§12. Changes of Deformation Mechanism in V-Cr-Ti Alloys by Ti(OCN) Precipitation during Aging Process

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A vanadium alloy is expected as an advanced nuclear fusion reactor material because of the superior characteristics such as high temperature performance and high radiation-resistance. But susceptibility of vanadium base alloys to low temperature embrittlement during neutron irradiation may limit the application of these alloys in low temperature (~<400°C) regimes. It may be attributed to fine precipitates containing C, O and N. The reduction of these elements is expected to improve the radiation resistance of the alloys at low temperature. However, it is still unclear how the formation of Ti(OCN) precipitates proceed during aging process and the mechanical property changes due to the variation of impurity component inside the precipitate.

In this study, tensile tests and TEM observation were examined for V-4Cr-xTi alloys with aging heat treatment. The purpose of this study is to make clear the thermal process of Ti(OCN) precipitation during aging process.

The SSJ tensile specimens of V-4Cr-xTi(x=0.1, 0.3, 1) were used. The impurity levels are 500-600 wppm for O and <20 wppm for N and C. The annealing conditions are 1000°C for 2 hrs. The specimens wrapped with Ta and Zr foils were enclosed in a quartz tube in vacuum. The examinations of thermal aging treatment were performed in Univ. of Fukui using the sealed quartz tubes in Muffle furnace at 600 and 800 ˚C for 100 and 1000 hours. After the heat treatment, tensile tests were performed at a strain rate of $6.67x10^{-4}$/s at room temperature and 500 ˚C in a vacuum. TEM samples were punched from non-deformed areas of tested specimens. The microstructural observations used a JEM-2000FX operating at 200kV.

Stress-strain curves of V-4Cr-xTi alloys aged at 600 ˚C shows hardening behaviors compared with those of original specimens, however the deformation behaviors of V-4Cr-xTi alloys aged at 800 ˚C showed softening ones. Serrations on the flow stress in the stress strain curves were observed in the original specimens at 500 ˚C test. but no serration behavior could be seen in the 600 ˚C aging specimens at 500 ˚C test and small serration behavior could be seen in the 800 ˚C aging specimens at 500 ˚C test. Fig.1 shows the aging time dependence of the serration amplitude in V-4Cr-1Ti alloys. At 100 hours in aging, the serration amplitude behavior almost did not changed. Generally there is a proportional relationship between the serration amplitude height and interstitial impurity concentration, which affect the dislocation motion. Fig. 3 shows the TEM microstructures of V-4Cr-1Ti alloys after heat treatment. From TEM observations, it is assumed that the large Ti(OCN) precipitate were formed in the original specimens and the interstitial impurity also co exist with precipitates in the matrix. On the other hand, it is suggested that most of interstitial impurities such as oxygen or the carbon in the 600 ˚C aging specimens were newly aggregated into the tiny precipitates. In the 800 ˚C aged specimens, the interstitial impurities may contribute to coarsen the large precipitates that existed as original specimens and grew up with absorbing the interstitial impurities during aging process.

From the combination of TEM observation with tensile test at 500 ˚C for V-Cr-Ti alloys, the behavior of interstitial impurities during thermal aging process can be well-understood qualitatively and it can be able to evaluate the interstitial concentration of residual impurity in the matrix as a solute. In future, these similar method will be adopted to NIFS-Heat alloys in order to make clear the precipitation behavior at high temperature relative to fusion reactor operation.

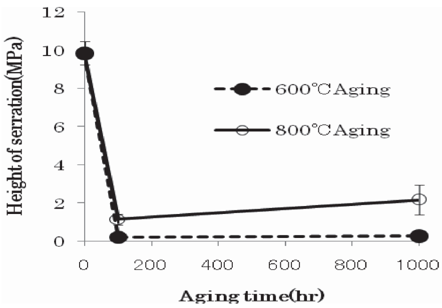

Fig.1. Aging time dependence of the serration amplitude width of V-4Cr-1Ti

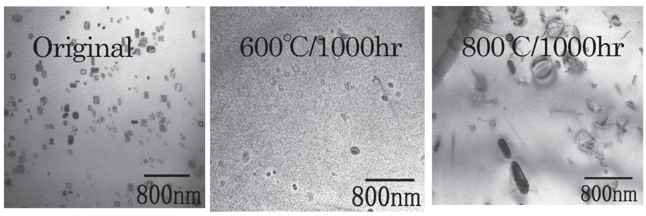

Fig.2. TEM photos of V-4Cr-1Ti after heat treatment