19PB-116 High-temperature strength of high-purity low-activation vanadium alloy NIFS-HEAT-2

高純度低放射化バナジウム合金NIFS-HEAT-2の高温強度

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Purification for a low-activation vanadium alloy NIFS-HEAT-2 lead to improvement of workability and weldability of low-acrivation vanadium alloy. However, it is concerned that high-temperature strength is degraded due to loss of solution hardening and precipitation hardening by the impurities. In the present study, creep property of NIFS-HEAT-2 are compared with that of a conventional vanadium alloy with more impurities. It is indicated that creep rate at high stress level around yield point is enhanced, while no evidence for degradation of creep properties was observed at lower stress level.

1. Introduction

Vanadium alloys are known as sensitive material to concentration of interstitial impurities, such as carbon, nitrogen and oxygen. High-purity V-4Cr-4Ti alloys designated as NFS-HEAT has been developed and exhibited superior workability and low-temperature ductility of weld joint as a result of oxygen impurity reduction [1]. On the other hand, it has been reported that impurity reduction could degrade their creep strength at elevated temperatures [2]. The purpose of the present study is to evaluate the high-temperature strength of NIFS-HEAT by creep tests, to reveal the effect of the purification, and to estimate the limit for operation temperature of vanadium alloy blanket.

2. Experimental procedure

The material used was a 0.25 mm-thick sheet of NIFS-HEAT-2 (NH2). The chemical composition of NH2 is given in Table 1. Table 1 lists also the composition of another vanadium alloy US832665 for comparison. The concentration of oxygen in NH2 is half the one in US832665. SSJ type tensile specimens with a gauge size of 5 x 1.2 x 0.25 mm were punched out from the sheet, followed by annealing at 1000°C for 2 h. The grain size after the annealing was 18 mm. Creep tests were conducted up to 1073 K in a vacuum better than 1 x 10^{-4} Pa. In order to reduce contamination with residue gas in the vacuum, zirconium getter foil surrounded the specimen and specimen holders.

3. Results and discussion

Creep rupture time for NH2 under 100, 150 and 200 MPa at 1073 K was 538, 46.4 and 6.8 hr, respectively. Total elongation was 39, 19 and 26 %, respectively. Minimum creep rate was 5.4 x 10^{-5}, 4.3 x 10^{-4} h^{-1} and 1.1 x 10^{-2} h^{-1}, respectively. Fig. 1 plots the creep rate for NH2 compared with the ones for US832665 [3]. Higher creep rate means more creep deformation thus lower creep strength of the materials. The creep rate for NH2 and US832665 could be connected with the same trend line (solid line) in the stress range from 100 MPa to 180 MPa, therefore no degradation of creep strength is expected in these conditions. The creep rate at 200 MPa for NH2 seemed higher than the extrapolation of the line. The yield stress for NH2 at 800°C is 195 MPa. Since the applied stress 200 MPa in creep test was comparable to the yield stress, deformation due to dislocation gliding could enhance creep deformation.

The design stress for blanket is expected to be around 100 MPa, therefore the above-mentioned enhancement of the creep rate at 200 MPa is likely not a problem. Creep data for lower temperature will be reported in the presentation for discussion on the operation temperature limit for vanadium alloy blanket. Creep mechanisms and effect of purification will be discussed based on analyses on creep mechanisms.

4. Summary

No degradation of creep properties was observed for the high-purity low-activation vanadium alloy NIFS-HEAT-2 under the stress of 100 MPa and 150

MPa at 800°C, compared with a conventional vanadium alloy with more oxygen impurity. The evaluation of creep properties at lower temperature is ongoing.

Table I. Chemical composition of V-4Cr-4Ti alloys NIFS-HEAT-2 (NH2) and US832665 (US).

	Cr	Ti	C	N	O
NH2	4.02	3.98	0.0069	0.0122	0.0148
US	3.25	4.05	0.0037	0.0130	0.0357

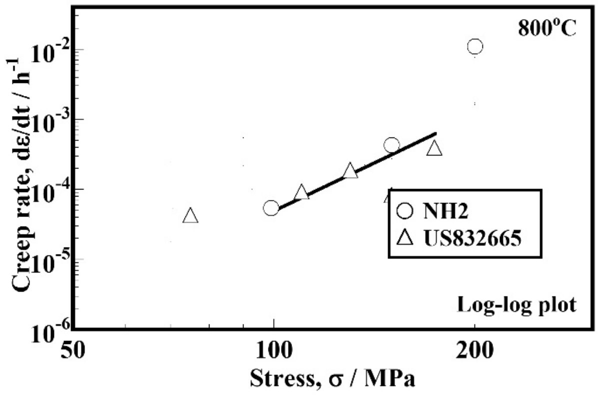

Fig.1. Creep rate for the vanadium alloys at 800°C.

Acknowledgments

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References

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