Engineering Failure Analysis 18 (2011) 2260–2271

Contents lists available at SciVerse ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Determination of correlation functions of the oxide scale growth and the temperature increase

B.H. Salman [a,*], M.Z. Hamzah [a], J. Purbolaksono [b], J.I. Inayat-Hussain [a], H.A. Mohammed [a], M.W. Muhieldeen [c]

[a] Department of Mechanical Engineering, College of Engineering, Universiti Tenaga Nasional, Km 7, Jalan Kajang-Puchong, 43900 Kajang, Selangor, Malaysia
[b] Department of Engineering Design and Manufacturing, University of Malaya, 50603 Kuala Lumpur, Malaysia
[c] Department of Mechanical Engineering, University Putra Malaysia, Serdang, Malaysia

ARTICLE INFO

Article history:
Received 30 May 2011
Received in revised form 22 July 2011
Accepted 4 August 2011
Available online 11 August 2011

Keywords:
Oxidation
Superheater and reheater
Numerical simulation
Heat transfer

ABSTRACT

In this paper, a method for estimating the scale growth of superheater and reheater tubes of boiler and generating the constant *B* which is correlating the scale growth and the increased tube metal temperature, for different operational conditions is reported. This method utilizes an empirical formula correlating the scale thickness with Larson-Miller Parameter (LMP). Finite element modeling to estimate the scale thickness on the inner surface of the tube over period of time is developed. The effects of tube geometry, mass flow rate and temperature of steam, flue gas temperature and the convection coefficient on the external surface of the tube that influenced the temperature increase in the tube metal are examined. The present results provide better estimation of the oxide scale growth and temperature increase over period of time.

1. Introduction

Some boilers had been operated for long durations. In order to continue the operation, techniques and methodologies are needed to assess the current condition of plant components and to predict their remaining lives. The life estimation technology is beneficial for relatively new plants in terms of safety, availability, equipment reliability and also to reduce the costly failure through good design. Many researchers displayed the mode and mechanism of boiler failure, e.g. Ray et al. [1], Babcock and Wilcox Company [2], Baoyou et al. [3], Ganapathy [4], Armitt et al. [5], Bhatt [6], Das et al. [7], Ennis and Quadakkers [8], Viswanathan et al. [9,10], Zuo et al. [11], Rehn et al. [12], and Uhlig [13]. However, Port and Herro [14] reported that more than 80% of boiler failures caused by long term overheating occurred in boiler tubes. The deposits layer inside the tube over period of time reduced the coolant flow, and experienced excessive fire-side heat input. The deposit insulates the metal from the cooling effects of the steam, resulting in reduced heat transfer into the steam and increase the temperature of metal tube. In prolonged exposure, this phenomenon will worsen the situation that leads to potential failure in the boiler tubes. Scales inside the boiler tubes have also been found to be one of the major contributors to the tube failure. Heat transfer rate across the tube decreases due to the accumulated scales inside the tube.

The growing scales affect the tube to have higher temperatures than those as originally specified. Such exposure may cause degradation of the tube alloy, and this eventually will lead to tube rupture. It is estimated that 10% of all power-plant breakdowns are caused by creep fractures of boiler tubes due to the scales [15]. Computer program was developed by French [16] to simulate the aging of a superheated tube in service and used to predict failure times. The program does a series of

* Corresponding author.
E-mail address: eng.bassam2007@yahoo.com (B.H. Salman).

1350-6307/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engfailanal.2011.08.001