Accepted Manuscript

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PII: S0141-6359(16)30330-0
DOI: http://dx.doi.org/doi:10.1016/j.precisioneng.2017.02.018
Reference: PRE 6544

To appear in: *Precision Engineering*

Received date: 4-11-2016
Revised date: 11-1-2017
Accepted date: 24-2-2017

Please cite this article as: Brinksmeier Ekkard, Preuss Werner, Riemer Oltmann, Rentsch R*ü*diger.Cutting forces, tool wear and surface finish in high speed diamond machining.*Precision Engineering* http://dx.doi.org/10.1016/j.precisioneng.2017.02.018

Cutting forces, tool wear and surface finish in high speed diamond machining

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Highlights

- High speed diamond machining with cutting speeds of several thousand meters per minute has been realized for the first time.
- The transition to adiabatic shearing has been verified by experiment and by FEM simulations.
- The abrasive wear of diamond tools was found to be reduced in HSC compared to cutting at ordinary speeds.
- Chemically induced wear in the diamond milling of steel was found to depend on the contact time per tool engagement.
- The surface finish was found to be reduced in HSC compared to cutting at ordinary speeds.

Abstract

We have investigated the cutting forces, the tool wear and the surface finish obtained in high speed diamond turning and milling of OFHC copper, brass CuZn39Pb3, aluminum AlMg5, and electroless nickel. In face turning experiments with constant material removal rate the cutting forces were recorded as a function of cutting speed between v_c = 150 m/min and 4500 m/min revealing a transition to adiabatic shearing which is supported by FEM simulations of the cutting process. Fly-cutting experiments carried out at low (v_c = 380 m/min) and at high cutting speed (v_c = 3800 m/min) showed that the rate of abrasive wear of the cutting edge is significantly higher at ordinary cutting speed than at high cutting speed in contrast to the experience made in conventional machining. Furthermore, it was found that the rate of chemically induced tool wear in diamond milling of steel is decreasing with decreasing tool engagement time per revolution. High speed diamond machining may also yield an improved surface roughness which was confirmed by comparing the step heights at grain boundaries obtained in diamond milling of OFHC copper and brass CuZn39Pb3 at low (v_c = 100 m/min) and high cutting speed (v_c = 2000 m/min). Thus, high speed diamond machining offers several advantages, let alone a major reduction of machining time.

Keywords:
High speed diamond machining