Simulation of anisotropic tensile failure in high-strength aluminium alloy by localization theory

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ABSTRACT

High-strength aluminium alloys often display anisotropic mechanical properties, e.g. yield stress, plastic flow and tensile ductility, due to the rolling or extrusion process. The anisotropy of the yield stress and plastic flow is mainly governed by the crystallographic texture, while other microstructural features, e.g. particle distribution, grain size and morphology, and grain boundaries, are assumed to be important for the anisotropy of the tensile ductility. The aim of the current study is to evaluate the influence of plastic anisotropy on the direction dependence of the failure strain in tension tests.

Experiments presented by Fourmeau et al. [1] demonstrate that the aluminium alloy AA7075-T651 has strong plastic anisotropy in yield stress and plastic flow and even stronger direction dependence of the tensile strain to failure. In addition, the AA7075-T651 alloy was shown to have a complex microstructure with strong crystallographic texture, elongated grains, particles aligned in stringers and precipitate-free zones [2], while the role of these microstructural features on the anisotropic tensile ductility remains to be established.

In order to evaluate the influence of plastic anisotropy on tensile ductility, an anisotropic plasticity model was used in this study to simulate tension tests on smooth and notched axisymmetric samples with varying tensile direction within the plane of the rolled AA7075-T651 plate. The strain histories from these simulations were then used in localization analyses adopting the imperfection band approach [3][4]. In the localization analyses, the anisotropic plasticity model was used outside the imperfection band, while an anisotropic porous plasticity model based on the Gurson model was used inside the band. Failure was assumed to coincide with localization inside the band. The simulation results indicate that plastic anisotropy plays a major part in determining the directional dependence of the tensile ductility of the alloy; partly by changing the plastic flow and the multiaxial stress state in the neck region and partly by changing the stress level with tensile direction.

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