PROZESS SIGNATUREN

TRANSREGIONALER SONDERFORSCHUNGSBEREICH 136

Universität Bremen RWTH AACHEN UNIVERSITY

Modelling of transport phenomena in machining processes

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Objective and approach

The process signature results in the material modification as a function of the material loads. In the case of electrical discharge machining, the material stresses cannot be measured directly today, so that they have to be described on a numerical basis. In this subproject, the thermal energy balance of the electrical discharge process is numerically simulated, taking into account the purging process, the local gas bubble formation due to evaporation, and the material removal, in order to determine the material stresses. In the high-resolution discrete analysis of the flushing flow, the heat transfer between the liquid-gas dielectric, the workpiece and the removed material particles is taken into account.

Current state of knowledge (May 2021)

In the first phase, the influence of the flow on the heat transfer was characterized [3]. To determine the process Signature component (PSC) of the residual stresses in the EDM process the heat conduction due to superposed single discharges was investigated simulatively. The results are used as input for a downstream FEM simulation to determine the residual stresses and thus enable the determination of the PSC. The simulative procedure was also validated experimentally [5,6,7]. Due to the temporal and spatial distance between the discharges being sufficiently large, the representation of the continuous process as a superposition of single discharges proved to be acceptable (Fig. 1).

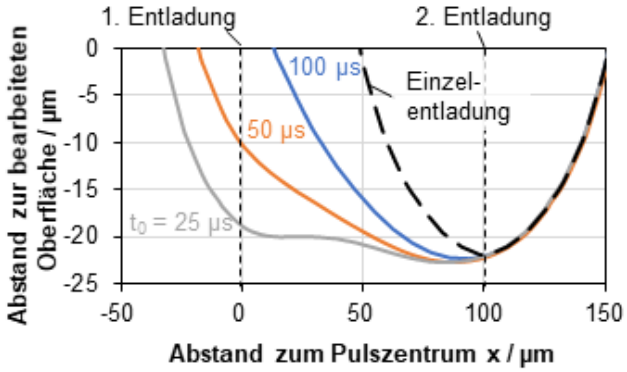

Abb.1: Iso contour of the Ac1 temperature of 42CrMo4 after consecutive discharges

Conclusion and further procedure

The determination of residual stresses in the EDM process took place in this phase without the influence of the solid-liquid-gas flushing flow. The developed method for simulating the multiphase flow will be further improved in the upcoming phase and eventually used to answer further questions:

- Particle concentrations in the sink and wire EDM process and their influence on component functionality
- Influence of the temperature distribution in the ECM process on the local electrochemical erosion

Publications

1. *Underlying Mechanisms for Developing Process Signatures in Manufacturing, Journal of Nanomanufacturing and Metrology, 2018.*
2. *Comparison of laser induced thermal heat impact on 42CrMo4 in gaseous and liquid ambient, Proceedings of the 14th INSECT, 2018.*
3. *Direct particle-fluid simulations of flushing flow in electrical discharge machining, Journal of Engineering Applications of Computational Fluid Mechanics, Volume 15, 2021.*
4. *Formation of Flow-Grooves during Electrochemical Machining, Proceedings of the 16th INSECT, 2020.*
5. *Determination of residual stresses in processes with multiple thermal loads, Procedia CIRP 87, 2020.*
6. *Investigation on residual stress induced by multiple EDM discharges, 18th CIRP Conference on Modelling of Machining Operations, accepted for publication 2021.*
7. *Comparison of Process Signatures for thermally dominated processes, CIRP Journal of Manufacturing Science and Technology, submitted 2021.*