Research on the failure mechanism of heat-resistant alloys for A-USC boiler under the synergy of fireside corrosion and creep stress

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Abstract: To address the escalating demand for electricity and reduce the CO_2 emission, advanced ultra-supercritical (A-USC) coal-fired power generation technology has attracted attention for their efficient nuclear cleanliness. By improving the operating steam parameter to 38 MPa/700 °C/720 °C/720 °C, the unit efficiency of A-USC coal-fired power plants can reach 48~50%. The corrosion/stress failure risk of structural material serviced in such environment is increased for the higher temperature and stress. The present study investigated the failure mechanism of candidate materials for different A-USC boilers under the synergy of corrosion and stress. The results show that the creep rupture life of Super 304H steel and a new Ni-Fe based superalloy decreases under the fireside corrosion. The internal sulfidation along grain boundaries of Ni-Fe based superalloy reduces the period of creep crack initiation, leading to the decrease in creep rupture life. The transition of corrosion pits to surface cracks in Super 304H contributes to its degradation of creep performance in fireside environment. In addition, the creep stress accelerates the formation of nodular corrosion products by breaking the surface oxide scale on Ni-Fe based superalloy. While the primary influence of creep stress on fireside corrosion of Super 304H is the widening of corrosion affected area. The interaction between creep stress and fireside corrosion amplifies their effects, leading to the deterioration in high-temperature performance of Ni-Fe based superalloy and Super 304H.