PROZESS SIGNATUREN

TRANSREGIONALER SONDERFORSCHUNGSBEREICH 136

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Thermo-mechanical coupled process modelling of microstructure evolution

Subproject M03 – Prof. Dr.-Ing. Stefanie Reese, Prof. Dr. rer. nat. Bob Svendsen

Objective and approach

In subproject M03, we develop a thermomechanically coupled material model [3] that links the two relevant scales for simulation, the microscale and the macroscale, in an efficient and numerically robust approach. The aim is to capture both the material loads resulting from the processes and the material modifications arising in the microstructure. This connection provides essential information for the definition of process signatures.

Current state of knowledge

Subproject M03 has initially been concerned with the development of an innovative two-scale material model [1, 5, 6] that describes the process behavior and the evolution of the microstructure (e.g., the accumulated plastic strains). Herein, the finite element method on the macroscale is coupled with the fast Fourier transform and phase field method on the microscale. In cooperation with subproject M01 the developed method enabled the two-scale simulation of the deep rolling process (see Figure 1) [1]. Furthermore, the cooperation with subprojects F01, M01, C02 and C06 enables the comparison of the resulting local fields to the experimental results.

In order to make the microscale simulation more accurate but additionally also more efficient, the material model was extended including finite strains [1] and model order reduction techniques [2,4].

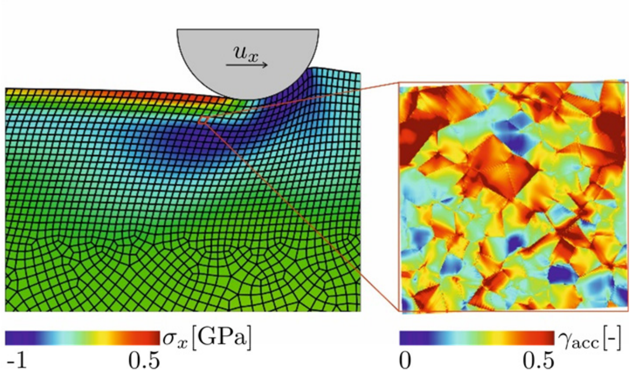

Figure 1: Two-scale FE-FFT-based simulation of the deep rolling process.

Conclusion and further procedure

A key challenge of the research project is to use the developed method for the simulation of processes investigated within the CRC 136. This results in the objectives of subproject M03 for the third funding period, which can be divided into the topics of material modeling, efficiency improvement and process modeling. Based on experimental investigations of subproject C02, a dislocation-based crystal plasticity model is proposed for a more accurate material modeling. Grain changes will additionally be represented by means of non-conservative phase fields. Furthermore, by using improved algorithms and model order reduction methods, a significant increase in efficiency is expected, which should enable two-scale simulations of complex processes. In cooperation with various C, F and M projects, real processes and the sequences of different processes (process chains) will thus be investigated and compared.

Publications

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[3] Gladkov, S.; Kochmann, J.; Reese, S.; Hütter, M.; Svendsen, B.: J. Non-Equilib. Thermodyn. 41(2) (2016), 131-139. 10.1515/jnet-2015-0062.

[4] Kochmann, J.; Manjunatha, K.; Gierden, C.; Wulfinghoff, S.; Svendsen, B.; Reese, S.: Comput. Methods Appl. Mech. Eng. 347 (2019), 622-638. 10.1016/j.cma.2018.11.032.

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[6] Kochmann, J.; Wulfinghoff, S.; Reese, S.; Rezaei Mianroodi, J.; Svendsen, B.: Comput. Methods Appl. Mech. Eng. 305 (2016), 89-110. 10.1016/j.cma.2016.03.001.