EFFECT OF HEAT TREATMENT AND IRRADIATION TEMPERATURE ON IMPACT PROPERTIES OF Cr-W-V FERRITIC STEELS—R. L. Klueh (Oak Ridge National Laboratory) and D. J. Alexander (Los Alamos National Laboratory)

Extended Abstract*

In the development of reduced-activation steels at ORNL, eight experimental steels have been studied. The steels are basically Fe-XCr-2W-0.25V-0.1C (compositions in wt. %) with 2.25% Cr (designated 2¼Cr-2WV) 5% Cr (5Cr-2WV), 9% Cr (9Cr-2WV), and 12% Cr (12Cr-2WV). Also, compositions with 2.25% Cr and 0% W (2¼CrV), 1% W (2¼Cr-1WV), and 0% V (2¼Cr-2W) were studied along with the 9Cr-2WV steel to which 0.07% Ta was added (9Cr-2WVTa).

To determine the effect of heat treatment (cooling rate from the austenitization temperature), specimens were taken from normalized-and-tempered 15.9-mm plate and 3.3-mm bar. Charpy impact properties were determined on the eight reduced-activation Cr-W ferritic steels in the normalized-and-tempered condition and after irradiation in FFTF to ≈14 dpa at 393°C.

In the normalized-and-tempered condition, the microstructure of the 2¼Cr steels in the 15.9-mm plate (slow cool) were bainite with various amounts of polygonal ferrite, and they were 100% bainite when heat treated as 3.3-mm bar. The 5Cr steel and the two 9Cr steels were 100% martensite and the 12Cr steel was martensite with ≈25% δ-ferrite after heat treatment in either geometry.

The change in microstructure caused by heat treatment of the 2¼Cr steels from duplex microstructures of bainite plus ferrite to 100% bainite resulted in improvement in the Charpy impact properties before irradiation. After irradiation, however, there was little difference in the properties for the two different heat treatments. As expected, cooling rate had little effect on the high-chromium (9 and 12% Cr) steels before or after irradiation. However, the Charpy properties for the 5Cr-2WV steel before and after irradiation were improved by the faster cooling rate. The reason for this change is unclear, but it may be due to the different precipitates present in the 5Cr steel as compared to the other martensitic steels (M_7C_3 is the primary precipitate present in the 5Cr-2WV steel, and $M_{23}C_6$ is the primary precipitate in the other martensitic steels).

Results from the present irradiation experiment at 393°C were compared with previous experiments for irradiation at a lower temperature (365°C) but at similar dpa levels. The DBTT values of all but the 5Cr-2WV and 9Cr-2WVTa steels were lower after irradiation at 393°C than after irradiation at 365°C, which is the expected behavior. The contrary behavior of the 5Cr steel was tentatively attributed to the M_7C_3 carbides that form in this composition that are not present in the 9Cr and 12Cr steels. The inverse temperature effect in the 9Cr-2WVTa steel was suggested to be due to the loss of tantalum from solution during irradiation at the higher temperature. Tantalum in solution may give the 9Cr-2WVTa steel its advantage over the other steels by increasing the cleavage fracture stress or changing the flow stress-temperature relationship, and this advantage is decreased by the precipitation of tantalum from solution during irradiation. However, a thorough analytical TEM examination of these steels is required to confirm the suggested mechanism.

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