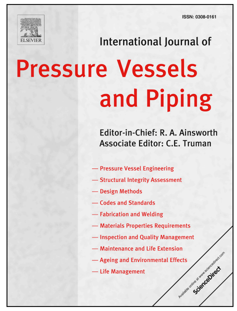
Accepted Manuscript



Oxide-scale thickness measurement for predicting crack growth history in elevated temperature components

Ralph E. Huneycutt, IV, Ashok Saxena, Kee Bong Yoon

PII: S0308-0161(17)30233-8

DOI: 10.1016/j.ijpvp.2017.12.004

Reference: IPVP 3674

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

Received Date: 8 July 2017

Revised Date: 3 December 2017

Accepted Date: 29 December 2017

Please cite this article as: Huneycutt IV RE, Saxena A, Yoon KB, Oxide-scale thickness measurement for predicting crack growth history in elevated temperature components, *International Journal of Pressure Vessels and Piping* (2018), doi: 10.1016/j.ijpvp.2017.12.004.

Oxide-Scale Thickness Measurement for Predicting Crack Growth History in Elevated Temperature Components

Ralph E. Huneycutt IV[1], Ashok Saxena*[1] and Kee Bong Yoon[2]
[1]Department of Mechanical Engineering, University of Arkansas, Fayetteville, AR
[2] Department of Mechanical Engineering, Chung Ang University, Seoul, S. Korea
*Corresponding author, asaxena@uark.edu

Abstract

Structural components from ferritic steels are known to oxidize in air when exposed to high temperatures and can develop cracks during service. Oxide thickness on the surface of the crack is related to the exposure time, and temperature and can be used to determine the history of cracks. A model for describing the kinetics of oxide formation in ASTM grade P91 piping steel is developed using flat, polished specimens of the steel and exposing them to high temperatures. Oxide thickness measurements were made and an oxidation kinetics model was developed. Oxide thickness profiles on the creep-fatigue crack surfaces of compact type specimens with a known crack growth history were also characterized using scanning electron microscopy. The oxidation model is then used to predict drack growth rates in compact type specimens. Good agreement between the measured and predicted crack growth rates were found.

Key words: Oxide scale, cracks, creep-fatigue, P91 Steel, oxidation kinetics

1. Introduction

There are only a few techniques available for predicting the age of cracks in structural components. Among them is the oxide thickness measurement technique that is most suitable for analyzing the history of cracks subjected to elevated temperature service conditions [1]. In this technique, a model that describes the kinetics of oxide formation for the material from which the component is made is developed.

The literature shows that there are four primary mechanisms that influence the oxide thickness during high temperature service, Fig. 1 [2]. Initially, the oxide thickness increases linearly or logarithmically with time and then as steady-state conditions are established, the parabolic relationship takes over which is due to the formation of passivation layer in the form of the oxide itself. Multiple types of oxides with different rate characteristics can also form. Oxide spallation can occur due to porosity and formation of cracks, and evaporation or volatility can result in loss of oxide thickness. In the service temperature range of this study, evaporation or volatility is not expected to be a factor and care was taken to