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(HT1) or 1050°C for two hours (HT2). Specimens given the HT1 treatment were annealed after final machining, whereas the HT2 specimens received the 1050°C anneal at Teledyne Wah Chang prior to final machining. Following machining HT2 specimens were than vacuum annealed at 180°C for two hours to remove hydrogen. Specimens treated using HT1 had a partially recrystallized microstructure and those treated using HT2 had a fully recrystallized microstructure. The fracture toughness as 25°C was determined by J-integral tests and at -196°C by ASTM 399 type tests. Toughness values obtained at -196°C were converted to J-integral values for comparison to the 25°C data. The 25°C fracture toughness was very high with none of the specimens giving valid results per ASTM criteria. Specimens fractured by microvoid coalescence. The fracture toughness at -196°C was much lower than that at 25°C and the fracture surface showed predominantly cleavage features. The present results show a transition from ductile to brittle behavior with decreasing test temperature which is not observed from one-third scale Charpy impact tests. The fracture toughness at -196°C was still quite high, however, at about 75 kK/m^2.

Delaminations in planes normal to the thickness direction wee seen at both test temperatures. Fracture surfaces inside the delaminations exhibited nearly 100% cleavage facets. The cause of the brittle delaminations was not determined, but will be a subject for further investigation.

Grain growth studies were conducted to evaluate the effect of time and temperature on the grain size of pure V,V-4 wt.%Cr-4 wt.%Ti, and V-5 wt.%Cr-5 wt.%Ti alloys. The temperatures used in the study were 500, 650, 800, and 1000°C, and exposure times ranged between 100 and ≈5000 h. All three materials exhibited negligible grain growth at 500, 650, and 800°C, even after ≈5000 h. At 1000°C, pure V showed substantial grain growth after only 100 h, and V-4Cr-4Ti showed growth after 2000 h, while V-5Cr-5Ti showed no grain growth after exposure for up to 2000 h.

Tensile testing was carried out on SS-3 tensile specimens punched from 0.762-mm-thick sheets of the large heat of V-4Cr-4Ti and small heats of V-3Cr-3Ti and V-6Cr-6Ti. The tensile specimens were annealed at 1000° for 2 h to obtain a fully recrystallized, fine grain microstructure with a grain size in the range of 10-19 µm. Room temperature tests at strain rates ranging from 10^{-3} to 5×10^{-1}/s were carried out in air; elevated temperature testing up to 700°C was conducted in a vacuum better than 1×10^{-5} torr ($<10^{-3}$ Pa). To study the effect of atomic hydrogen on ductility, tensile tests were conducted at room temperature in an ultra high vacuum chamber (UHV) with a hydrogen leak system.

Tensile properties of V-3Cr-3Ti, V-4Cr-4Ti, and V-6Cr-6Ti were measured at room temperature and 100–700°C at a strain rate of 1.1×10^{-3}/s. The ultimate tensile strength of all the alloys exhibited a minima at 300°C, whereas the 0.2% yield strength was relatively independent of temperature between 400° and 700°C. The total and uniform elongations were relatively insensitive to variation in test temperature above 400°C. All the alloys exhibited good ductility (e.g., uniform elongation >15%) and a large amount of work hardening ability. A yield point

V(C,O,N) precipitates, which appear to clean away O, C, and N from grain matrices. This process is accompanied by simultaneous annealing-out of the dense dislocations present in the weld fusion zone. It seems possible to produce high-quality welds under practical conditions by controlling and adjusting the cooling rage of the weld zone by some innovative method to maximize the precipitation of V(C,O,N).

Automated Ball Indentation (ABI) testing, was successfully employed to determine the flow properties of the fusion zone, heat affected zone (HAZ), and base metal of the gas tungsten arc (GTA) and electron beam (EB) welds of the V-4Cr-4Ti (large heat no. 832665) and the V-5Cr-5Ti (heat 832394) alloys. ABI test results showed a clear distinction among the properties of the fusion zone, HAZ, and base metal in both GTA and EB welds of the two alloys. GTA and EB welds of both V-4Cr-4Ti and V-5Cr-5Ti alloys show strengthening of both the fusion zone and the HAZ (compared to base metal) with the fusion zone having higher strength than the HAZ. These data correlate well with the Brinell hardness. On the other hand, GTA welds of both alloys, after a post–weld heat treatment of 950°C for 2 h, show a recovery of the properties to base metal values with V-5Cr-5Ti showing a higher degree of recovery compared to V-4Cr-4Ti. These measurements correlate with the reported recovery of the Charpy impact properties.[1,2]

In the Dynamic Helium Charging Experiment (DHCE), helium was produced uniformly in vanadium alloy specimens by the decay of tritium during irradiation to 18-31 dpa at 425-600°C in lithium-filled capsules in the Fast Flux Test Facility. This report presents results of postirradiation tests of tensile properties and density change in V-8Cr-6Ti and V-9Cr-5Ti. Compared to tensile properties of the alloys irradiated in the non-DHCE (helium generation negligible), the effect of helium on tensile strength and ductility of V-8Cr-6Ti and V-9Cr-5Ti was insignificant after irradiation and testing at 420, 500, and 600°C. Both alloys retained a total elongation of >11% at these temperatures. Density change was <0.48% for both alloys.

V-(4-15)Cr-5Ti alloys were irradiated in a helium environment to ≈400°C in the High Flux Isotope Reactor (HFIR). This report presents results of postirradiation tests of tensile properties of V-4Cr-4Ti, V-8Cr-6Ti, V-10Cr-5Ti, and V-15Cr-5Ti. Despite concerns on the effects of transmutation of vanadium to Cr and impurity pickup from the helium environment, all of the alloys exhibited ductile tensile behavior. However, the alloys exhibited ductilities somewhat lower than those of the specimens irradiated to a similar dose and at a similar temperature in an Li environment in fast reactors. Uniform plastic strain in the V-Cr-(4-5)Ti alloy decreased monotonically with increasing Cr content.

An effort is now underway to design an experiment that will allow the irradiation creep behavior of SiC_f/SiC composites to be quantified. Numerous difficulties must be overcome to achieve this goal, including determining an appropriate specimen geometry that will fit in the irradiation volumes available and developing a fabrication procedure for such a specimen. A specimen design has been selected, and development of fabrication methods is proceeding. Thermal and stress analyses are being performed to evaluate the viability of the specimen and to assist with determining the design parameters. A possible alternate type of creep test is also being considered. Progress in each of these areas is described in this report.

Tensile tests were conducted on eight reduced-activation Cr-W steels after irradiation to 15-17 and 26-29 dpa, and Charpy impact tests were conducted on the steels irradiated to 26-29 dpa. Irradiation was in the Fast Flux Test Facility at 365°C on steels containing 2.25-12% C4, varying amounts of W, V, and Ta, and 0.1%C. Previously, tensile specimens were irradiated to 6-8 dpa and Charpy specimens to 6-8, 15-17, and 20-24 dpa. Tensile and Charpy specimens were also thermally aged to 20000 h at 365°C. Thermal aging had little effect on the tensile behavior or the ductile-brittle transition temperature (DBTT), but several steels showed a slight increase in the upper-shelf energy (USE). After ≈7 dpa, the strength of the steels increased and then remained relatively unchanged through 26-29 dpa (i.e., the strength saturated with fluence). Postirradiation Charpy impact tests after 26-29 dpa showed that the loss of impact toughness, as measured by an increase in DBTT and a decrease in the USE, remained relatively unchanged from the values after 20-24 dpa, which had been relatively unchanged from the earlier irradiations. As before, the two 9Cr steels were the most irradiation resistant.

Miniature CVN specimens of four low activation ferritic alloys have been impact tested following irradiation at 370°C to 15 dpa. Comparison of the results with those of control specimens indicates that degradation in the impact behavior occurs in each of these four alloys. The 9Cr-2W alloy referred to as GA3X and the similar alloy F82H with 7.8Cr-2W appear most promising for further consideration as candidate structural materials in fusion reactor applications. These two alloys exhibit a small DBTT shift to higher temperatures but show increased absorbed energy on the upper shelf.

A series of alloys have been made adding various isotopes of nickel in order to vary the production of helium during irradiation by a two step nuclear reaction in a mixed spectrum reactor. The alloys use a base composition of Fe-12Cr with an addition of 1.5% nickel, either in the form of ^{60}Ni which produces no helium, ^{59}Ni which produces helium at a rate of about 10 appm He/dpa, or natural nickel (^{Nat}Ni) which provides an intermediate level of helium due to delayed development of ^{59}Ni. Specimens were irradiated in the HFIR at Oak Ridge, TN, to ≈7 dpa at 300 and 400°C. Microstructural examinations indicated that nickel additions promote precipitation in all alloys, but the effect appears to be much stronger at 400°C that at 300°C. There is sufficient dose by 7 dpa (and with 2 appm He) to initiate void swelling in ferritic/martensitic alloys. Little difference was found between response from ^{59}Ni and ^{Nat}Ni. Also, helium bubble development for high helium generation conditions appeared to be very different at 300 and 400°C. At 300°C, it appeared that high densities of bubbles formed whereas at 400°C, bubbles could not be identified, possibly because of the complexity of the microstructure, but more likely because helium accumulated at precipitate interfaces.

The unirradiated tensile properties of two different heats of Hycon 3HP™ CuNiBe have been measured over the temperature range of 20-500°C for longitudinal and long transverse orientations. The room temperature electrical conductivity has also been measured for both heats. Both heats exhibited a very good combination of strength and conductivity at room temperature. The strength remained relatively high at all test temperatures, with a yield strength of 420-520 MPa at 500°C. However, low levels of ductility (<5% uniform elongation) were observed at test temperatures above 200-250°C, due to flow localization adjacent to grain boundaries. Fission neutron irradiation to a dose of ~0.7 dpa at temperatures between 100 and 240°C produced a slight increase in strength and a significant decrease in ductility. The measured tensile elongation increased with increasing irradiation temperature, with a uniform elongation of ~3.3% observed at 240°C. The electrical conductivity decreased slightly following irradiation, due to the presence of defect clusters and Ni, Zn, Co transmutation products. The data indicate that CuNiBe alloys have irradiated tensile and electrical properties comparable or superior to CuCrZr and oxide dispersion strengthened copper at temperatures <250°C, and may be suitable for certain fusion energy structural applications.

The fracture toughness of an oxide-dispersion strengthened copper alloy AL-15 has been examined at room temperature and 250°C, in air and in vacuum (<10^{-6}) torr). Increasing test temperature causes a significant decrease in the fracture toughness of this material, in either air or vacuum environments. In addition, specimens oriented in the T-L orientation (crack growth parallel to the extrusion direction)