Study of Size Effects in Nickel with High Purity

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Abstract. The interest of a better understanding of mechanical behavior of metal material at small length scale (typically close to the size of grains inside the material) is growing with the demands of micro mechanical devices in microelectronics field, automotive sector, biomechanical applications and so on.

The effects of the grain characters, such as the spatial orientations of grains, the textures, the distortion of lattice, the densities of grain boundaries and dislocations, on the macroscopic mechanical behavior are quite limited when the material length scale largely outweighs the grain size. On the contrary, the mechanical behavior of each individual grain is more dominant when the grain size is comparable to the material size.

The mechanical behavior of the material at micro-/meso length scale depends on the properties of grain aggregate, e.g. the number of grains in the sample, the orientations of each individual grain, the textures, the slips of lattice and the dislocation densities etc. A decrease of flow stress with a decrease of number of grains through the thickness is reported by e.g. (Keller et al., 2011)(Hug et al., 2015) for some FCC materials, for instant, the Ni-20wt.%Cr alloy, the nickel and the cooper with high purity.

The main objective of this paper is to study the grain size effects at micro-/meso- length scale for FCC material when a low triaxiality stress path is applied. An experimental campaign (Yuan et al., 2018) will be described and an inverse modeling is employed to identify a macroscopic elastic-plastic constitutive law. The microscopic behavior at meso scale is investigated with a 3D mesh covering a few grains with a strain gradient crystal plasticity model (Keller et al., 2015).

Reference

Hug, E., Dubos, P.A., Keller, C., Duchêne, L., Habraken, A.M., 2015. Size effects and temperature dependence on strain-hardening mechanisms in some face centered cubic materials. Mech. Mater. 91, 136–151. https://doi.org/10.1016/j.mechmat.2015.07.001

Keller, C., Hug, E., Feaugas, X., 2011. Microstructural size effects on mechanical properties of high purity nickel. Int. J. Plast. 27, 635–654. https://doi.org/10.1016/j.ijplas.2010.08.002

Keller, C., Hug, E., Habraken, A.M., Duchêne, L., 2015. Effect of stress path on the miniaturization size effect for nickel polycrystals. Int. J. Plast. 64, 26–39. https://doi.org/10.1016/j.ijplas.2014.07.001

Yuan, S., Duchêne, L., Milis, O., Keller, C., Hug, E., Habraken, A.-M., 2018. A Novel Geometry for Shear Test Using Axial Tensile Setup. Proceedings 2, 422. https://doi.org/10.3390/ICEM18-05277