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Creep fracture behavior of dissimilar weld joints between T92 martensitic and HR3C austenitic steels

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The creep fracture of T92/HR3C dissimilar weld joints is investigated. HR3C austenitic steel is welded with T92 martensitic steel to obtain a T92/HR3C weld joint. After welding, creep tests are carried out at 625 °C in the stress range 110–180 MPa. The results indicate that the creep fracture mechanism is dependent on stress. When stresses ≥140 MPa, the fracture location is at the T92 base material and the connection of adjacent dimples results in transcrystalline fracture. For stresses <140 MPa, the fracture location is at the T92 coarse-grained heat affected zone and growth of $M_{23}C_6$ particles as well as Laves phase (Fe_2(W, Mo)) precipitation on the grain boundaries leads to intergranular fracture.

1. Introduction

In order to improve the efficiency of thermal power generation and protect the environment, many countries are developing Ultra-Supercritical (USC) coal-fired power plants with steam temperature up to 600 °C and pressures exceeding 27 MPa. By increasing the steam temperature to 600 °C, the efficiency can rise to around 45%, compared with 41% for supercritical (SC) boilers. Many new generation steels have been developed for USC application in recent years, including T92 (9Cr0.5Mo2WVNb) martensitic and HR3C (TP310HCbN) austenitic steels.

T92 steel was developed in the late 1990s through chemical compositions modification to T91 (9Cr1MoVNb) for improved high temperature properties [1]. This steel is designated NF616 (ASTM Standards A213) and contains 0.5% Mo, 1.8% W, as well as small additions of Nb, V and B. The creep strength of T92 at 600 °C is about 10–20% higher than that of T91 [2–5]. HR3C was developed from TP310 is an austenitic steel, which possesses excellent resistance to high-temperature corrosion and steam oxidation due to it's high Cr content. Thus, HR3C is widely used for superheaters and reheaters, which have the severest service environment in USC boilers. Commonly, T92 is used as pipes linking superheaters and reheaters, and inevitably there are dissimilar welds with HR3C, and the integrity of these welds plays a significant role for USC boilers in service. Many researches have indicated that creep is the dominant factor for the failures of dissimilar weld joints. However for different dissimilar weld joints, the creep fracture mechanisms are different [6–9]. Research on T92 steel has mainly focused on T92 similar weld joints [10–15]. For T92/HR3C dissimilar weld joints, there is little research. Therefore, it is necessary to study the creep mechanism of T92/HR3C dissimilar weld joints at high temperatures.

In the current work, the long-term service life of T92/HR3C dissimilar weld joints at 625 °C is evaluated according to the creep test results. In addition, the creep fracture mechanism of the joint is carefully analyzed.

2. Experimental

2.1. Materials and welding procedure

Two base materials, namely, T92 (48OD×8.4 mm thickness) and HR3C (48.26OD×10.16 mm thickness) steels, are used. The heat treatment conditions are: 1) T92: 1050 °C × 20 min (normalizing) + 760 °C × 60 min (tempering); 2) HR3C: solution-treated at 1110 °C. The chemical compositions of these are given in Table 1. The T92/HR3C weld joint is welded by gas tungsten arc welding with pure argon gas (Ar) as the shielding gas and AWS ERNiCr-3 (corresponding to INCONEL 82/182) as the filler material. Post weld heat

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