ICFRM2007/285
In-Pile Creep Rupture Properties of ODS Ferritic Steel Claddings


aFusion Research and Development Directorate, Japan Atomic Energy Agency, 4002, Narita-cho, Oarai-machi, Higashiibaraki-gun, 311-1393 Ibaraki-ken, Japan
bAdvanced Nuclear System R&D Directorate, Japan Atomic Energy Agency, 4002, Narita, Oarai, 311-1393 Ibaraki, Japan
cGraduate School of Engineering: Hokkaido, Hokkaido university, N-13 W-8, 060-8628 Sapporo, Japan
dJapan Aerospace Exploration Agency, Mitaka, Tokyo, Japan
eJapan Atomic Energy Agency, 801-1 Mukoyama, Naka, 311-0193 Ibaragi, Japan
kaito.takeji@jaea.go.jp

Oxide Dispersion Strengthened (ODS) ferritic steels are the most prospective material for both advanced sodium cooled fast breeder reactor (SFR) fuels and fusion reactor components. In the SFR core, superior radiation resistance and high temperature capability are essential for fuel pin cladding tubes which will be exposed to high neutron doses up to 250 dpa relevant to peak burnup of 250 GWd/t in high temperature flowing sodium ranging from 673 K to 973 K. Japan Atomic Energy Agency (JAEA) has been developing two types of ODS steels, which are 9Cr-ODS steel (9Cr-0.13C-2W-0.2Ti-0.35Y2O3) and 12Cr-ODS steel (12Cr-0.05C-2W-0.3Ti-0.25Y2O3). For the cladding tubes, internal creep rupture strength is one of the most important properties; for example, internal pressure gradually increases with burnup and finally reaches at 120 MPa in the highest burnup fuel pins. In order to examine irradiation effect on creep rupture strength of the ODS steels, an in-pile internal creep rupture test has been conducted in the experimental fast reactor JOYO using Material Testing Rig with Temperature Control (MARICO).

Twenty-four pressurized tube specimens made from both 9Cr- and 12Cr-ODS steels have been irradiated at temperatures of 943 K, 973 K and 1023 K up to 20 dpa. Hoop stress for each specimen was varied with filling helium gas volume to attain predetermined pressure ranging from 45 MPa to 155 MPa at desired test temperature. Small amount of xenon and krypton mixed gas with unique isotopic composition was also filled into each specimen and released into cover gas systems after creep rupture in order to identify its creep rupture time by analyzing gas species by means of Laser Resonance Ionization Mass Spectrometry (RIMS).

In MARICÔ test, 14 creep ruptures have been detected by the end of February 2007. Up to now, no irradiation effect on creep rupture strength of the ODS steels has been distinguished. This indicates that nanometer size oxide particles distributed in the matrices effectively stabilize microstructures and result in excellent radiation resistance. After the irradiation, visual inspection and diameter measurement for all specimens will be conducted to confirm creep ruptures and TEM observations will reveal microstructure stability.