



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Saptarshi Dutta
Roll Number : 156103010
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Name of Thesis Supervisor(s) : Prof. P.S. Robi
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SHORT ABSTRACT

Pressure tubes (PT) are a key component of Pressurized Heavy Water Reactors used in Nuclear Power Plants. They support the fuel bundles and offer structural stability. Zr-2.5Nb alloys are widely employed as PT materials because of their excellent corrosion resistance, low neutron absorption cross-section, and good mechanical properties. A thorough understanding and prediction of the creep life of PTs along both the longitudinal and transverse directions becomes imperative for the proper functioning of reactors. Hence, this work was carried out to investigate the microstructure, high-temperature tensile behaviour, and constant stress creep behaviour of Zr-2.5Nb alloys.

At all conditions of temperatures, the longitudinal samples displayed lower strength and higher ductility than the transverse ones. TEM studies on sample tensile tested at 800°C showed a network of Nb-enriched β -Zr phase around the α - phase, which led to grain boundary sliding. Zr-2.5Nb alloy exhibited superplasticity at elevated temperatures. Tensile properties obtained for both the specimen orientations were correlated with respect to temperature with high accuracy, having an R^2 value of 0.99. Creep behaviour of the PT material was investigated by carrying out accelerated creep tests in the temperature range of 600-850°C and in the stress range of 2-5MPa and 22-58MPa for the longitudinal and transverse samples, respectively. Analysis of minimum creep rate, strain to rupture, and rupture time by Monkman-Grant relation and modified Monkman-Grant relation indicate both methods are valid for the investigated alloy.

Artificial Neural Network (ANN) and Multiple Linear Regression (MLR) modeling were used to predict the creep curves of Zr-2.5Nb alloy. It was found that although MLR could effectively predict the primary creep region, it over-predicted the secondary creep region. However, the ANN model could accurately predict all three creep regions very distinctively. In this model, 98 % of the creep strains could be successfully predicted within a deviation error of $\pm 5\%$. Prediction of the creep life of Zr-2.5Nb alloy under various combinations of temperatures and stresses was carried out using Larson-Miller parametric technique. It was observed that the C_{L-M} value was stress-dependent. Creep life prediction was done by considering C_{L-M} as a constant as well as a stress-dependent function. The result obtained from the analysis indicated lower creep life by considering C_{L-M} as a function of stress rather than a constant, thus giving a more conservative prediction.