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Low cycle fatigue behaviour of nickel base superalloy IN 740H at 760°C: Influence of fireside corrosion atmosphere

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Abstract

Interaction of fireside corrosion atmosphere and fatigue damage in A-USC boiler alloy IN740H is studied by conducting fatigue experiments on bare and salt coated ($58\%Na_2SO_4+39\%K_2S_2O_7+2\%NaCl+0.5\%CaSO_4$) specimens at 760°C followed by extensive electron microscopy. The salt mixture fuse and release SO_3 gas during fatigue tests. Fatigue life is significantly reduced due to fireside corrosion atmosphere. Fluxing of complex oxide layer and extensive surface cracking is ascertained to be the reason of premature fatigue failure at lower $\Delta\varepsilon_t/2$ (e.g. 0.3%), however, at higher $\Delta\varepsilon_t/2$ e.g. 0.7%, breaking of oxide scales and surface pitting are the causes of early fatigue failure.

Key words: IN 740H; low cycle fatigue; fireside corrosion; oxide fluxing; pitting

1. Introduction

Nickel base superalloy IN740H is a candidate material for manufacturing pipes and super heater tubes in boilers of advanced ultra-supercritical (A-USC) power plants to be operated with 760°C steam temperature and 35 MPa pressure [1, 2]. For achieving such high steam temperature, A-USC power plants will have (i) radiation super heaters and/or (ii) convective super heaters [3]. In radiation super heater the heat transfer is proportional to the fourth power of temperature difference between tube wall and flame. Therefore, small fluctuation of heat transfer causes significant change in temperature of the material at different sections and raises the risk of thermal fatigue. Moreover, thermal fatigue also originates from cyclic operations in present day power plants. In addition, high temperature flame in boiler furnaces causes deposition of molten salt-ash mixture over the fireside of furnace tubes in a flue gas atmosphere. Therefore, it is safety significant to design the boiler components against combined damage caused due to fireside corrosion and low cycle fatigue (LCF) interaction.

A few studies on hot corrosion and fatigue interaction have been reported particularly for nickel base superalloys used for manufacturing aero engine components [4, 5]. In a recent study