which the processing parameters like cutting force and temperature can be detected and accordingly the setting parameters primarily the machine input parameters (spindle speed, feed etc.) can be optimized.

1 Introduction

Today micro machining operations, mainly milling, drilling or turning of micro structures as the case may be cutting of micro workpieces with a small volume of several cubicmillimeters is not adequately provided with suitable setting parameters and the process is not perfectly controlled because today the processing parameters cannot be detected due to the extremely small working zone. Of course it is not possible to carry out a linear downscaling of the machining parameters used in the conventional or macroscopic machining to micro machining, because non-linear physical size effects are influencing the process and have to be considered.

In order to avoid unwanted result alterations and getting optimal setting parameters, mainly the machine input parameters, the relevant parameters must be measured metrologically. Therefore on the one hand the working results and on the other hand the processing parameters must be recorded and analyzed. Table 1 presents beside the setting parameters the most important process parameters and working results.

Table1: Setting Parameters, Processing Parameters and Working Results

setting parameters	processing parameters	working results
spindle speed	cutting force	surface roughness
cutting speed	turning torque	dimension fault
feed / feed speed	temperature	defect of form
cutting depth / infeed	energy	influence of the
tool	output	peripheral zone
cooling lubrication	abrasion	

2 Data Acquisition of Processing Parameters

In order to characterize the micro machining operations mainly forces, torques, temperatures and energy flows have to be detected. Especially for the detection of cutting forces a new measurement system (dynamometer) with a high natural frequency (Figure1) was developed, which considers the influence of much higher exciting frequencies in micro machining operations with a number of revolutions up to 160.000 min^{-1}. Main characteristics is the use of material with higher E-Modulus, lower specific weight and damping measures. The functionality of this new force measurement system which can be used in laboratory experiments and in the serial production are verified in cutting experiments. The dynamic suitability of this force measurement system is proved by using modal analysis measurements. [1]

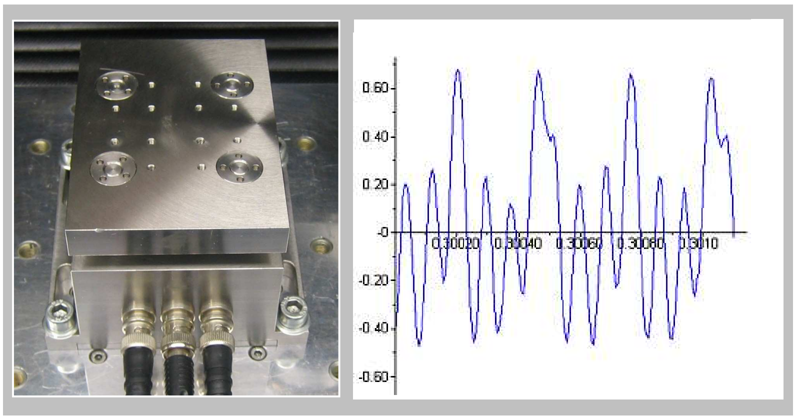

Figure 1: New force measurement system with high natural frequency and an exemplary cutting force measurement

For the detection of cutting temperatures during micro machining operations a two-color pyrometer [2] and a guiding system were installed in front of the spindle (Figure 2 left hand). The guiding system enabled an exact calibration of the pyrometer in the micromachining center in all three axis. The smallest adjustable measuring point is 25µm.

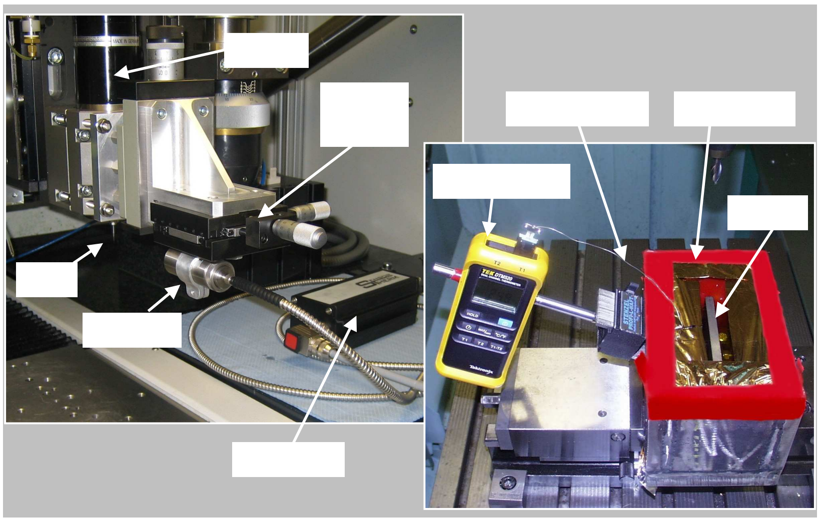

Figure 2: Temperature measurement system (left hand), calorimetric measurement system (right hand) adapted in micromachining center

The examination of the heat flow and energy distribution during the micro machining operations is based on the calorimetric principle [3]. A calorimeter is composed of a heat insulated box filled with a fluid with low specific heat capacity. The workpiece is fixed at the bottom (Figure 2 right hand). By different fluid levels the heat flow can be measured which attain to workpiece, tool or surrounding.

3 Optimization of Setting Parameters

By using the knowledge of the relevant processing parameters (cp. Chapter 2) and the analysis of the generated working results, mainly the surface roughness, the optimal setting parameters for micro machining operations are defined. This is accomplished for several materials like the stainless steel 1.4301 (X5CrNi18 10). Figure 3 shows exemplary the influence of the infeed a_e on the surface roughness R_a and the influence of the feed speed v_f on the cutting force in the infeed direction F_c for the identification of optimal setting parameters during micro milling of 1.4301.

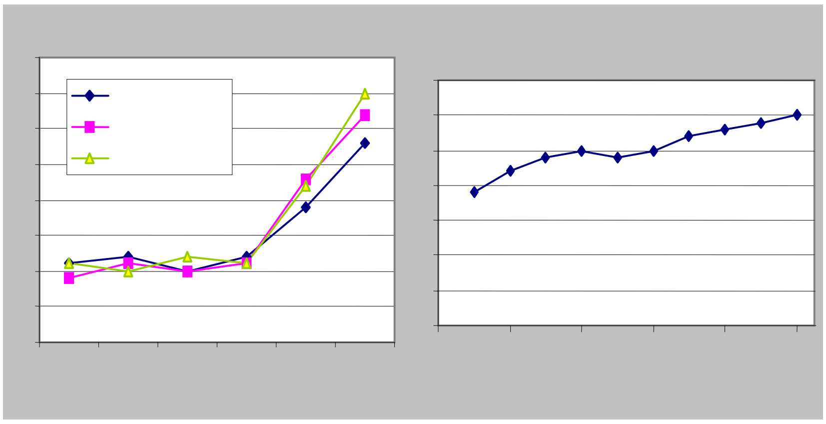

Figure 3: Identification of optimal Setting Parameters

4 Conclusion

Under the precondition that it is not possible to scale down the parameters of conventional machining operations linearly to micro machining conditions which leads often to totally unrealistic input variables, the setting parameters of micro machining operations must be experimentally determined. Therefore the working results and the processing parameters are recorded and analyzed using new developed sensors and experimental setups. In further developments a new sensor which detects the electrical transition resistance between tool and workpiece will be realized in order to identify out of roundness errors, tool breakage, tool wear and first cut detections during machining.

References:

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