Abstract

The primary aim of the thesis work is to study the response of different ferritic steels (2.25Cr-1Mo and 9Cr-1Mo and modified 9Cr-1Mo steels) to multiaxial state of stress on creep rupture behaviour. Multiaxial state of stress was incorporated by introducing circumferential U-notches with various notch root radius and creep tests were carried out at different stresses on the plain and notched specimens of the steels. The creep rupture life of the steels increased in presence of notch. The strengthening was found to increase with increase in notch sharpness and tend to saturate at higher notch sharpness. The extent of strengthening was comparable in 2.25Cr-1Mo and 9Cr-1Mo steels and was significantly higher for modified 9Cr-1Mo steel. Fractographic observations revealed plasticity induced intragranular ductile failure with dimple appearance for relatively shallow notches and creep cavitation induced intergranular brittle failure for relatively sharp notches. The creep damage was found to initiate at the centre of notch throat plane for shallow notches and at the notch root for sharper notches. Finite element (FE) analysis coupled with continuum damage mechanics (CDM) has been carried out incorporating material’s elasto-plastic-creep behaviour to understand the effect of notch sharpness on creep damage and rupture life. The observed fracture behaviour has been explained based on the distribution of different stress components across the notch throat plane. Higher notch strengthening in modified 9Cr-1Mo steel has been attributed to the higher reduction in von-Mises stress across the notch throat plane than those in other two steels. Higher principal stress along with higher von-Mises stress at notch root region for relatively sharper notches induced intergranular creep cavitation. The FE-CDM has clearly brought out the change in the fracture appearance depending on the notch sharpness as observed experimentally. The creep rupture life of the steels under multiaxial state of stress could be predicted based on the finite element analysis of creep deformation and damage evolution within a factor of 3.