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Life assessment and inspection of a hot reheat turbine bifurcation

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ABSTRACT

A life assessment of a hot reheat bifurcation has been undertaken. Surface breaking crack-like indications were detected in the bifurcation weld. Subsequent replication showed that this was due to significant creep damage in a number of material zones within the weld. This damage was removed by hand dressing until it had been reduced to an acceptable level below which good material remained with minimal damage; this was confirmed by additional replication. A finite element analysis was undertaken based on the elastic rupture reference stress multiplied by weld redistribution factors which quantifies stress redistribution within the weldments. The results indicated that creep damage would be evident on both the external surface of the saddle region and on the inside surface at the crotch position. Additional analysis based on a RIKS procedure and an elastic-perfectly plastic analysis confirmed the results of the rupture reference method. A full re-inspection of the bifurcation branch was recommended before another 10,000 h of service was completed as a consequence of this study. At the next inspection recurrence of the damage was found, and internal inspection confirmed the analysis results with damage also present on the internal surface at the crotch position. Based on these findings replacement of the bifurcation has been recommended.

1. Introduction

High energy piping systems are designed to operate at high temperatures and high pressures, typically 540–560 °C and 40–60 MPa hoop stress; hot reheat pipes are included in this category. The remaining life of large high energy welded components subject to creep is often limited by the life of the welds. Experience and testing has shown that the creep strength of welds, and in particular of the heat-affected zone (HAZ), is generally less than that of the parent material. Estimating the remaining life of welded vessels then often becomes a matter of estimating the remaining creep life of the welds. Welds are heterogeneous, and the various material zones; the weld metal and the different regions of HAZ all have different creep properties. During stress relaxation caused by creep, the complex geometry and material properties leads to stress redistribution as a result of off-loading stresses occurring in the various material zones.

Failure of these types of branch intersections generally occurs at welds in the inter-critical zone of the HAZ and is categorised as Type IV failure [1]. Cr–Mo–V weldments are particularly prone to this type of cracking mechanism. Type IV failures is a worldwide problem in power generation systems and is attributed to localised microstructral region that has low creep strength [2,3]. In large megawatt (MW) coal fired steam generation stations, the intermediate pressure turbine is generally fed by the hot reheat (HRH) line. In this unit, the HRH line was made up of four legs A to D that link to two bifurcations C and D legs and A and B legs. This paper discusses the life assessment carried out on the HRH turbine bifurcations and

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