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“Development of Creep Damage Assessment Method for Welded Joints of Boiler Pipes at Fossil Power Stations

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Abstract

Internal pressure creep tests were conducted on welded tubes of high chromium steels, which have been used for high temperature components at ultra-super critical (USC) fossil power stations. Cracks occurred at fine grained heat-affected zone (HAZ) for both materials, i.e., the type IV mode fracture. Regarding creep voids distribution along thickness direction of the internal pressure specimens, the creep voids were predominantly observed in the middle of the thickness at the HAZ region while they might be negligible on outer and inner surface of the specimen. Finite element (FE) analysis of the specimens, in which HAZ and weld metal properties as well as base metal's one are considered, revealed that the principal stress and stress triaxiality factor become to be the largest in the middle of the thickness at the HAZ region after stress redistribution under the internal pressure creep conditions. It was suggested that the stress state might be reason the creep voids mainly exist in the middle of the thickness. A creep life prediction model was proposed for the high chromium longitudinal welded joints on the basis of the FE results. Then, an internal pressure creep test on a longitudinal welded pipe of 9Cr steel has been carried out to observe failure behavior of actual large diameter pipes, and the validity of the damage assessment model was examined on the basis of the experiment. In order to obtain stress-strain state in welded portions of high chromium steels pipes at power stations with high accuracy, an FE program was specifically developed for the boiler pipes analysis. The program uses 3D meshes to calculate complicated system stress of the boiler pipes and can also have a function of creep analysis. The integrated creep damage assessment system for the welded portions of the high chromium steels was applied to the boiler pipes at USC power stations, and the assessment results was used as a part of component diagnosis.