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ANISOTROPIC MULTISCALE MODELS APPLIED TO OLIGOGRANULAR COMPONENTS

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Directionally solidified materials represent a good compromise to build temperature resistant components in aeronautical engine or ground turbines. They are less expansive and easier to produce than single crystals, and they are much more resistant than classical polycrystals. Nevertheless, they introduce specific difficulties for component design, as grain size cannot be neglected with respect to component size. It follows that scale separability is not verified, and that both grain morphology and crystal orientations come into play for the calculation of the strain and stress fields. The designer must then have in hand a computational technique allowing him to evaluate the scatter in the mechanical response, in order to deduce a scatter in component life.

A first solution to evaluate the scatter is to perform a series of calculations of the component, with an explicit representation of the microstructure, and a realistic distribution of grain size and grain orientation. Crystal plasticity should be used in each grain. This approach offers a good opportunity to capture extremal situations, where severe grain mismatch can create large local stress or strain concentration. The drawback is that many different finite element calculations must be performed. This is why our paper proposes an alternative solution, namely an approach using a homogenized mean field model, that is directly introduced in a "one shot" finite element calculation. Even if the scale separability is not fulfilled, it has been shown that the scatter is properly captured.

The first section of the presentation is devoted to the choice of the scale transition rule and to the identification of the model. The difficulties attached to the approach are the elastoviscoplastic behaviour, coupled to the anisotropy of the material: since all the grains have a crystallographic axis in common, and a random secondary orientation, the resulting homogenized model has a funny shape, mixing a Tresca type yield surface and single crystal features. The presented model is able to reproduce these characteristics. It can reproduce the heterogeneity between the various phases as well, provided anisotropic elasticity is taken into account. The material parameters are calibrated by means of an experimental tension curve and Crystal Plasticity Finite Element simulations.

The new model is implemented in the finite element code Zset/Zebulon [1]. It is then applied to a notched specimen figuring the critical area of an aeronautical component. The results are analyzed in terms of stress and strain distributions. It is shown that a single calculation with the homogenized model allows to successfully reproduce the curves obtained with a series of finite element calculations, on explicit crystal geometries [2].

REFERENCES

[1] http://www.zset-software.com.

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