Effect Of Heat Treatment On Radiation Resistance Of 316 L(N) Steel

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316L(N) steel will be used in such ITER components as the divertor and the first wall, mainly as part of the Cu/SS bimetal composition. Hot isostatic pressing (HIP) is proposed to use for joining of copper alloy to steel. HIP treatment, when repeated many times at 900-1050 °C for 1 - 2 h, results in the grain growth in austenitic steels. Whereas the effect of neutron irradiation dose on the properties of 316 steel in the optimal condition (1050 °C, 1h) is relatively well studied, the dose dependencies for 316 L(N) after HIP are practically unknown.

This study presents the results of investigation of radiation resistance of solid HIPped 316 LN steel in comparison with 316L(N) steel in optimal condition.

Specimens of 316L(N) steel were irradiated at $T_{\text{irr}} = 80$ °C, 150 °C, 200 °C and 300 °C in the dose range of 0.001 - 1 dpa in the RBT - 6 and SM - 2 reactors.

Investigation of the stress-strain curves reveals that in all irradiation regimes the yield drop is missing. At the irradiation temperature of 150 °C the increase in yield strength at 1 dpa is about 240 MPa. At 300 °C this increase is about 220 MPa. The uniform elongation of the steel is reduced but in all regimes irradiation remains relatively high, i.e. $\delta > 32\%$. SEM and optical metallography demonstrate that even after irradiation to the maximum dose the fracture remains ductile.

Investigations into the strain rate effect on 316L(N) steel properties showed that at $T_{\text{test}} = 300$ °C at low rates about $10^{-5}$ s$^{-1}$ the plasticity of irradiated specimens diminishes ($\delta_{\text{total}} \sim 17\%$).

To assess the influence of overheating on properties of 316 L(N) HIP a number of specimens irradiated at 300 °C were annealed at 900 °C. Subsequent tests at 300 °C showed that annealing at 900 °C recovered the plasticity and yield strength of irradiated specimens practically to the initial values.

Dose dependencies of the mechanical properties were obtained and compared with those for the optimized state. HIPped steel after irradiation was shown to differ by somewhat less yield strength and uniform elongation. The conclusion was made that the HIP treatment, when repeated many times, does not reduce the radiation resistance of 316 L(N) steel.