EFFECT OF ANISOTROPY IN THE PLASTIC DEFORMATION OF TEXTURED ZIRCALOY

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SUMMARY

The influence of crystallographic anisotropy on the mechanical properties of Zircaloy-2 has been investigated at 25°C and 300-400°C. True stress-strain curves were determined in the two temperature regimes under a strain rate of .01 min^{-1}. Creep strains were measured at elevated temperatures for times up to 750 hours. In-reactor creep behavior of Zircaloy-2 was simulated by five MeV proton bombardment of foil specimens.

Two cold-rolled Zircaloy-2 plates, 0.5 inch thick with controlled crystallographic texture, were tested in this program. Plate K exhibited axisymmetric basal pole (0002) alignment normal to the rolling plane. Plate J had a (0002) texture similar to that of commercial cladding, that is with basal pole density maxima at $\pm 40°$ from the normal direction in the normal-transverse plane.

Uniaxial tension and compression tests were performed in the three principal directions of the two plates, in an argon atmosphere. The friction coefficients of the compression tests were measured and found not to contribute significantly to the results.

A marked yield strength-differential was observed in each of the three test directions of both plates. It ranged from 25MPa to 250MPa at 0.2% plastic offset, increased with plastic strain the normal and transverse directions and decreased in the rolling direction. The temperature dependence of the strength-differential is also being measured. Measurements of the ratio of transverse plastic strains and correlation of these strain ratios with the stress-strain data shows that the work hardening behavior can be related to the rate of change of the strain ratio. These observations can be explained on the basis of the relative importance of slip and twinning, the two principal modes of plastic deformation.

Creep tests were performed on the J plate at temperatures up to 400°C and stresses up to 175MPa in an argon atmosphere. Creep strains were measured in uniaxial tension and uniaxial compression in the three principal plate directions. Reduced strain rates in the dynamic strain-aging regime were found. Differential creep rate effects were also measured; the creep rate in compression was found to be half the creep rate in tension.

Radiation creep tests were performed with .003 inch thick Zircaloy foils in the 5 MeV proton beam of a Van de Graaf Accelerator. The simulated damage rates are equivalent to neutron fluxes in the range of 10^{14} to 10^{15} neutrons/cm^2 sec. Proton beam current, specimen temperature, and applied stress were carefully controlled. The first results indicate that strain rates can be resolved within 10 hours. Thermal creep strains may overshadow radiation-induced creep for applied stresses greater than half the yield stress.

In summary, the effect of crystallographic texture on the mechanical behavior of Zircaloy-2 has been characterized in tension and compression over a large range of plastic strains. The collected data can be used in defining realistic constitutive equations which should be used in predicting the behavior of Zircaloy cladding. Of prime importance is accounting for the temperature and plastic strain dependence of a strong strength-differential.