PERFORMANCE OF V-Cr-Ti ALLOYS IN A HYDROGEN ENVIRONMENT*

K. Natesan and W. K. Soppet (Argonne National Laboratory)

OBJECTIVE

The objectives of this task are to (a) determine the hydrogen uptake of several heats of V-Cr-Ti alloys as a function of temperature and partial pressure of hydrogen (pH_2) in the exposure environment, (b) examine the microstructural characteristics of surfaces and cross sections of the alloys after exposure, (c) evaluate the influence of hydrogen uptake in low-pH_2 environments on the tensile properties and cracking propensity of the alloys at room and elevated temperatures, and (d) determine the effects of oxygen/hydrogen interactions on the tensile properties of the alloys.

EXTENDED ABSTRACT

A paper on this subject was presented at the 9th International Conference on Fusion Reactor Materials in Colorado Springs, Oct. 10-15, 1999. An extended abstract of that paper is given below.

A systematic study is being conducted to evaluate the performance of several V-Cr-Ti alloys after exposure to environments containing hydrogen at various partial pressures. The goal is to correlate the chemistry of the exposure environment with hydrogen uptake by the samples and the resulting influence on the microstructures and tensile properties of the alloys. Other variables of interest are the effect of initial grain size on hydrogen uptake and tensile properties, and the synergistic effects, if any, of oxygen and hydrogen on the tensile behavior of the alloys.

Experiments were conducted on specimens of various V-Cr-Ti alloys exposed to pH_2 levels of 0.05 and 3×10^{-6} torr at temperatures between 200 and 500°C. Negligible effect of H_2 was observed on either maximum engineering stress or uniform and total elongation. The uniform and total elongation values for the alloy ranged between 0.14-0.20 and 0.18-0.31, respectively, at temperatures between 200 and 500°C and in a pH_2 of<0.05 torr. However, uniform and total elongation decreased to 0.002 when the alloys were exposed at 500°C to 1.0 torr H_2 pressure. This corresponded to an H concentration of 358 wppm in the alloy.

Preliminary data from sequential exposures of the materials to low-pO_2 and several low-pH_2 environments were obtained in a subsequent study. The preexposure of the specimens to a low-pO_2 environment, followed by exposure to a pH_2 environment, resulted in O concentrations in a range of 550-2230 wppm and H concentrations in a range of 6-16 wppm. For example, a V-4Cr-4Ti specimen that was pretreated for 100 h in 3×10^{-6} torr pO_2 at 500°C and subsequently exposed for 100 h in a pH_2 of 3×10^{-6} torr at 500°C contained O, N, and H concentrations of 1030, 100, and 7 wppm,

* This work has been supported by the U.S. Department of Energy, Office of Fusion Science, under Contract W-31-109-Eng-38.

respectively. The specimen exhibited uniform and total elongation values of 0.15 and 0.23, respectively. TEM examination of the specimen showed precipitates measuring 100-200 Å in size, predominantly along the grain boundaries; these can be attributed to the pretreatment in low-pressure O_2 environment. Similarly, a V-4Cr-4Ti specimen that was pretreated for 100 h in 1×10^{-4} torr pO_2 at 500°C and subsequently exposed for 100 h in pH_2 of 3×10^{-6} torr at 500°C contained O, N, and H concentrations of 2000, 110, and 12 wppm, respectively. That specimen exhibited uniform and total elongation values of 0.14 and 0.18, respectively. Based on these results, we concluded that such a pretreatment had no significant effect on the tensile properties of the alloy, indicating no synergistic effect of O and H on the properties in the range of our investigation.