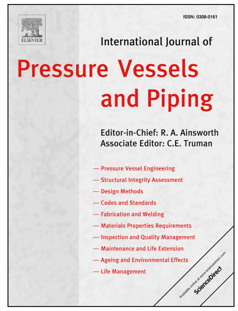

The effect of creep strain rate on damage accumulation in Type 316H austenitic stainless steel

E.A. Hares, M. Mostafavi, R. Bradford, C.E. Truman

PII: S0308-0161(18)30141-8

DOI: 10.1016/j.ijpvp.2018.09.015

Reference: IPVP 3764

To appear in: *International Journal of Pressure Vessels and Piping*

Received Date: 17 April 2018

Revised Date: 25 September 2018

Accepted Date: 28 September 2018

THE EFFECT OF CREEP STRAIN RATE ON DAMAGE ACCUMULATION IN TYPE 316H AUSTENITIC STAINLESS STEEL

E.A. Hares, M. Mostafavi, R. Bradford and C.E. Truman
Department of Mechanical Engineering, University of Bristol, UK

Abstract: Many service components in power generation and aerospace industries operate at high temperatures and stresses that make them susceptible to creep deformation and damage. Their complex geometries and load multi-axiality are often treated only approximately in assessing their structural integrity via assessment codes that are based on standard creep tests. For example, the forward creep (defined here as constant load creep) test of round bars is not a true representation of the stress state that service components generally experience. The experiments conducted in this work used notched bar specimens to simulate the effect of stress triaxiality. The results from these experiments were then used to validate a well-established creep ductility exhaustion damage model. Although the damage model is largely based on uniaxial creep rupture tests, it has been previously adapted so that it can be applied to more complex states of stress. Rupture calculations were conducted prior to experimental testing to obtain an estimation of the duration of the experiments. The finite element simulation results, which utilised previously developed creep deformation and damage models, were then compared to the experimental data. It was shown that the model predicted the correct trend for the creep deformation and failure of the specimens and primary, secondary and tertiary creep behaviour of notched bars could be captured. The tests imply that the effective creep ductility was smaller at lower stresses, i.e., at slower strain rates creep strain was more damaging.

1. Introduction

Stainless steel is commonly used in the fabrication of components in the power generation industry. These components are subjected to high temperature creep during plant operation, typically at 550˚C, and therefore it was important to evaluate their behaviour in the creep regime. Both creep deformation and creep damage play a significant role in the fitness for service of such components. Creep damage is a phenomenon that occurs in metals after prolonged exposure to high stress and high temperature and it can lead to catastrophic failure. It can initiate early in operation and develop gradually throughout the life of a component [1, 2]. The main aim of this research was to determine whether creep strain is more damaging to a specimen if accumulated more slowly. A model capable of forecasting creep damage correctly within a material/component can be used to estimate its creep life. With an increasing need to extend the lives of UK nuclear power plants, it is important to be able to accurately predict when failures are likely to occur so that safe operation can be achieved. It has been observed that the current methods for forecasting the accumulation of creep damage tend to be very conservative [3, 4], whereas the more modern technique reported in this work is thought to be more accurate, but has not been implemented extensively.

Uniaxial stress relaxation behaviour has been investigated in previous research by Spindler [5]. Uniaxial loading conditions are not truly representative of plant operating conditions because complex geometries and loading conditions are often present. Notched bar tests have been conducted by previous researchers to determine the multiaxial effect on creep ductility [6-8], defining creep ductility as the creep strain on failure. In this research notched bar specimens have been used to introduce a stress triaxiality [4, 9-11]. The degree of triaxiality of the stress state is defined through a stress triaxiality factor, η, defined as: