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MICROSTRUCTURE-BASED COMPUTATIONAL ANALYSIS OF PLASTIC STRAIN LOCALIZATION AND FRACTURE IN POLYCRYSTALLINE ALUMINUM

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Fracture behavior of materials is influenced by many factors. At the micro-level, this may be structural heterogeneity, since grain boundaries and triple junction regions of the grains are the stress concentrators and affect the crack propagation throughout the entire volume of a specimen. At the macro-level, the fracture process is affected by the specimen shape and boundary conditions. Experimental techniques do not allow us considering the effect of each of these factors separately on the material fracture behavior. Three-dimensional models taking into account the aluminum polycrystalline microstructure in an explicit form are generated by a step-by-step packing method. Thermomechanical constitutive equations describing the nonlinear behavior of the specimens at different strain rates are used. The boundary-value problems are solved numerically by the finite-element method. An analysis of the effect of a polycrystalline microstructure, strain rate, and additional constraint boundary conditions simulating a quasi-plane strain on the fracture behavior of the polycrystalline aluminum is performed. Conclusions about the effect of each of these factors are drawn.

It was shown that quasi-plane boundary conditions have a significant effect on the plastic strain localization and on the fracture behavior of polycrystalline aluminum. When imposing boundary conditions simulating a quasi-plane strain, cracks tended to propagate at an angle of 45 degrees to the loading axis at fixed boundaries. It was found that the sites of primary cracks initiation changed with an increase in the strain rate, the fraction of the fractured material increased, and the multiple cracking divided the specimens into several parts. At low strain rates, the samples were divided into two parts approximately equal in volume.

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