PROZESS SIGNATUREN
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Energy based Process Analysis for characteristic Prozess Signatures

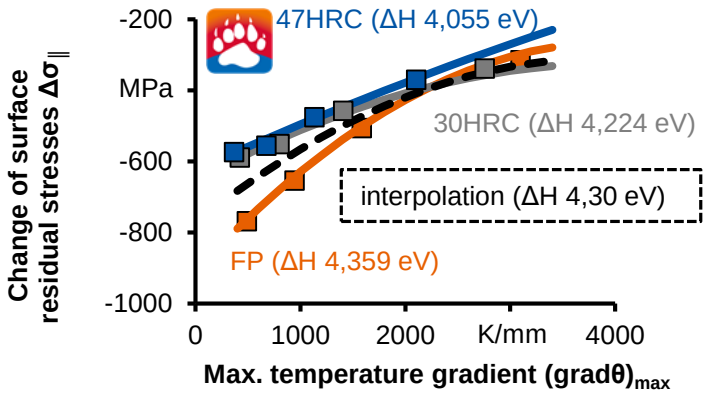
Subprojekt M01 – Prof. Dr.-Ing. habil. Prof. h.c. Dr. h.c. Dr. h.c. Bernhard Karpuschewski, Dr. Ing. Thomas Lübben, Dr.-Ing. Jens Sölter

Objective and Procedure

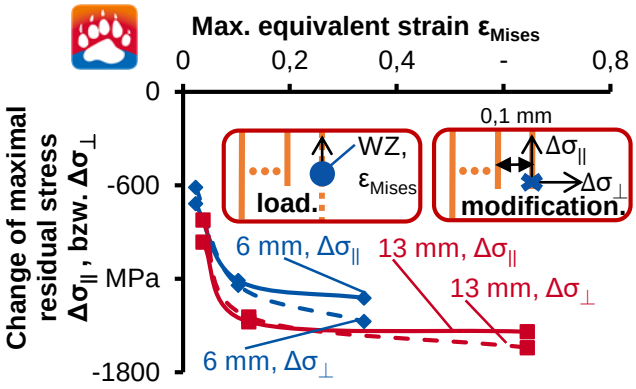
The central task of M01 is to give impetus for approaches for process signatures (PS) that link material modifications and loads for different manufacturing processes. The subproject works with numerical methods to determine stress variables and modifications that are difficult to access experimentally. Currently, the PS already developed for ferritic-pearlitic input conditions for single loads with only one cycle are being further developed so that they also take into account modifications for different input conditions with multiple loads and/or multiple cycles.

Current state of knowledge (May 2021)

Up to now, processes with predominantly mechanical [1] as well as predominantly thermal loadings [2,3] have been investigated for quantitative relationships between material loads and modifications. An extended understanding of mechanisms is achieved. In order to test the applicability of PS for the widest possible range of processes, different input microstructures are considered for thermal processes. The figure on the left shows an example of the process signature component (PSC) “Change of surface residual stress as a function of the maximum occurring temperature gradient". It depends on the activation enthalpy ΔH of austenitisation if equal quenching conditions are applied. For mechanical processes deep rolling is considered. For this purpose, a equivalent strain calculated according to von-Mises has proven to be a suitable stress description. The figure on the right shows an example of a PSC for the 15th pass of a surface machining operation.



PSC "Change of the surface residual stress as a function of the maximum temperature gradient during heating" (simulated results)



PSC "Change in maximum residual stress as a function of maximum equivalent strain during machining" (simulated results).

Conclusions and further Procedure

Process chains are in principle forms of multiple loads. For this purpose, the process chains hardening/tempering, followed by the processes milling (F08) and deep rolling (F01) or laser hardening (F07), are investigated. In order to approach the description of processes with thermo-mechanical loads, in particular grinding (F06), combined laser-deep-rolling processing is currently being studied. Presently, it is also being examined whether the PSC can also be formulated independently of the tool during multi-step deep rolling. To this end, their development and the development of the load in the form of the equivalent strain during processing are analysed.

[1] Kinner-Becker, T.; Sölter, J.; Karpuschewski, B.: A simulation-based analysis of internal material loads and material modifications in multi-step deep rolling. Procedia CIRP 87 (2020), 515–520. 10.1016/j.procir.2020.02.060.
[2] Frerichs, F.; Lübben, T.: Influence of initial microstructure on manufacturing processes with thermal loads accompanied by hardening. Procedia CIRP 87 (2020), 521-526. 10.1016/j.procir.2020.02.075.
[3] Frerichs, F.; Lu, Y.; Lübben, Th.; Radel, T.: Process Signature for Laser hardening. Metals, 11, 465, (2021), 10.3390/met11030465.