§17. Comparison of 9Cr-ODS Martensitic Steel with 12Cr-ODS Ferritic Steel as Fusion Blanket Structural Materials

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Introduction

ODS steels are considered as the advanced structural materials in fusion blanket and also fuel tube in Gen VI fission reactors, due to their excellent creep properties at high temperature and good resistance to irradiation [1)]. Two ODS alloys with different Cr content and thus with different microstructures, called as 9Cr-ODS martensitic steel and 12Cr-ODS ferritic steel, respectively, were produced in NIFS. In this report, the comparison for two ODS steels was focused on tensile properties and microstructure.

Experimental

The new 9Cr-ODS and 12Cr-ODS steels were produced in NIFS and distributed for collaboration research. The chemical composition (in wt%) were 9.02Cr, 1.91W, 0.13C, 0.28Y, 0.21Ti, 0.128O and balance Fe for 9Cr-ODS, and 11.65Cr, 1.90W, 0.035C, 0.18Y, 0.29Ti, 0.083O and balance Fe for 12Cr-ODS, respectively. The final heat treatments for 9Cr-ODS included normalization at 1323 K for 1 h followed by air cooling, and tempering at 1023 K for 1 h followed by air cooling. While the12Cr-ODS was normalized at 1473 K for 1 hour followed by air cooling.

SSJ samples for tensile were machined along longitudinal direction (LD) which parallels to the extrusion direction (ED). The tensile properties were tested from RT to 973 K with an initial strain rate of 6.67×10^{-4}/s in a vacuum of $\sim1.0\times10^{-6}$ Torr. The microstructural characterization was examined by electron back-scattered diffraction (EBSD).

Results

Fig. 1 shows the comparison of tensile properties for 9Cr-ODS and 12Cr-ODS steels. Both ODS steels showed excellent tensile strength relative to RAFM steels [2)]. Compared with these two ODS steels, the yield strength (YS) of 12Cr-ODS were smaller in relative lower temperature region (<~823 K) and almost similar in elevated temperature region (823-973 K). The total elongation (TE) of 12Cr-ODS was almost slightly higher than that of 9Cr-ODS.

Fig.2 Shows the difference of grain morphology by EBSD. The average grain size in 12Cr-ODS was significantly higher than that in 9Cr-ODS, which is one of reasons for their lower strength than that in 9Cr-ODS. In addition, 12Cr-ODS showed non-uniform microstructure. Some coarse grains were elongated along ED, which may leads to the anistotropy in mechanical properties. While 9Cr-ODS exhibited almost equiaxial grains, and thus it was expected that the anisotropy should be lower than that of 12Cr-ODS steel.

Conclusion:

Both ODS steels showed excellent tensile strength at higher temperature compared with those of non-ODS steels. The tensile strength of 12Cr-ODS were lower than 9Cr-ODS at relative lower temperature and almost similar at elevated temperature. The different microstructure especially grain size and morphology are responsible for the different mechanical properties between these two ODS steels.

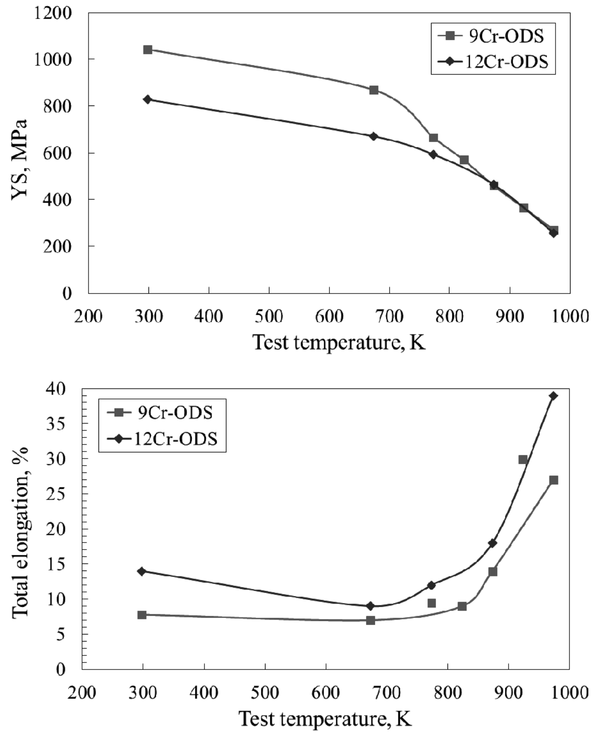

Fig.1 Comparison of tensile properties of 12Cr-ODS and 9Cr-ODS steels.

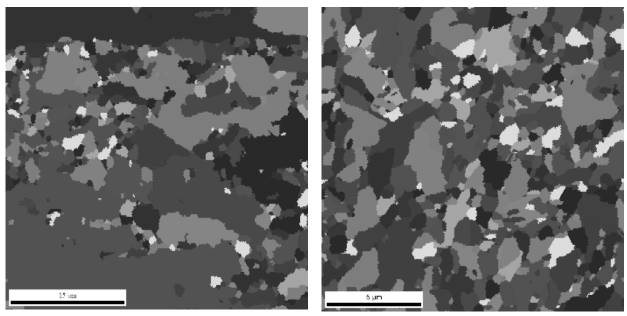

Fig.2 Microstructure by EBSD grain maps of 12Cr-ODS (left) and 9Cr-ODS (right) steels.

1) S. Ukai, et al.: ISIJ Int. *43* (2003) 2038.
2) Li, Y.F, et al.: Fusion Eng. Des. **86** (2011) 2495.