§18. Evaluation of Mechanical Properties and Aging of High-chromium and Yttrium-added Vanadium Alloys

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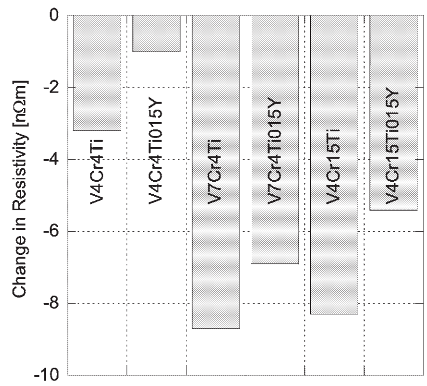
It has been demonstrated that controlling of interstitial impurity levels by means of modification of melting process or addition of scavenging elements like yttrium improved the material performance through evaluation of baseline properties and irradiation behaviors for V-4Cr-4Ti alloy(as known as NIFS-heats). Further improvement in strength of the alloy at high temperature is one of the issues for applications of fusion reactor blanket. Solid-solution-hardening by chromium addition controlling interstitial impurity level low and thermo-mechanical treatment including thermal aging are adopted to improve the high-temperature strength. In this study, mechanical properties of high-Cr vanadium alloys with yttrium addition were examined to understand and to deepen knowledge of improvement of the material performance.

It has been shown that small additions of yttrium improve mechanical properties after neutron irradiation by means of its scavenging effects. To reduce interstitial impurity level, however, may decrease the strength of the alloys. At temperature ranging from 650 to 700°C, tensile strength of the vanadium alloys showed relatively large temperature dependence, so that it may be better to reduce temperature dependence from engineering points of view. It had been determined suitable chromium contents of V-Cr-Ti type alloy from its impact property and workability. In this study, thermal aging conditions of V-Cr-Ti-Y type alloys and effects of alloying elements, such as chromium, titanium, and yttrium, were discussed in terms of high-temperature performance as a structure material of fusion reactor blanket.

Tensile tests, micro-hardness tests and electrical resistivity measurements were carried out for V-7Cr-4Ti-Y type alloys and V-4Cr-15Ti-Y type alloys which were annealed for 2 hours or 10 hours at 600°C after cold rolling. As shown in figure 1, electrical resistivity measured at room temperature by four-probe method decreases for all of the alloys about 5 to 8 nΩm. The decrease of the resistivity supposed to be corresponding to decreasing interstitial impurities like oxygen in solution due to formation of precipitation. In the case of tensile properties, decrease in yield stress and recovery of elongation are observed clearly in the specimens annealed for 10 h compared to for 2 h. For comparison, the results for V-4Cr-4Ti-Y type alloy after aging followed by re-crystallized heat treatment are shown in the fig.1. Smaller changes in resistivity are observed for the alloy with small addition of yttrium.

The results of the V-Cr-Ti-Y type alloys with small addition of yttrium indicated that to maintain the microstructures or mechanical properties of the alloys after thermal aging, addition of yttrium was effective so far. Further mechanistic study will be continued to reveal mechanical properties of the alloys together with a series of microstructure examination. Development of practically tough materials, that is, easy to use for engineering applications, of vanadium alloys which have chemically stable, that is, proof-oxidation and proof-corrosion in liquid metal coolant are going to be continued.



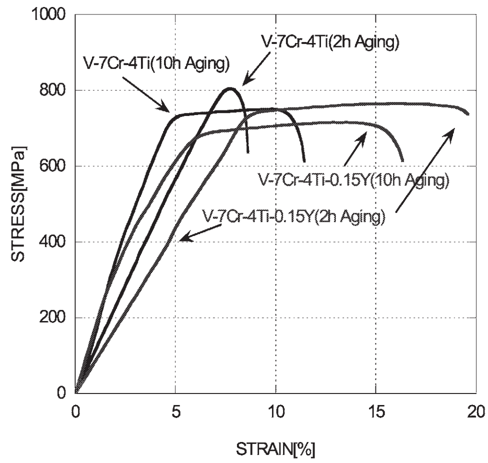


Fig. 1 Tensile behaviors and electrical resistivity of V-Cr-Ti-Y type alloys after thermal aging at 600°C for 10 hours.