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Creep in Ni-based superalloys on two scales

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Nickel-based superalloys are the key material representing the state of the art for gas turbines. These alloys are designed to resist mechanical load and oxidative environments at temperatures of up to 90 % of their melting point [1]. Nonetheless, due to such extreme service conditions, the microstructure undergoes continuous degradation. Polycrystalline alloys accumulate damage at grain boundaries, which led to the development of alloys with ever increasing grain sizes and finally macroscopic single crystals. Single crystals (single grains) exhibit severe anisotropy in flow behaviour as dislocations glide on a set of slip planes which are disturbed by uniformly distributed particles of the γ'-phase. It is well established that the formidable properties of nickel based superalloys can be attributed to such particles.
Targeting a suitable but computationally feasible description of this complex alloy, two models are presented: one for the polycrystalline grain scale and another for the two-phase microstructure in the grain interior. The physics-based local crystal plasticity material model of the grain scale [2] incorporates features of the grain-interior which is modeled by resorting to an XFEM formulation for the material heterogeneity [3].
The two-scaled approach aims at an improved insight into the interaction of rafting and polycrystalline behaviour.

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