Dislocation density-based modelling of plastic deformation of Zircaloy-4

Abstract

This paper considers the deformation of the zirconium alloy Zircaloy-4. Experimental data for constant strain rate and creep tests in the temperature and stress regime expected during dry storage of spent fuel are presented and modelled. The model used follows the approach of Kocks and Mecking in which the dislocation density is considered as the governing internal variable. The model is extended in a phenomenological manner, to take into account the incompatibility stress that develops as a consequence of the anisotropy of the hcp zirconium. An equation that accounts for the evolution of the incompatibility stress with strain is used in conjunction with the evolution equation for dislocation density thus providing a full description of the deformation behaviour. A set of parameters determined experimentally enables the prediction of the mechanical response under constant strain rate and creep conditions. A reasonably good predictive capability of the model is demonstrated.

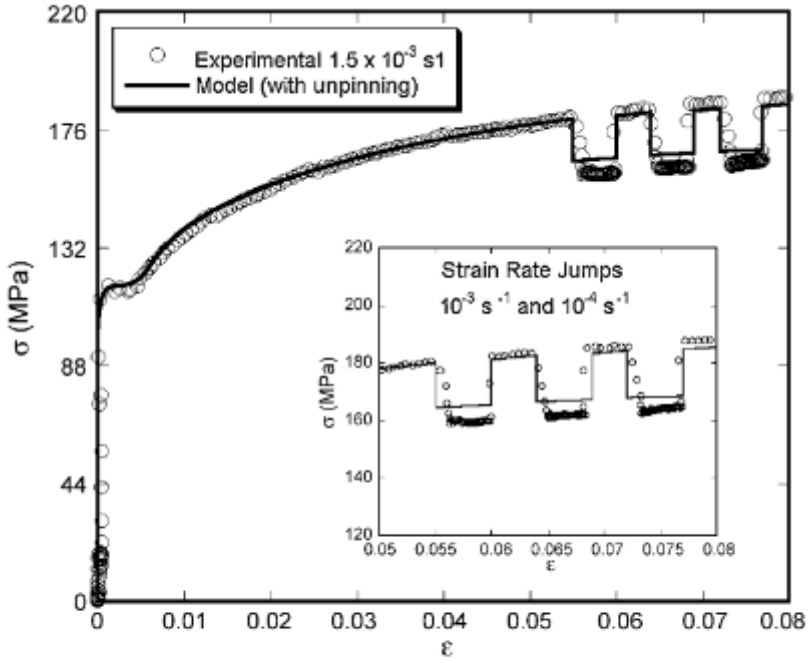

Fig. 10. Application of the modified KME model, with the unpinning model, to a constant strain rate tensile test with strain rate jumps. Recrystallised Zircaloy-4 (470 °C 1.5×10^{-3} s^{-1}).