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STUDY OF MECHANICAL PROPERTIES AND FRACTURE FEATURES OF FERRITE-MARTENSITIC STEEL EP-450 IRRADIATED BY NEUTRONS IN THE BN-350 REACTOR

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Fast reactor cores require steels and alloys resistant to high-energy neutron fluxes and capable of maintaining sufficient medium-temperature (300-500℃) strength. EP-450 (1Cr13Mo2NbVB) ferritic-martensitic steel, containing 11-13.5% chromium, is used as an acceptable material for cladding and covers of fuel assemblies (FA) of sodium cooled fast reactors. Its competitive advantage is the high resistance to swelling, especially at elevated core temperatures. One of the problems of ferrite-martensitic steels is that with increasing dose of neutron irradiation the brittle-ductile transition temperature increases, which leads to a sharp decrease in ductility at relatively low temperatures typical of operation.

In this work, samples of EP-450 steel were cut from hexagonal wrappers of fuel assemblies from the BN-350 sodium-cooled reactor located in Aktau, Kazakhstan, in both the unirradiated and neutron-irradiated states to 50.4 dpa. Heat treatment was carried out before irradiation at 1050℃ for 30 minutes followed by tempering at 720℃ for 1 hour. Uniaxial tensile tests 10×3.5×0.3 mm in size were then carried out at room temperature. Microstructure was investigated using a Hitachi TM-4000 PLUS electron scanning microscope and a JEOL JEM-2100 transmission electron microscope. Vickers microhardness was determined using an eVick-1A microhardness tester.

It was revealed that irradiation of EP-450 steel with fast neutrons leads to a decrease in ductility and increase in strength of the material as expected, though the object of our study was the mechanism. Uniform deformation following irradiation to 50.4 dpa decreases catastrophically to 1-2% due to the effect of low-temperature radiation embrittlement. Deformation was limited to a few ferrite grains favorably oriented to the loading axis. The fracture in the unirradiated steel is ductile, while that of the irradiated steel is brittle-ductile or brittle depending on the irradiation temperature. This paper discusses the influence of irradiation parameters on the strength, ductility and fracture of EP-450 steel.

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