PROZESS SIGNATUREN

TRANSREGIONALER SONDERFORSCHUNGSBEREICH 136

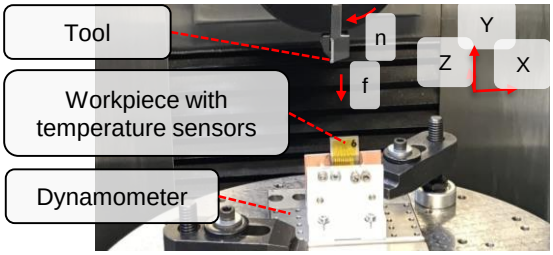
University of Bremen · RWTH AACHEN UNIVERSITY · IWT Leibniz-Institut für Werkstofforientierte Technologien · ifam Institute of Applied Mechanics

Processes with thermo-mechanical impact in precision cutting

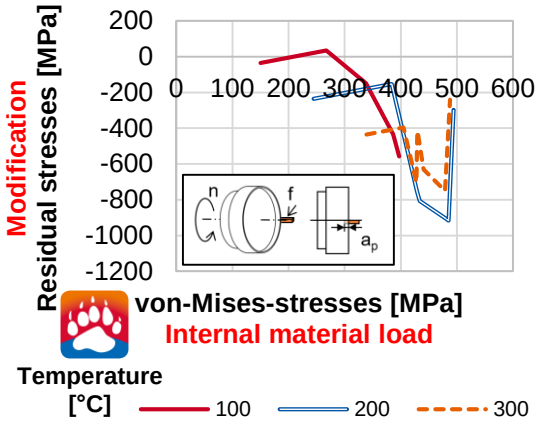
F05/Präzisionsspanen – Karpuschewski, Riemer

Objective and approach

The main research focus of this sub-project is the development of fundamental findings on internal material loads and material modifications in the surface and subsurface during high precision cutting using a geometrically determined cutting edge. With the help of experimental investigations and the characterization of thermal and mechanical loads, a process simulation is validated. Furthermore the simulation is used to determine the correlation between internal material loads as a result of the thermo-mechanical load introduced by the cutting process and the material modification of the residual stresses.



Setup for experimental characterization of mechanical and thermal loads



Correlation between residual stresses and numerical determined internal material loads

Current state of knowledge

In subproject F05/Präzisionsspanen (precision cutting), material modifications in from of stresses were investigated and characterized in machining experiments and corresponding process simulations. The workpiece materials were steel 42CrMo4 in two heat treatment states, ferritic-pearlitic (FP) as well as quenched and tempered (QT). An identification and correlation of the generated material modifications of the surface layer were analyzed spatially resolved. The numerical determination of the temperature occurring directly in the cutting zone has a sufficiently high spatial resolution for consideration as an internal material load and was validated with the data of specifically developed temperature sensors. A material modification due to thermally induced plastic flow can be excluded because of the comparatively low temperatures. With the process simulation, it was possible to correlate the internal material loads in form of the von-Mises-equivalent-stress , the total strain and the absolute temperature with the experimentally determined residual stresses in a process signature component.

Conclusion and further procedure

The experimentally and numerically obtained results show that the generation of modifications by internal material loads is mutually influenced due to thermal and mechanical loads during precision machining only at a very small depth below the workpiece surface. Due to the low temperatures and short exposure times, thermally induced plastic flow or a tempering processes cannot be assumed. Instead, the material modification and the separation mechanisms in cutting are both influenced by temperature-dependent material properties. Therefore, a constant mechanical internal material load can lead to different material modification and surface generation dependent of the thermal load. Following investigations, will consider the modification of the surface topography as a material modification relevant for precision cutting, as the topography largely depends on the cutting mechanisms that occur during machining.

Publications

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