Influence of Strain Rate Sensitivity on Cube Texture Evolution in Aluminium Alloys

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Abstract

Optimization of the final crystallographic texture of aluminium sheets is important for good formability during drawing. Controlling the distribution and morphology of cube texture in rolled sheets is fundamental to avoid preferential growth of cube grains during final recrystallization annealing. During rolling, the formation of transition bands is undesirable because they are responsible for growth of cube grains in the final microstructure upon heating. Transition bands are characterized by diverging orientation changes of the same original cube grain into different orientations, with the cube orientation preserved in the inside. Aluminium alloys can exhibit a wide range of strain rate sensitivity depending on strain rate and temperature of deformation. The influence of strain rate sensitivity on the development of cube texture is often neglected both in experiments and in simulations approaches. In this work, the influence of strain rate sensitivity on texture evolution and on cube distribution was assessed through full field crystal plasticity simulations using the freeware simulation package DAMASK. These simulations are performed following texture evolution up to 86% of thickness reduction both in hot and cold rolling while systematically changing the value of strain rate sensitivity. For hot rolling, activation of non-octahedral slip systems {110} <110> is considered in the simulations. Results suggest that among all rolling texture components (i.e. Cube, Brass, Goss, S and Copper), Cube is the crystallographic orientation that is most affected by changes in strain rate sensitivity. During hot rolling, Cube is stabilized for high values of strain rate sensitivity and preferred activation of non-octahedral slip system over activation of octahedral slip systems. S texture is not affected by changes of strain rate sensitivity. Brass and Copper textures evolution depends both on strain rate sensitivity and activation of non-octahedral slip systems.

In the DAMASK simulation, during cold rolling, low values of strain rate sensitivity lead to a fragmentation of cube grains. High values of strain rate sensitivity promote the formation of cube transition bands leaving thin cube grains aligned in rolling direction in the microstructure. These elongated cube grains are difficult to misorient with further compression or with shear loading. During cold rolling, Brass and S crystallographic orientations of the beta fiber are not affected by strain rate sensitivity, while the volume fraction of Copper orientation diminishes as the strain rate sensitivity decreases. Cold rolling tests performed at different lamination speeds confirm the influence of strain rate sensitivity on texture evolution which is predicted in the full field crystal plasticity simulations.

References

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