§25. Chraracterization of Microstructure and Mechanical Property of Ferritic 12Cr-ODS Steel Compared with Martensitic 9Cr-ODS Steel

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Introduction

Low activation ferritic/martensitic steels (RAFMs) have been considered to be the primary candidates for fusion blanket structural materials. Because of their inferior creep properties at elevated temperature, efforts have been made to develop oxide dispersion strengthening (ODS) steels by introducing oxide particles into the ferritic matrix with the aims of drastic improvement of their creep properties and thus extending the upper operation temperature limit to ~700℃. A 12Cr-ODS steel was produced in NIFS in 2013. The performance will be investigated and compared with 9Cr-ODS produced around 2009.

Experimental

The material used is the 12Cr-ODS steel with a chemical composition (wt%) of Fe-11.65Cr-1.90W-0.035C-0.18Y-0.29Ti-0.083O. The steel was normalized at 1200℃ for 1 hour and followed by air cooling..

The Vickers hardness was measured at RT. Tensile properties were tested from RT to 700℃ with an initial strain rate of $6.67\times10^{-4}s^{-1}$ in a vacuum of $\sim1.0\times10^{-6}$ Torr.

Results

The hardness results are shown in Fig.1. The hardness of 12Cr-ODS was significantly lower than that of 9Cr-ODS. The change in hardness was negligibly small by the annealing from 700℃ to 1000℃, showing the stability of microstructure and absence of the phase change by the heat treatments. This is considered to be a benefit of the 12Cr-ODS relative to 9Cr-ODS.

Fig. 2 shows the variation of tensile properties with the testing temperature for 12Cr-ODS steel. 12Cr-ODS steel showed the excellent tensile strength relative to RAFM steels. Compared with those of 9Cr-ODS steel [1)], the ultimate tensile strength (UTS) and yield strength (YS) of 12Cr-ODS were smaller in relative lower temperature region (<~500 ℃) and almost similar in elevated temperature region (500-700℃). The total elongation (TE) were always larger than those of 9Cr-ODS.

Fig.3 Shows the difference of microstructure by optical microscope. 9Cr-ODS exhibts almost equiaxial grains and tempered martensitic microstructure. Different from that of 9Cr-ODS, 12Cr-ODS showed the elongated grains along the extrusion direction and ferritic phase. The larger grain size of 12Cr-ODS is one of reasons for the lower strength and hardness than those of 9Cr-ODS.

Conclusion:

12Cr-ODS steel showed the hardness stability and has the potential for higher temperation operation. The hardess and tensile strength of 12Cr-ODS were lower than 9Cr-ODS at relative lower temperature. However, the tensile strength at elevated temperature of these two steels are almost similar. The different microstructure are responsible for the different mechanical properties.

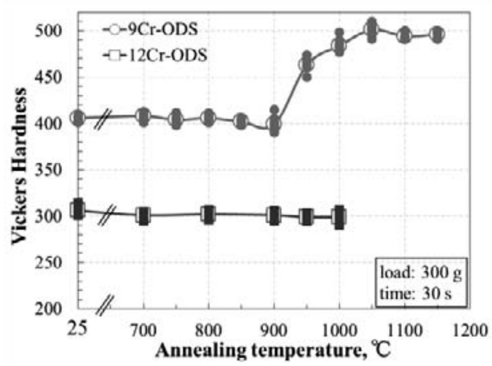

Fig.1 Variation of Vickers hardness of 12Cr-ODS and 9Cr-ODS steels with the annealing temperature.

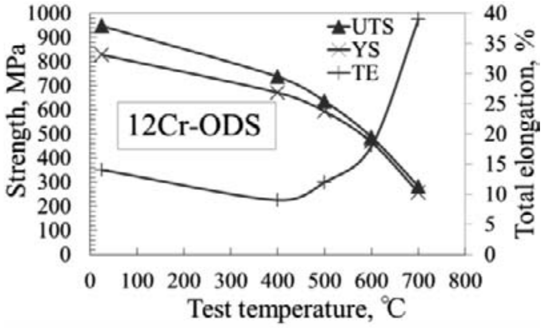

Fig.2 Variation of tensile properties of 12Cr-ODS steel with the testing temperature.

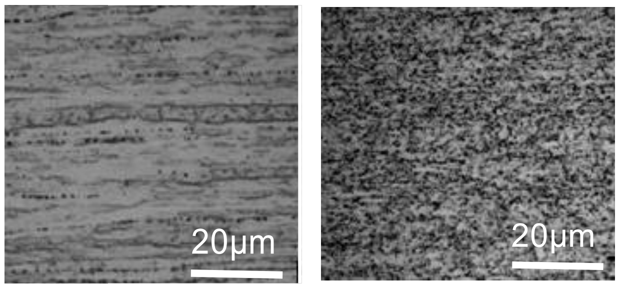

Fig.3 Microstructure by optical microscope of 12Cr-ODS (left) and 9Cr-ODS (right) steels.

1) Li, Y.F, et al.: Fusion Eng. Des. **86** (2011) 2495.