Modelling and simulation of diffusion driven pore formation in martensitic steels during creep

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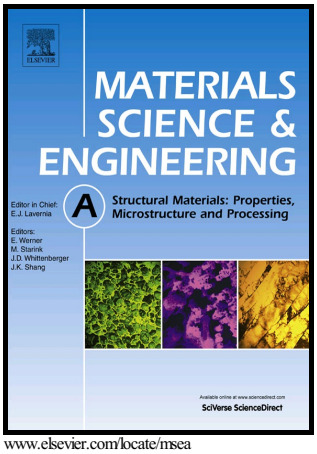

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Abstract

A model has been developed to describe the nucleation and growth of creep pores in crystalline material under service conditions. The nucleation model is based on Becker-Döring (BD) nucleation theory using Helmholtz free energy, while for the growth of pores, a vacancy flux model towards nucleated or existing pores is utilized. The whole model is able to describe nucleation and growth rates of pores in the matrix (homogeneous nucleation), at grain boundaries, at triple and at quadruple grain boundary points as well as at particles/inclusions. Nucleation and growth rates of pores in creep process are considered to be a function of external and internal stress due to the residual stresses, working temperature, local microstructure (nucleation and growth of particles), nucleation sites, interfacial energy of grain boundaries and phase boundary energies, diffusion rates in different paths, and pore geometry. Interrupted creep tests are performed for 9Cr-1Mo martensitic (ASME Gr.91) steels under 66 MPa uniaxial creep loading at 650°C to track the pore evolution after 0, 2189, 4009, 5272 and 8030 hours. The model results are then compared to experimental findings in terms of mean pore size, and volume fraction. The model has good prediction and description power of the physical phenomena.

Keywords: modelling and simulation; creep cavitation; nucleation and growth of pores