§6. Thermal Creep Mechanism of NIFS-Heat2 Alloys by Using Pressurized Creep Tubes

Fukumoto, K. (Univ. Fukui.),
Matsui, H., Narui, M. (IMR/Tohoku Univ.),
Nagasaka, T., Muroga, T.

Vanadium alloys are candidate materials for fusion reactor blanket structural materials because of their potentially high operation temperatures. However the knowledge about mechanical properties of vanadium alloys at high temperatures is limited and there are uncertainties that may have influenced the results such as the interstitial impurity content of specimens. The National Institute for Fusion Science (NIFS), in collaboration with Japanese industry has initiated a program to fabricate a large ingot of highly purified V-4Cr-4Ti alloys [1]. A medium size (~160kg) ingot of V-4Cr-4Ti was fabricated by EB and VAR methods, which was designated as NIFS-Heat2. The impurity level for fabricating large V-Cr-Ti ingots was achieved as ~80wppm C, ~100ppm O. ~120wppm N and 1wppm or less of metallic elements. The objective of this study is to investigate the creep properties and microstructural changes of the high-purified V-4Cr-4Ti alloys, NIFS-HEAT2 by using pressurized creep tubes (PCTs), in order to prepare for in-pile creep tests.

The V-4Cr-4Ti alloy used in this study was produced by NIFS and Taiyo Koko Co. and designated as the NIFS-HEAT2 [1]. Tube processing of NIFS-Heat2 alloys was successfully done by NIFS and Daido Co. and the tube fabrication was done by JAEA and IMR/Tohoku Univ. The final heat treatment of PCTs was done at 1000°C for 2 hrs in vacuum of <1×10^{-4} Pa. The detailed tubing process and fabrication process of pressurized creep tubes have been reported in the ref [2]. The PCTs wrapped with Ta and Zr foils were enclosed in a quartz tube in vacuum. Thermal creep tests were done in Univ. of Fukui using the sealed quartz tubes in Muffle furnace at 600, 700, 750, 800 and 850°C. Dimensional changes of PCTs were measured with a precision laser profilometer at five axial and 18 azimuthal locations to an accuracy of 1μm for the outer diameter measurement.

The incursion of impurities in PCTs was not accepted by a result of analysis of chemical composition before and after creep tests. The result of chemical analysis is shown in table 1.

Table1. Chemical analysis before and after creep test.

Condition	Oxygen conc. (wppm)	Nitrogen conc. (wppm)
Pre-creep test	370	80
850°C, 150MPa 50hrs	330	110
750°C, 150MPa 660hrs (Ex.3times)	270	110

From the results of dimensional changes, the activation energy of creep deformation in the NIFS-Heat2 alloys was about 210kJ/mol. This amount of creep activation energy of PCTs is very similar to that of uniaxial creep specimens of NIFS-Heat1 alloys in the previous study [3]. The absolute value of creep strain rate of PCTs is several times larger than that of uniaxial specimens. On the powerlaw dependence of secondary creep rate on stress, $d\varepsilon/dt = A\sigma^n$, where ε is creep strain, A is constant and σ is creep effective stress, n=4.9 in this study is good agreement with the value of creep stress exponent of n=~4 in a review of thermal creep for V-4Cr-4Ti by Kurtz [3]. This result also suggests that creep mechanism appears to be climb-assisted dislocation motion and the idea is supported by the result of microstructural analysis. From the results of this study, the database of thermal creep behavior is established as the reference for irradiation creep behavior that will be obtained in the future plan.

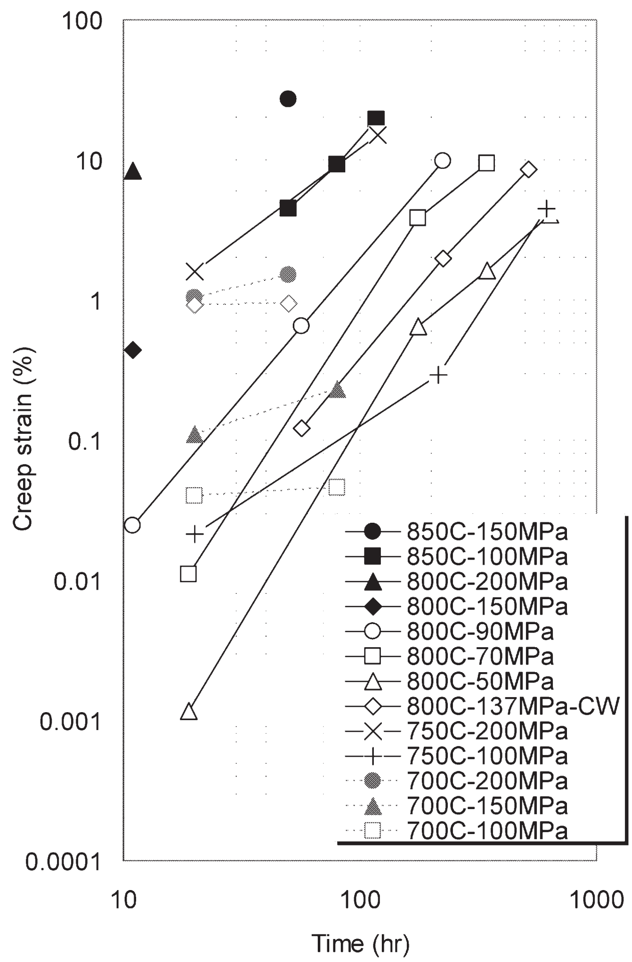

Fig. 1. Time dependence of creep strain rate in temperature from 700°C to 800°C examined by using PCTs

Reference
1) Muroga,T., et al., J. Nucl. Mater. 283-287 (2000) 711
2) Fukumoto, K., et al., J. Nucl. Mater. 335 (2004) 103
3) Kurtz, R. J.., et al., J. Nucl. Mater. 283-287 (2000) 628