The effect of mechanical-thermal treatments on the microstructure of niobium stabilised stainless steel after creep

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Abstract – The influence microstructural variables on the creep strength of niobium stabilised stainless steel DIN 1.4981, was studied. The effect of the solution treatment, predeformation, predeformation plus ageing and cycles of predeformation - ageing on the microstructure after creep at 990 K was analysed.

The influence of mechanical-thermal treatments and creep testing at 990 K on the microstructure of DIN Werkstoff Nr. 1.4981 stainless steel, a material meant for use as cladding of nuclear reactor fuel elements, was studied. The effect of the solution treatment, predeformation, predeformation plus aging and cycles of predeformation-aging, on the creep results obtained at 990 K, for applied stresses in the range of 70 MPa – 310 MPa, was undertaken. The results show: this material presents a creep strength superior to that show by AISI 316 stainless steel; the minimum creep rate, $\dot{\varepsilon}_{min}$, can be described by power law equation, $\dot{\varepsilon}_{min} = \sigma n$, where σ is the applied stress, A is a constant and n is the stress sensitivity coefficient – A and n; the mechanical – thermal treatments were seen to be ineffective on the improvement of the creep strength. Transmission electron microscopy was used to characterize the microstructure of this material after creep testing. The results show that the microstructure is dependent on the mechanical thermal treatment and on the creep test condition utilised, see Fig. 1. The presence of the following phases, NbC, Fe_2Nb, and sigma phase Fe-Cr, was detected. The dislocation substructure observed can be characterized by the presence of either a uniform array of dislocations, aligned dislocations, incipient cell structures (equiaxial and / or aligned) or slighted elongated subgrains, depending on the used conditions, see fig. 1. The mechanical and microstructural results obtained in this work, indicated that the precipitation of the strengthening phases, when occurring simultaneously to the creep deformation is much more effective in improving the creep strength.

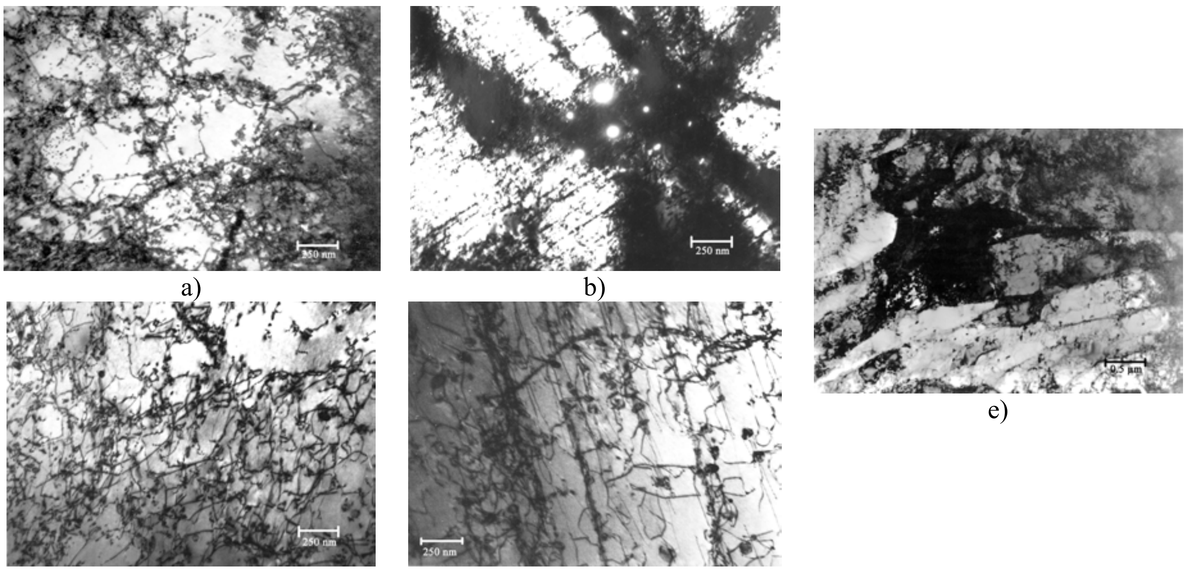

Fig. 1. TEM micrographs showing five developed substructures, observed during creep at 990 K. a) Incipient equiaxial cell array (solubilisation 1150 ˚C, 1 h; 10% axial cold deformation; aging at 1073 K, 800 ˚C, 24 h; σ = 269.5 MPa). b) Cellular arrangement, preferential alignment and electron diffraction pattern over, zone axis = [011] (solubilisation; 5% cold deformation; σ = 173.1 MPa). c) Uniform dislocation array (solubilised steel). d) Dislocation array with a tendency to rectilinear alignment (solubilisation, σ = 259.3 MPa). e) Elongated subgrains (solubilisation, σ = 259.3 MPa).

References

[1] Rossi, J.L. The effect of mechanical-thermal treatments on the creep behaviour of a niobium stabilised stainless steel. M.Sc. Dissertation, IPEN/USP, 1987. (In Portuguese).