LOW-CHROMIUM REDUCED-ACTIVATION FERRITIC STEELS FOR FUSION -- R. L. Klueh, D. J. Alexander, and E. A. Kenik (Oak Ridge National Laboratory)

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EXTENDED ABSTRACT

Development of reduced-activation ferritic steels has concentrated on high-chromium (8-10 wt.% Cr) steels. However, there are advantages for a low-chromium steel, and initial ORNL studies on reduced-activation steels were on compositions with 2.25 to 12% Cr. Those studies showed an Fe-2.25Cr-2W-0.25V-0.1C (2 1/4Cr-2WV) steel to have the highest strength of the steels studied. Although this steel had the best strength, Charpy impact properties were inferior to those of an Fe-9Cr-2W-0.25V-0.07Ta-0.1C (9Cr-2WVTa) and an Fe-2.25Cr-2W-0.1C (2 1/4Cr-2W) steel. Therefore, further development of the low-chromium Cr-W steels was required.

Microstructural studies indicated the superior impact properties of 2 1/4Cr-2W relative to 2 1/4Cr-2WV were due to the type of bainite formed in the two steels. The 2 1/4Cr-2WV contained granular bainite, and the 2 1/4Cr-2W contained acicular bainite. Based on these and previous observations, it was concluded that the difference in microstructure was due to cooling rate, with the acicular bainite being formed by the faster cooling rate. It was concluded that acicular bainite formation should also be promoted by increasing the hardenability.

A small amount of boron (0.005%) is known to improve hardenability, and a 2 1/4Cr-2WVB steel with 0.005% B had improved Charpy properties over 2 1/4Cr steels without boron. A combination of 0.005% B and 0.07% Ta (2 1/4Cr-2WVTaB) gave Charpy properties comparable to those of 2 1/4Cr-2WVB. Thus, improving hardenability improved impact toughness. Chromium will also increase hardenability, and a chromium addition to obtain 2.6Cr-2WVTa and 2.6Cr-2WVTaB steels gave Charpy properties better than those of 9Cr-2WVTa after tempering at both 700 and 750°C.

Previous work showed that the 9Cr-2WVTa steel had properties comparable or better than those for 9Cr-1MoVNb and 12Cr-1MoVW steels, the conventional Cr-Mo steels that were considered for fusion applications. The present results therefore indicate that the low-chromium steels also have properties that exceed those for 9Cr-1MoVNb and 12Cr-1MoVW.

These results indicate that it is possible to develop low-chromium reduced-activation ferritic steels that have tensile and impact properties as good or better than those of high-chromium (7-9% Cr) steels. Further improvement of properties should be possible by optimizing the composition.