PROZESS SIGNATUREN

TRANSREGIONALER SONDERFORSCHUNGSBEREICH 136

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Analysis of materials modification by diffraction methods

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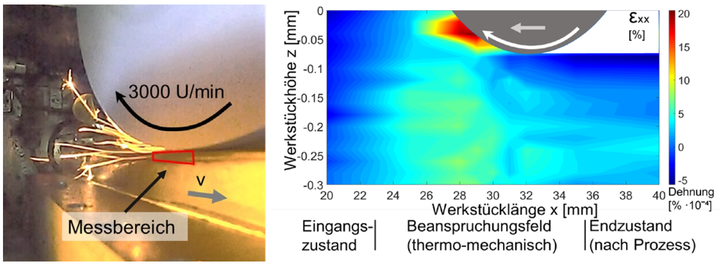
Objectives and approach

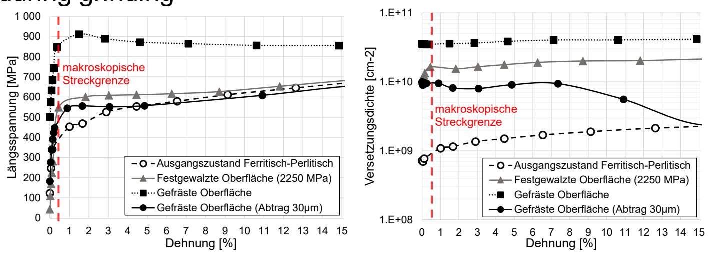
The modified surface material state properties achieved via process chains or process sequences are analyzed by X-ray diffraction methods and the change is quantitatively determined as a function of the initial state. These results are used to develop process signatures for residual stresses of 1st kind, dislocation density or crystallite size. During in-situ investigations, additional loads are applied to machined surfaces under controlled conditions to determine specific material modification. Furthermore, in-situ experiments are performed during grinding or deep rolling at the synchrotron to be able to analyze the internal material loads in-process under the contact point and the resulting material modifications.

Current state of knowledge

Based on the successful deep rolling experiments in the 1st funding phase, a new grinding device was developed and operated at the synchrotron. Through the analysis, the local strains in the vicinity of the grinding contact could be determined in a depth-dependent manner and thus the transition to the residual strains in the final state could be represented, whereby the data situation for future evaluations holds out the prospect of further results, also for comparison with simulations that have been carried out. To investigate the effects of specific strains on already modified surface states, specially prepared tensile specimens were examined in a diffractometer with in-situ tensile equipment. It was determined that the modified surface material states exhibit significantly higher local yield strengths due to the increased dislocation density. These hardly develop further under load, although the samples are macroscopically deformed. Finally, the Cos-α diffractometer could be used to analyze the residual stress development in different process steps during grinding with F01.



In situ grinding setup at the synchrotron with internal view of the process and measured strain with spacial resolution during grinding



Evolution of stresses and dislocation density for different surface material states during applied tensile load

Conclusion and further procedure

By combining ex-situ and in-situ X-ray diffraction investigations, information is obtained on the evolution of the material state in relation to the initial state of processed samples, with the aim of analyzing the stresses in the material. In cooperation with F-projects, this information is used to develop process signatures. Therefore, the priority for C01 is to develop new test rigs and appropriate methods for in-situ experiments, such as the mobile Cos-α X-ray diffractometer, deep rolling and grinding rigs for experiments at the synchrotron, and XRD tensile tests to resolve the transient material states. The data obtained enable mechanism-based analyses of the processes.

Publications

Meyer, H., & **Epp, J.** (2020). Spatial Internal Material Load and Residual Stress Distribution Evolution in Synchrotron In Situ Investigations of Deep Rolling. *Quantum Beam Science*, *4*(1), 3. doi.org/10.3390/qubs4010003

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Borchers, F.; Clausen, B.; Eckert, S.; Ehle, L.; **Epp, J.**; Harst, S.; Hettig, M.; Klink, A.; Kohls, E.; **Meyer, H.**; Meurer, M.; Rommes, B.; Schneider, S.; Strunk, R. (2020). Comparison of Different Manufacturing Processes of AISI 4140 Steel with Regard to Surface Modification and Its Influencing Depth. *Metals*, *10*(7), 895. doi.org/10.3390/met10070895