PROZESS SIGNATUREN
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Processes with thermo-mechanical effect - finishing with geomatrically determined cutting edges

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Objective and approach

The aim of the subproject (SP) F08 is the simulation-based development of process signature components for hard milling. For this purpose, it is necessary to systematically investigate the effect of mechanical and thermal stresses (temperatures, temperature gradients, strains/stresses) on the resulting material modifications (residual stresses, plastic strain, change of phase fractions). The focus is on the effect of multiple stresses (influence of corner radius and tooth feed as well as milling strategy) and the analysis of thermo-mechanical stresses and their effect on the material modifications.

Current state of knowledge (Juli 2021)

To achieve the formulated objective, extensive milling tests were carried out on the quenched and tempered steel 42 CrMo4. In parallel, the chip formation simulation of hard milling was carried out for the first time by using a coupled Euler-Lagrange (CEL) method. After the successful validation of process forces, the influence of the cutting edge corner radius and the secondary cutting edge on the loads and modifications for the process steps roughing and finishing was investigated separately. With regard to a multiple load, a multi-stage process with the two different cutting depths ap1 and ap2 (ap1 > ap2) was investigated. The process signature components were set up with the help of a variation of manipulated variables taking into account multiple loads and are to be used further for a simulation-based prediction of the functional properties.

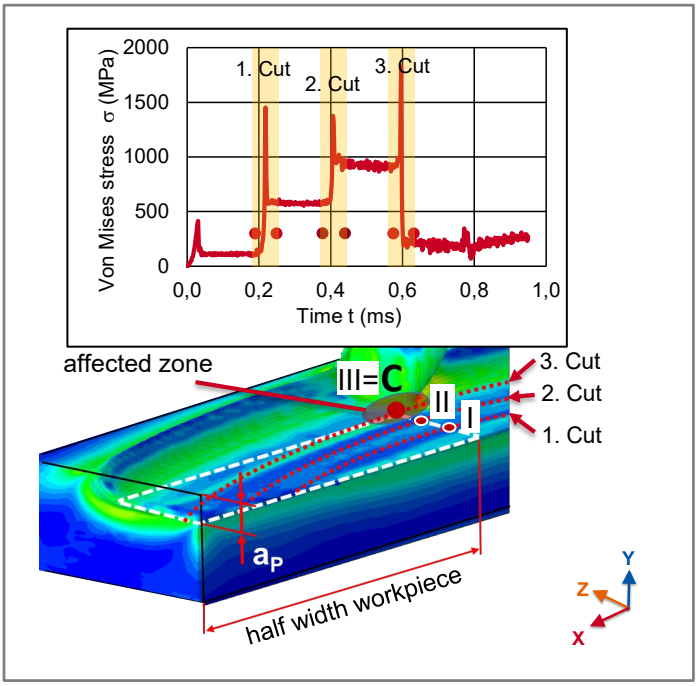

Figure 1: Process signature component due to overlapping effect of single cutting interventions in point C

Conclusion and further procedure

The elaboration of process signature components for hard milling with special consideration of multiple loads is proposed for the first time using a coupled Euler-Lagrange (CEL) method. The establishment of process signature components is carried out in the following steps:

- Model generation and model validation (material model, friction model).
- Establishment of process signature components as a function of the cutting edge geometry, influence of the secondary cutting edge on the material loads and modifications, taking into account the milling strategy and influence of the material input state.

In the third funding phase, the work is to be extended within the framework of the alliance to the resulting functional properties of components.

Publications

[1] Vovk A., Sölter J., Karpuschewski B., Finite element simulations of the material loads and residual stresses in milling utilizing the CEL method, Procedia CIRP Volume 87, 2020, Pages 539-544.
[2] Gräbner, D.; Vovk, A.; Zielinski, T.; Riemer, O.; Lang, W.: An Investigation on High-Resolution Temperature Measurement in Precision Fly-Cutting. Sensors 2021, 21, 1530. https://doi.org/10.3390/s21041530.
[3] Vovk A., Sölter J., Karpuschewski B., Numerical investigation of the influence of multiple loads on material modifications during hard milling, 18th CIRP Conference on Modelling of Machining Operations , June 15-17, 2021.
[4] Zielinski, T.; Vovk, A.; Riemer, O.; Karpuschewski, B.: An investigation on material loads and modifications in precision turning of steel 42CrMo4, MDPI Micromachines2021, 12, 526.; https://doi.org/10.3390/mi12050526