EFFECT OF CHROMIUM, TUNGSTEN, TANTALUM, AND BORON ON MECHANICAL PROPERTIES OF 5-9Cr-WVTaB STEELS—R. L. Klueh, M. A. Sokolov (Oak Ridge National Laboratory), and D. J. Alexander (Los Alamos National Laboratory)

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Extended Abstract

The reduced-activation ferritic/martensitic steels use tungsten and tantalum as substitutes for molybdenum and niobium in the Cr-Mo steels that the reduced-activation steels replaced as candidate materials for fusion reactor applications. Studies were made to determine the effect of the composition of these elements on the properties of the steels. Chromium variations were also studied. Boron has a long history of use in steels to improve properties, and the effect of boron was also examined. Such information will be of use if the properties of the reduced-activation steels are to be optimized.

The effect of Ta, W, B, and Cr composition in Cr-2WV reduced-activation steels was investigated in the normalized-and-tempered (tempered at 700 and 750ºC) condition. Steels with 5, 7, and 9% Cr were examined, to determine the effect of increasing tungsten from 2 to 3%, changing tantalum from 0 to 0.1%, and changing boron from 0 to 0.013%. The effect of W, Ta, and B was investigated for the 5Cr steel, W and B for the 7Cr steel, and Ta and B for the 9Cr steel.

The following are the nominal compositions of the heats of steel used in this experiment:

(1) Fe-5Cr-2W-0.25V-0.1C (designated 5Cr-2WV),
(2) the 5Cr-2WV with 0.5% Ta (5Cr-2WVTa1),
(3) the 5Cr-2WV with 0.1% Ta (5Cr-2WVTa2),
(4) an Fe-5Cr-3W-0.25V-0.1C (5Cr-3WV),
(5) the 5Cr-3WV with 0.05% Ta (5Cr-3WVTa1),
(6) the 5Cr-3WVTa1 with 0.005% B (5Cr-3WVTa1B1),
(7) the 5Cr-3WVTa1 with 0.013% B (5Cr-3WVTa1B2),
(8) an Fe-7Cr-2W-0.25V-0.05Ta-0.1C (7Cr-2WVTa),
(9) an Fe-7Cr-3W-0.25V-0.05Ta-0.1C (7Cr-3WVTa),
(10) the 7Cr-2WVTa with 0.005% B (7Cr-2WVTaB),
(11) Fe-9Cr-2W-0.25V-0.1C (9Cr-2WV), and
(12) the 9Cr-2WV with 0.07% Ta (9Cr-2WVTa).

Results of the study are summarized as follows:

Tantalum Effect: Ta had a positive effect on strength and DBTT of the 5Cr and 9Cr steels. The USE was not affected by Ta for either steel.

Tungsten Effect: 3% W instead of 2% W in the 5Cr steels had no effect on strength in the absence of Ta. For 0.05% Ta, there was little effect after the 700ºC temper, but there was a positive effect when tempered at 750ºC. 3% W improved the DBTT for the 5% Cr steel after a 750ºC temper and had a slight effect on the 7% Cr steel after a 700ºC temper. The USE was unaffected by W in the 5Cr and 7Cr steels.

Boron Effect: B had no favorable effect on the properties of the 5 and 7% Cr steels but did favorably affect the strength and impact properties of 9Cr-2WVTa.

Chromium Effect: The 5Cr-2WVTa and 9Cr-2WVTa steels with 0.05% Ta appeared to be near the optimum composition for the compositions examined. After tempering at 750ºC, there was no

difference in the strength and ductility of the 5Cr-2WVTa and 9Cr-2WVTa, and they were superior to 7Cr-2WVTa. A composition of 7.5-9Cr-2WVTa has been accepted in the literature as best for future fusion applications. If the apparent minimum in strength between 5 and 9% Cr is an accurate representation, then steels with at least 9% Cr should be used. For the 5Cr-2WVTa, 7Cr-2WVTa, and 9Cr-2WVTa steels, the 5Cr-2WVTa had a clear advantage. The DBTT and USE of this steel after tempering at 700ºC are as good or better than those of the 7Cr-2WVTa and 9Cr-2WVTa tempered at 750ºC. Since 9Cr-2WVTa needs to be tempered at 750ºC for adequate toughness, the 5Cr-2WVTa steel may have advantages in both strength and impact toughness in the unirradiated condition.