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Experience and results of material science research conducted on spent fuel assemblies from the BN-350 fast reactor

O. Maksimkin, M. Gusev, L.G. Turubarova, K.V. Tsai and A.V. Yarovchuk
Institute of Nuclear Physics, Almaty, Kazakhstan
maksimkin@inp.kz

The BN-350 fast reactor was commissioned in 1973, ran successfully for many years and is now in the decommission stage. Its unique operational parameters (low temperature of sodium at the input, wide range of damage rates, etc.) allowed the investigation of a number of new radiation effects on both austenitic and ferritic-martensitic steels. The latter class of steel was extensively employed as wrappers for fuel assemblies. Much of the accumulated experience in BN-350 is relevant to development of fusion devices.

Results are presented on post-operational research of steels 12Cr18Ni10Ti, 08Cr16Ni11Mo3, and 12Cr13Mo2BFR, all serving as hexagonal shrouds of fuel assemblies. Structural materials in the active core zone operated at temperatures of 280-430°C, and were irradiated the range of 0.25-83 dpa with damage rates of 10^{-9} - 10^{-6} dpa/s).

Investigations of irradiated hexagonal shroud materials were performed with using traditional techniques of transmission and scanning electron microscopy, metallography, mechanical tests, hydrostatic weighing, magnitometry, etc. Additionally, new techniques have been developed and employed with great success on these highly irradiated materials, such as optical computer extensometry, and magnetization cartography.

Typical results to be covered in this presentation are:

a) In 12Cr18Ni10Ti steel irradiated at a low dose rate of 0.12x10^{-8} dpa/s voids were found at 281°C after only 0.65 dpa, demonstrating once again the acceleration of swelling at low dpa rates observed in other steels.
b) Data on helium release during annealing of highly irradiated sample are presented.
c) Differences in deformation-induced hardening between the shroud’s corners and faces leads to post-irradiation differences in swelling and mechanical properties.
d) During room temperature mechanical tests of 12Cr18Ni10Ti steel at ~56dpa at 350°C it was found that ductility lost at lower doses recovers, yielding an abnormally high plasticity (>20 %) that is a consequence of martensite instability.
e) Ferritic-martensitic 12Cr13Mo2BFR steel experienced significant phase recrystallization after irradiation to 83 dpa, leading to changes in shares of ferrite and sorbite components during irradiation.
f) Peculiarities of corrosion damage in irradiated stainless steels after longtime (~2-25 years) storage in water pool were also investigated.

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