Anisotropic swelling observed during stress-free reirradiation of AISI 304 tubes previously irradiated under stress

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Structural steels anticipated for fusion applications will experience time-dependent changes in the radiation environment, i.e. stress level, stress state, irradiation temperature and dpa rate. There are insufficient data available to allow confident prediction of the effects of such environmental changes on subsequent behavior of swelling and irradiation creep. Data on the effect of changes in stress state or irradiation temperature are especially lacking.

In this paper are presented the results of a reirradiation experiment conducted in EBR-II. Cladding tubes constructed from 304L stainless steel were removed from irradiated metal-driver fuel elements. These tubes were stressed during irradiation by fission gas buildup and fuel clad mechanical interaction. After cutting and cleaning, the density and diameter changes of each section were measured to determine swelling and irradiation creep. The tubes sections were re-irradiated in the absence of stress to 10 dpa, followed by measurement of their density and changes in both diameter and length.

Also irradiated beside the previously stressed specimens were adjacent tube sections of 304L that encapsulated the fuel pins during the original irradiation. The cladding/capsule pairs experienced the same flux-spectral exposures, but the capsules were stressfree and operating at \(\sim 50^\circ\text{C}\) lower temperatures. Tube pairs were irradiated at either the original irradiation temperature or at significantly different temperatures.

The first major conclusion is that once significant swelling was reached in the initial irradiation, the swelling continued thereafter without changing in response to temperature or stress changes, approaching or reaching \(\sim 1\%/\text{dpa}\). The second major conclusion is that the previously-stressed material retained a memory of its earlier stress state, swelling in absence of stress with an anisotropic distribution of strains. The swelling of the previously unstressed material, however, proceeded with an isotropic distribution of strains. The implications of these finding will be discussed for both fusion and fission reactors.