Effects of Aluminum, and Yttrium Oxide on Microstructure and Mechanical property of Oxide Dispersion Strengthened Ferritic Steel

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1. Introduction

The power efficiency of the next generation nuclear systems such as Gen.IV fission and fusion reactor is strongly dependent on the operating temperature [1]. The structures and cladding materials of next-generation nuclear power plant need to maintain good physical properties for safe and efficient operation. Oxide dispersion strengthened (ODS) steel has shown excellent irradiation and creep resistance at high temperatures [2]. The additions of Al and Y_2O_3 is well known to enhance the characters of ODS [3, 4].

This study was focused on the effects of Al and Y_2O_3 about change of microstructure and tensile test for 12 Cr ODS steel.

2. Methods ad Results

2.1 Experimental procedure

12Cr ODS steel was fabricated by several processes. Both metal and Y_2O_3 powders were mechanically alloyed using a Symoloyer CM08 mill at 300 rpm in high purity argon gas atmosphere for 40 hr. A ball to powder ratio of 10:1 was applied. After the ball milling process, the MA powders were transferred to steel can. The steel can was injected with H_2 at 500℃ for 1hr to deoxidize after being sealed and degassed under the same condition. Hipping treatment was performed at 1150℃ under a pressure of 100MPa for 4hr. The hipping alloys were hot-rolled to a 15mm in thickness after preheating at 1150℃ for 2hr. Optical microscopes(OM) sample were prepared by means of mechanical polishing and etching with a mixed solution of 13% nitric acid, 37% hydrochloric acid and 50% water. The size distribution of the precipitates were applied by TEM images.

Table I : Chemical compositions of ODS ferritic steel (wt.%).

	Fe	Cr	W	Al	Ti	Zr	Y_2O_3
A	Bal.	12	2		0.3		0.35
B	Bal.	12	2	2	0.3		0.35
C	Bal.	12	2	3.5	0.3		0.35
D	Bal.	12	2	2	0.1	0.3	0.35
E	Bal.	12	2	2	0.3	0.3	0.7

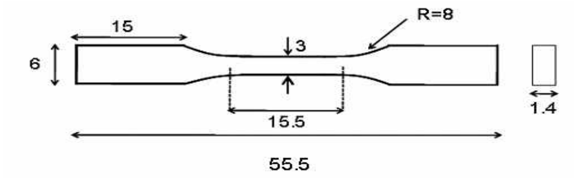

Fig. 1. Specimen used for tensile test

Replica TEM samples were prepared with a solution of 10% perchloric acid and 90% ethanol. The schematic figures of the specimens for a tensile test are represented in Fig. 1. The Chemical compositions of ODS ferritic steel for specimens is explained in Table. Ⅰ.

2.2 Microstructure

Fig.2 shows the OM images about grain boundary of Al added ODS specimens in rolling direction planes. Fig. 2 shows OM images of the grain boundaries of Al added ODS specimens in the rolling direction planes. The result shows that the grain size will increase and the grain boundary will be coarser when Al was added. Grain size also will increase when Y_2O_3 was added to ODS steel, and it also causes the grain boundary coarser as shown in Fig.3.

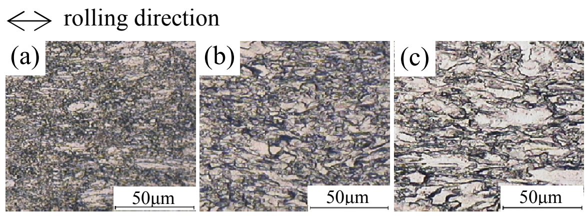

Fig. 2. Optical Microstructures for rolling direction planes of differentially added Al ODS : (a) Al 0wt.%, (b) Al 2wt.% , (a) Al 3.5wt.%

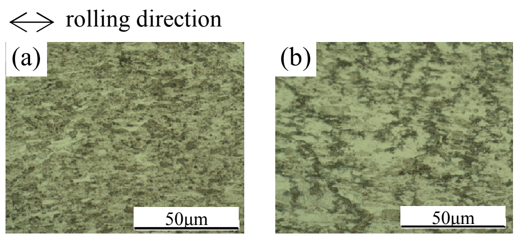

Fig. 3. Optical Microstructures for rolling direction planes of added Y_2O_3 ODS (a) 0.35 wt. % , (b) 0.7 wt.%.

2.3 Tensile test

The results in Fig. 4-(a) are present as tensile strength transition from Al added ODS steel. It is shown that a higher Al content leads to a higher UTS but lower elongation. Fig. 4-(b) shows that a Y_2O_3 addition also shows a the similar trend.

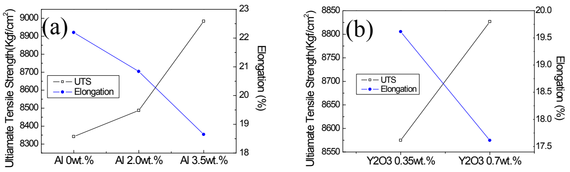

Fig. 4. Tensile strength and elongation length of ODS gradationally added (a) Al, (b) Y_2O_3.

2.4 Size distribution of the precipitates

The results shown in Fig. 5-(a)~(c) demonstrate the size distributions of particle with a higher Al addition. Fig. 5-(a)~(c) also shown that the mean particle sizes tends to gradually increasing. Also, the results show in Fig. 6-(a)~(b) are size distribution of dispersoid with different Y_2O_3.

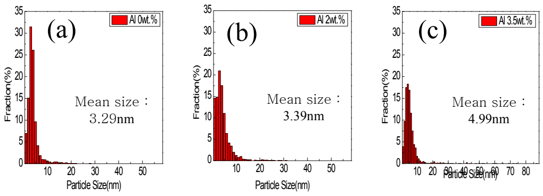

Fig. 5. Size distributions of precipitate in Al addition ODS steel (a) Al 0wt.%, (b) Al 2wt.% (c) Al 3wt.%.

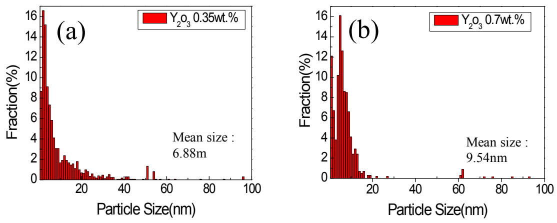

Fig. 6. Size distributions of precipitate about Y_2O_3 effect in ODS steel (a) Y_2O_3 0.35wt. %, (b) Y_2O_3 0.7wt. %.

2.5 EDS

The EDS results from Fig.7 are presented in table. Ⅱ. The results indicate that the chemical composition of the dispersoid is different. The Y-Al-O and Al-O were formed by Al added.[5].

Table II : Chemical compositions of precipitate by EDS(wt.%).

	O	Al	Ti	Cr	Y
S1	48.44		18.29	5.85	27.42
S2	54.37	15.14		30.50	

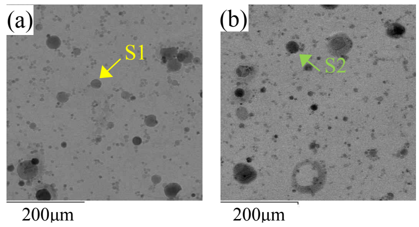

Fig. 7. EDS for TEM images of added Al ODS (a) Al 0wt.%, (b) Al 3.5wt.%

3. Conclusions

Al addition in 12Cr-ODS steels indicated that the grain size became lager than before and lead to an increased particle size. It makes the UTS of this steel increasing whereas the elongation decreasing. but elongation was decreased. Also the chemical compositions of oxide particles were changed by the addition of Al. Y_2O_3 in 12Cr-ODS steel indicates that the grain size become coarse with Al addition and lead to an increased particle size.

Acknowledgements

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