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# Creep Crack Growth by Grain Boundary Cavitation under Monotonic and Cyclic Loading

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**Abstract**

Plane strain finite deformation finite element calculations of mode I crack growth under small scale creep conditions are carried out. Attention is confined to isothermal conditions and two time histories of the applied stress intensity factor: (i) a mononpočetic increase to a plateau value subsequently held fixed; and (ii) a cyclic time variation. The crack growth calculations are based on a micromechanics constitutive relation that couples creep deformation and damage due to grain boundary cavitation. Grain boundary cavitation, with cavity growth due to both creep and diffusion, is taken as the sole failure mechanism contributing to crack growth. The influence on the crack growth rate of loading history parameters, such as the magnitude of the applied stress intensity factor, the ratio of the applied minimum to maximum stress intensity factors, the loading rate, the hold time and the cyclic loading frequency, are explored. The crack growth rate under cyclic loading conditions is found to be greater than under monotonic creep loading with the plateau applied stress intensity factor equal to its maximum value under cyclic loading conditions. Several features of the crack growth behavior observed in creep-fatigue tests naturally emerge, for example, a Paris law type relation is obtained for cyclic loading.

*Keywords:* Creep, Creep-fatigue, Grain boundary cavitation, Crack growth, Finite element calculation

## 1. Introduction

Steam turbine, jet engine and nuclear reactor components are commonly exposed to time varying mechanical and thermal loading at elevated temperatures. The useful lifetime of such components can be limited by dimensional changes or by the nucleation and growth of one or more cracks. Accurately predicting the service life and estimating safe inspection intervals under conditions involving high temperatures and time varying loading are challenging issues.

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