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Project Report

On

"Effect of Composition, Sensitization and Product Form on Creep Deformation Behaviour of Ti Modified 15Cr-15Ni SS Type Fuel Cladding Material"

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Master of Technology

(Materials Engineering)

By

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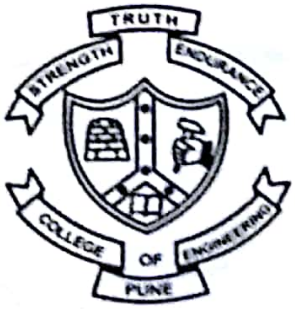

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ABSTRACT

Alloy D9 SS and D9I austenitic stainless steel in 20% cold worked condition has been chosen for the fuel clad tubes of current Prototype Fast Breeder Reactor (PFBR, which is at an advanced stage of construction at Kalpakkam) and future FBRs of India, respectively. The addition of titanium improves the high temperature mechanical properties due to the precipitation of particles, titanium carbide (TiC). Cold-working promotes the precipitation of carbides in stainless steel. The fine precipitates of titanium carbide resist void swelling and give good high temperature mechanical properties. During steady operating conditions of the reactor, the clad tubes would be subjected to a temperature profile that increases from 673 K at the lower ends of the fuel assembly to 973 K at the top end of the fuel assembly. Thermal creep resistance of the fuel cladding materials is therefore an important consideration in the design of fuel subassemblies.

In the present study, the effect of chemical composition (D9 and D9I SS), product form (clad tube and cylindrical rod) and sensitization (at 973 K/40 hours, on D9I) have been investigated on the creep deformation and damage behavior. The materials thus considered for the present study is either D9 or D9I SS. For all the investigations, uniaxial creep tests were conducted at 973 K at the stress of 175 MPa. The rupture lives in the current study were in the range 800–2500 h. Alloy D9I SS has shown higher rupture life and ductility, associated with a lower minimum creep rate in comparison to the Alloy D9. This is attributed to the compositional differences with respect to the alloying elements P and B, both of which improves strength and ductility respectively. This is also further complemented by the smaller grain size of alloy D9I. The sensitization of the D9I is observed to be detrimental, as it lead to both reduction in rupture life, high minimum creep rate and importantly an enhanced the tertiary creep rate. Creep testing of D9I either in the form of clad tube or in the form or rod did not alter the rupture life considerably, expect for the resulting creep ductility which is found to be much lower in the rod-type specimen.