Creep rupture tests of FeCrAl alloy for accident tolerant fuel cladding

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Events occurred in the Fukushima Daiichi nuclear power plant initiated the research and development of new nuclear fuels and cladding materials with enhanced accident tolerance compared to the current uranium dioxide and zirconium alloy system. The iron-chromium-aluminum (FeCrAl) alloy family is postulated as a light-water reactor cladding candidate because of its excellent high-temperature (1200°C) steam-oxidation resistance compared to zirconium alloys. However, the studies on the creep deformation behavior of FeCrAl base alloys are very limited especially at temperatures below 600 ^{0}C. In this study, the burst/creep tests of nuclear-grade Fe-12wt%Cr-6Al-0.05Y (C26M2) thin wall tubing were carried out at a wide range of hoop stresses (σ_θ) in the temperature range of 480-600 °C. Two different fracture modes have been observed: the tubing failed either by direct open-up or small crack and hole formation. The Larson-Miller parameter and the Monkman-Grant relationship were determined. A relationship between scatter in the Monkman-Grant relationship and fracture mode was noted. Further, the creep stress exponent was evaluated for the determination of the creep mechanism(s). In the temperature range of study, the values of stress exponents (n) and activation energy (Q_c for creep) were evaluated to be 5.1± 0.5 and 289 ± 25 kJ/mol respectively. The obtained results suggest dislocation climb as the main creep mechanism. Transition from power –law to the power-law breakdown was observed at very high stresses. Additionally, the results obtained at 600 °C in the stress range of 80-170 MPa suggest diffusional creep to be a dominant creep-rate controlling mechanism; this is the first time such diffusional creep was first reported in this alloy family.