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Cyclic Stress and Masing Behaviour of Modified 9Cr-1Mo at RT and 300 °C

Authors : Preeti Verma, P. Chellapandi, N.C. Santhi Srinivas, Vakil Singh

Abstract : Modified 9Cr-1Mo steel is widely used for structural components like heat exchangers, pressure vessels and steam generator in the nuclear reactors. It is also found to be a candidate material for future metallic fuel sodium cooled fast breeder reactor because of its high thermal conductivity, lower thermal expansion coefficient, micro structural stability, high irradiation void swelling resistance and higher resistance to stress corrosion cracking in water-steam systems compared to austenitic stainless steels. The components of steam generators that operate at elevated temperatures are often subjected to repeated thermal stresses as a result of temperature gradients which occur on heating and cooling during start-ups and shutdowns or during variations in operating conditions of a reactor. These transient thermal stresses give rise to LCF damage. In the present investigation strain controlled low cycle fatigue tests were conducted at room temperature and 300 °C in normalized and tempered condition using total strain amplitudes in the range from ±0.25% to ±0.5% at strain rate of 10-2 s-1. Cyclic Stress response at high strain amplitudes (±0.31% to ±0.5%) showed initial softening followed by hardening upto a few cycles and subsequent softening till failure. The extent of softening increased with increase in strain amplitude and temperature. Depends on the strain amplitude of the test the stress strain hysteresis loops displayed Masing behaviour at higher strain amplitudes and non-Masing at lower strain amplitudes at both the temperatures. It is quite opposite to the usual Masing and Non-Masing behaviour reported earlier for different materials. Low cycle fatigue damage was evaluated in terms of plastic strain and plastic strain energy approach at room temperature and 300 °C. It was observed that the plastic strain energy approach was found to be more closely matches with the experimental fatigue lives particularly, at 300 °C where dynamic strain aging was observed.

Keywords : Modified 9Cr-mo steel, low cycle fatigue, Masing behavior, cyclic softening
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