A Micro-Thermo-Mechanical Model for a Tailored Formed Joining Zone Deformed by Die Forging

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Abstract. In order to investigate new methodologies to produce light weight and load-adjusted hybrid solid components, a process chain using the technique of tailored forming is developed. Hereby, the two materials aluminum and steel are joined before being formed to a hybrid bearing bushing. A significant drawback of this technique is the weakened joining zone. This is due to the differences of material properties and the formation of an inter-metallic phase at the joined zone, resulting with high stresses during the forming process that might lead to damage and failure. To achieve a high mechanical strength of the hybrid solid component, it is important to evaluate the sensitivity of different process parameters and to accurately adjust the material behavior of the joining zone. Because of the strong dependence of the effective, macroscopic material behavior on the thermo-mechanical influences at the microscopic level, the polycrystalline joining zone is investigated on the microscopic length scale. Material models are developed for each of the constituents steel and aluminum using the framework of dislocation density based crystal plasticity as well as an elastic material model for the brittle inter-metallic phase. For the microscopic simulation of the die forging, a volume element of the joining zone is generated capturing the characteristic morphology of the different grains including their size distribution, non-convex shapes, elongation and volume fractions as well as the stochastic orientation of the grains. The microscopic boundary value problem is chosen to meet the macroscopically applied loads during the die forging of the bearing bushing.