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Assessment of adaptative meshing in CPFEM simulation of the anisotropy of polycristalline aggregates

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ABSTRACT

Mechanical properties of ductile metals are the result of physical phenomena occurring at the micron scale. At this scale, metals are polycrystalline aggregates. The shape, the size, the arrangement and the orientation of the grains influence the macroscopic anisotropy. The prediction of microstructure changes during forming operations as well as the resulting development of anisotropy is of great importance in practical applications.

One way to draw the link between microstructure characteristics and macroscopic mechanical response is the crystal-plasticity-based finite element method (CPFEM). However, so far, one has mostly relied on oversimplified representations of the microstructure where all grains have the same shape and size [1]. With the development of computer power, the generation of more realistic microstructure representations becomes a bottleneck to the improvement of CPFEM predictions.

Two microstructure generators are compared here. Both allow the obtention of a realistic reproduction of the grain topology in 3D with a reduced number of elements thanks to adaptative meshing. Model microstructures consist of a single phase with irregular grain shape. Grains are defined as Voronoi cells. Seed positions are chosen randomly but in such a way that the distance between all of them is superior to a threshold. The FE mesh is coarse within the grains and fine at the interfaces. Initial grain orientations are generated such that they constitute a statistically representative sampling of the global texture while accounting for the non-uniform grain size [2]. Two types of boundary conditions are compared. On one hand, we use periodic boundary conditions and on the other hand, the model microstructure is embedded in a uniform matrix with effective properties corresponding to the overall behaviour of the textured polycrystal.

Simulations with heterogeneous microstructures are compared to other micro-macro transition schemes including the conventional Taylor model, the ALAMEL model, and FE modelling with grains shaped as bricks. The two new CPFEM techniques yield a more accurate prediction of the rolling texture and of the planar anisotropy (R-value) of a steel sheet.

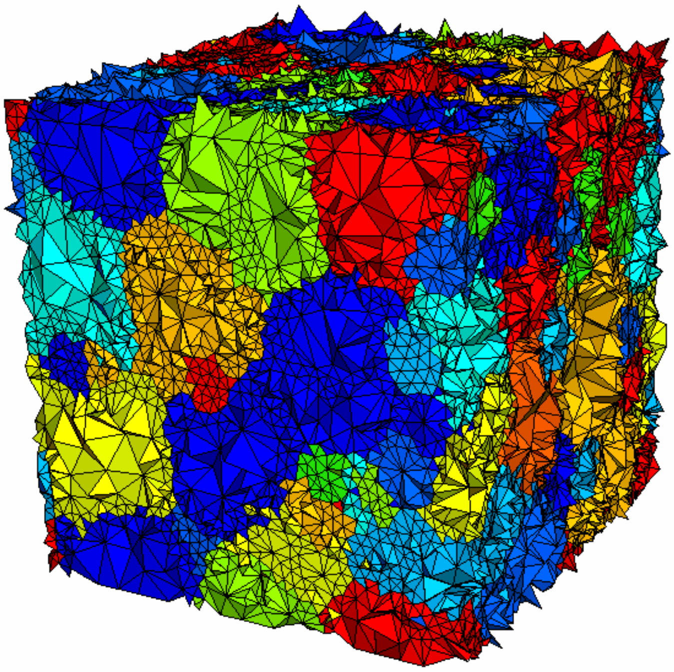

Figure 1: Periodic microstructure obtained after coarsening of the center of the grains.

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