ON THE VARIABILITY OF CLADDING DEFORMATION OF LMFBR FUEL ELEMENTS

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SUMMARY

Radiation-induced swelling and creep of austenitic stainless steel cladding causes a maximum increase in diameter near the core midplane of LMFBR fuel elements. The observed deformation rates exhibit large heat to heat variations within certain specified materials, and often a second maximum in the diameter increase occurs.

The failure of empirical correlations to properly account for these phenomena is a serious problem in fuel element modeling. The present paper is an attempt to solve this problem by beginning to quantitatively consider the role of first order metallurgical changes in irradiation induced cladding deformation. This is based on the realization that the stainless steels commonly used for LMFBR fuel element cladding are unstable alloys that undergo phase changes in-reactor. The precise extent and nature of these phase changes is extremely complex in that they are governed by small variations in alloy composition and fabrication procedure as well as operational variables such as temperature and irradiation environment. In this analysis it is assumed the most important phase change affecting the cladding deformation rates is carbide precipitation.

A model is proposed to explain when changes in deformation rate occur by including the effects of thermally activated carbide precipitation in present equations for irradiation swelling and creep. Swelling in austenitic steels has been shown to diminish with increase in the amount of, specifically, carbon in solid solution; we postulate that removal of carbon from solid solution by precipitation will have the reverse effect. Experimental observations support this view. For example, heat treatment that causes substantial precipitation before irradiation gives rise to greatly enhanced swelling and creep of cladding in-reactor. Similarly the second diameter peak in irradiated claddings is observed to coincide with the location of marked carbide precipitation. Irradiation results from fuel elements irradiated in Rapsodie and EBR-II are shown to be consistent with the proposed model.