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Tensile and Creep Anisotropy in ODS Steel Tubes for Nuclear Cladding Applications

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The development of advanced nuclear systems such as Gen. IV sodium cooled fast reactors relies upon the availability of reliable structural materials. In particular, oxide dispersion strengthened (ODS) steels are suitable candidates for fuel cladding applications due to low irradiation induced swelling and good creep strength and corrosion resistance [1][2]. Ferritic Fe-14Cr-1W-0.3Ti and martensitic Fe-9Cr-1W-0.3Ti ODS steel tubes are studied, obtained by means of hot extrusion and pilger cold rolling. Tensile and creep tests are performed on tile and ring specimens.

While higher chromium content benefits corrosion resistance, the α {001}<110> stable texture formed by cold rolling prevents proper recrystallization during heat treatments [1]. Thus the anisotropic microstructure created during the fabrication processes cannot be modified properly and the ferritic ODS steel tube exhibits anisotropic tensile properties, with higher yield strength in the extrusion direction in the range 400-750°C. While the ductility seems better at intermediate temperatures in this longitudinal direction, it falls at higher temperatures and becomes better in the transverse direction (Fig. 1a). Furthermore, another anisotropic behaviour can be seen with uniaxial creep tests, as shown in Fig. 1b. At a given stress the time to rupture (at 650°C) is much larger in the longitudinal direction than in the hoop one. These anisotropic features can be reduced on martensitic ODS steels with lower Cr content [3], though achieving an overall lower creep resistance along the extrusion direction but similar in the transverse/hoop direction (Fig. 1b).

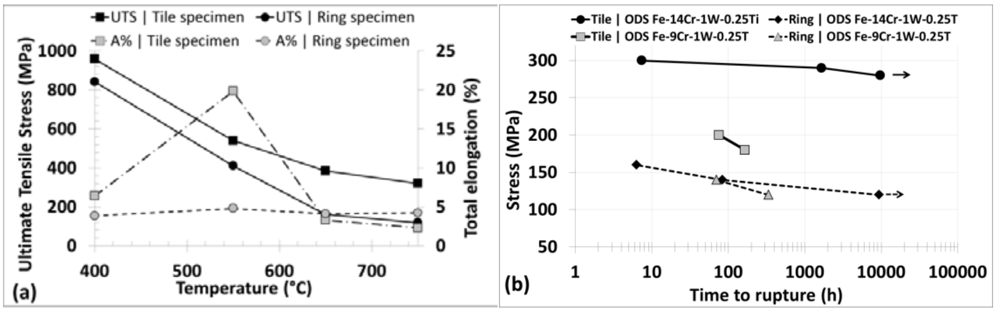

Figure 1. (a) Evolution with respect to the temperature of the ultimate tensile strength (UTS) and the total elongation for tensile tests performed at 1.10^{-5}s^{-1} on Fe-14Cr-1W-0.3Ti ODS steel tube. (b) Time to rupture/stress plot of uniaxial creep tests on ODS steel tubes. Arrows indicate ongoing tests

Examination of the fracture surfaces (tensile specimens) suggests damage is intra-granular at low temperatures (<550°C) and intergranular above. Fracture surfaces on creep specimens will be presented as well. Further work will be the development of a model describing the mechanical/damage behaviour of these ODS steel tubes.

[1] S. Ukai et al., *Structural Materials for Generation IV Nuclear Reactors*, pp. 357-414, (2017)
[2] A. Alamo et al., *Journal of Nuclear Materials* **329-333 A**, pp. 333-337, (2004)
[3] L. Toualbi et al., *Journal of Nuclear Materials* **442,** pp. 410-416, (2013)