FORECASTS OF VOID SWELLING, IRRADIATION CREEP AND TENSILE PROPERTIES OF FERRITIC-MARTENSITIC STEELS ENVISIONED FOR SERVICE IN ACCELERATOR-DRIVEN DEVICES *

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Abstract

The ferritic/martensitic class of steels is currently a candidate for service in accelerator-driven transmutation devices. Data derived on ferritic-martensitic steels in both U.S. and Russian fast reactors serve to enhance our understanding of the potential radiation response of this class of steels in spallation devices. Such data are especially valuable following irradiation in Russian reactors at temperatures below typical inlet temperatures characteristic of Western fast reactors.

HT-9 and Modified 9Cr-1Mo ferritic/martensitic (F/M) steels have been irradiated in U.S. fast reactors to exposures as large as 208 dpa. In addition EP-450 and EP-823 were developed in Russia with the first steel having been used extensively for hexagonal wrappers in various sodium-cooled fast reactors. The second Russian steel contains a relatively high silicon level and was developed for corrosion compatibility with Pb-Bi eutectic coolant. In addition to irradiation of EP-450 in BOR-60, exposures as high as 90 dpa have recently been reached on these two Russian steels in a series of irradiations conducted in the BN-350 fast reactor. Additional data at lower dose levels are available from other fast reactors.

Comparisons are made between the radiation-induced behavior of the Russian steels and those of Western production. The void swelling phenomenon appears to be confined to the lower temperature range (<450°C) at the dose levels attained in the various fast reactor experiments. Conclusions are drawn concerning the response characteristics common to all F/M steels for spallation applications. The impact of differences in radiation spectra on the application of these reactor-derived data to accelerator-driven spallation devices is also discussed.

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Foremost of these spectral differences will be the gas production (He, H) levels. These production rates are very low in iron-base alloys irradiated in fast reactors, but are very large in accelerator-driven devices. Structural components exposed to high-energy protons will generate ~160 appm/dpa of helium and much higher rates of hydrogen. There is a concern that the onset of void swelling will be accelerated in these steels in accelerator-driven devices and that swelling will also spread to higher temperatures than observed in fast reactors. The internal generation of such large hydrogen levels may also attack the protective oxide from the inside.