Environmental effects for irradiation creep behavior of highly purified V-4Cr-4Ti alloys, NIFS-Heats irradiated by neutrons


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Vanadium alloys are candidate materials for fusion reactor blanket structural materials because of their potentially high operation temperatures. However the knowledge about the mechanical property of vanadium alloys during neutron irradiation at high temperatures is limited. Recently, material irradiation technology in liquid metal environment has been developed and irradiation creep experiments in nuclear pile were carried out for vanadium alloys. Environmental effect and irradiation effect for creep deformation in irradiation creep experiment under neutron irradiation should be distinguished independently in order to understand the essential irradiation creep process in pile.

The objective of this study is to investigate the environmental effect of irradiation creep properties of the high-purified V-4Cr-4Ti alloys, NIFS-HEAT2 irradiated by neutrons. In order to examine the irradiation creep tests in pile, Na-enclosed irradiation rig in Joyo and Li-enclosed irradiation rig in HFIR-17J were used for pressurized creep tubes (PCTs) of NIFSHHeats alloys with suppressing the impurity contents during manufacturing process.

In HFIR-17J irradiation experiments, irradiation creep experiments were performed with PCTs in the 425 and 600°C lithium-containing capsules irradiated to 3.7 dpa. It was found that the creep strain rate exhibited a linear relationship with the effective stress up to 150 MPa at 425°C. At 600°C the data were scattered but the creep strain was much larger than that at 425°C.

In Joyo irradiation experiments, irradiation creep experiments were performed with PCTs in the 458 and 598°C sodium-containing capsules irradiated to 2-5 dpa. At both 458 and 598°C, the creep strain rate exhibit a linear relationship with the effective stress up to 200MPa. From Joyo creep experiments, the activation energy of irradiation creep was estimated to be 46kJ/mol·K.

The topical difference for irradiation creep behavior between liquid sodium and liquid lithium environment could not be seen. From previous work of ATR-A1, it was suggested that the irradiation creep strain rate is much larger even at low temperature. In this study, it was confirmed that the temperature dependence of irradiation creep was stronger than the data of ATR-A1 that revealed the less temperature dependence. The evidence of the reliability of this work will be reported in the conference.