

CREEP PROPERTIES OF V-4Cr-4Ti STRENGTHENED BY COLD WORKING AND AGING

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Vanadium alloys are attractive candidate materials for application in the first-wall and self-cooled liquid blanket of fusion reactors. V-4Cr-4Ti is the current reference composition. Though a lot of progresses have been made for this kind of vanadium alloy, the high temperature strength should be enhanced further to raise the operation temperature and thermal efficiency of the reactor. This study focused on some thermo-mechanical treatments for strengthening V-4Cr-4Ti alloys, such as NIFS-HEAT-2 and SWIP-11.

The main difference between the two alloys is oxygen concentration. It is 570wppm for SWIP-11, while 148wppm for NIFS-HEAT-2. The thermo-mechanical treatment conditions were:

- STD: standard heat treatment as 1000°C/2hrs for vanadium alloys;
 - SAA: solid solution annealing at 1100°C/1 hr + aging at 600°C/20hrs;
 - SAACW: solid solution annealing at 1100°C/1hr +aging at 600°C/20hrs+20% cold working;
 - SACWA: solid solution annealing at 1100°C/1hr+20% cold working +aging at 600°C/20hrs.
- Then, hardness tests were performed at room temperature. Uniaxial creep tests were carried out at 700°C and 750°C. Microstructural observations were conducted by a transmission electron microscope (TEM).

The 20% cold working hardened the alloys. The cold-worked alloy was hardened further by the following aging. Aging time to reach the maximum hardness for the cold-worked alloy was longer than that without cold working. The reason of longer aging time may be the lower trapping rate of C, O, and N by Ti under high density dislocations introduced by cold working. Creep strength was defined as an applied stress for a lifetime to 1% deformation in the present study. The relationship between the applied stress and lifetime was plotted as Figure 1. The results showed that the creep strength of NIFS-HEAT-2 in SACWA state was higher than that in STD and SAACW states at higher stress levels than 180MPa. TEM observation showed high density dislocations in SACWA specimens. Because high density precipitates were observed in SAA state, similar precipitates were expected to form with the dislocations in SACWA specimens. This could be the main reason of the further strengthening in SACWA state. SACWA strengthened SWIP-11 more than NIFS-HEAT-2. This might be due to more Ti-CON precipitates by mainly the higher oxygen concentration in SWIP-11.

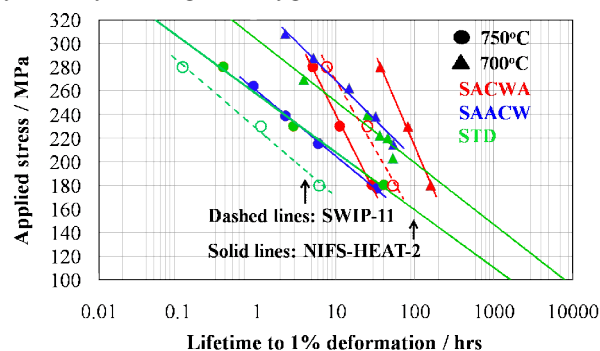


Figure 1: Relationship between applied stress and lifetime to 1% deformation.