BRASKI

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Alloy Development for Irradiation Performance

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The precipitation response of 20%-coZd-worked type 316 stainless steel was examined after irradiation in HFIR at 380–600°C, after irradiation in EBR-II at 500°C, and after thermal aging at 600 to 750°C. Eta phase is a major portion of the response during exposure to all environments. It is not normally reported in 20%-cold-worked type 316 stainless steel. Qualitatively eta phase, $M_{23}C_6$, Laves, sigma, and chi appear at similar temperatures after HFIR, EBR-11, or thermal exposure. However, relative amounts of phases, size, and distribution differ some among the various environments. Eta phase is the only carbide-type phase observed after irradiation in HFIR from 380 to 550°C. The large cavities associated with it at 380°C contribute significantly to swelling. Precipitate re-solution and re-precipitation of massive particles of sigma, $M_{23}C_6$, and chi are observed after recrystallization in HFiR.

Several finished product forms of the Path A Prime Candidate Alloy have been received from Teledyne Allvac and examined to characterize its homogeneity with respect to dissolved titaniton and TiC. Inhomogeneeities were found in materia2 removed at an intermediate stage of fabrication and worse in finished plate. Several fabrication experiments were conducted on the intermediate material, both as received and after homogenization at 1200°C for 24 h. Some sensitivity to cooling rate after homogenization was found in the TiC distribution and the resulting amount of recrystallization, but the greatest microstructural sensitivity was found when unhomogenized and homogenized material were compared. Severe macro and micro inhomogeneity develops during the fabrication sequences when the material is not properly homogenized initially. Cold work followed by recrystallization causes many more stringers than hot working. The final product form, in particular the 13-mm-thick plate, had reasonably uniform grain size but inhomogeneous distributions of coarse TiC particles from grain to grain. Some clusters of grains had many particles and about 1 wt % Ti, while other groups of grains had no TiC and about 0.35 wt % Ti. The as-received 13-mm plate had clearly unacceptable homogeneity and must be homogenized before preirradiation treatments to vary microstructure. Fabrication processes need to be developed so that gross inhomogeneity in titaniton and TiC does not hamper alloy development and microstructural variation.

thermal aging at the irradiation temperature, although the irradiation probably enhanced the transformation kinetics. The precipitation of fine beta phase in the Ti-6Al-4V, however, appeared to be an irradiation-induced effect, since the known thermal phase diagram for the alloy indicates that the preirradiation alpha phase should be stable at the irradiation temperature.

Postirradiation annealing studies of Ti-6Al-4V revealed that a temperature of 560°C was required for rapid annihilation of dislocations and dislocation loops. Similar tests on Ti-6242s showed that a temperature of 750°C was required to produce the same annealing effect found in Ti-6Al-4V. Annealing of the Ti-6242S at 750°C resulted in the formation of small beta precipitates in the primary alpha.

Three vanadiwn alloy and two niobium alloy compositions are being prepared for consumable arc melting and processing to plate, sheet, and rod for the Fusion Materials Stockpile. These are the Path C (V, Nb) Scoping Alloys selected for initial evaluations as candidate fusion reactor structural materials. All first and second are melting operations have been completed; chemical analyses are being obtained for both metallic solutes and interstitials (carbon, oxygen, and nitrogen). Extrusions to sheet bar and round bar will be carried out at 1200°C at reduction ratios of 6:1 and 11.4 :1, respectively. Extrusions should be completed by early May. Delivery of all materials to the Fusion Materials Stockpile at Oak Ridge is scheduled to be complete by July 10, 1979.

Irradiation of Mo, Mo—0.5% Ti, and TZM at 425 to 1000°C to fluences producing 11 dpa resulted in DBTTs in bending above room temperature for all irradiation temperatures. The most severe embrittlement was a DBTT between 550 and 700°C produced by irradiation at 585°C. Alloying at the concentrations in the two alloys tested had a relatively minor effect on the DBTT. For the two most embrittling irradiations, at 585 and 790°C, the alloys had lower DBTTs than did the unalloyed Mo. This may be related to the alloying raising grain boundary decohesion stress. The DBTT shift with irradiation temperature could not be quantitatively related to the observed microstructures.