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High Temperature Degradation Behavior and its Mechanical Properties of Inconel 617 alloy for Intermediate Heat Exchanger of VHTR

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1. Introduction

Inconel 617 alloy is a candidate material of intermediate heat exchanger (IHX) and hot gas duct (HGD) for very high temperature reactor (VHTR) because of its excellent strength, creep-rupture strength, stability and oxidation resistance at high temperature [1-3]. Among the alloying elements in Inconel 617, chromium (Cr) and aluminum (Al) can form dense oxide that act as a protective surface layer against degradation [4]. This alloy supports severe operating conditions of pressure over 8 MPa and 950°C in He gas with some impurities. Thus, high temperature stability of Inconel 617 is very important.

In this work, the oxidation behavior of Inconel 617 alloy was studied by exposure at high temperature and was discussed the high temperature degradation behavior with microstructural changes during the surface oxidation.

2. Methods and Results

2.1 The Materials

The chemical composition of Inconel 617 alloy is given in Table 1. This alloy was annealed at 1177°C and water-quenched and provided as plates 20 ㎜ thick. The specimen was carried out with cold rolling up to 50% and then recrystallized.

Table 1. Chemical composition of Inconel 617(wt.%)

	C	Ni	Fe	Si	Mn	Co	Cr
Max	0.08	53.16	1.49	0.06	0.11	11.58	22.16
	Ti	P	S	Mo	Al	B	Cu
Max	0.35	0.003	0.001	9.80	1.12	0.002	0.08

2.2 Cold Rolling and Recrystallization

The aspect ratio and hardness of Incoenl 617 were increased with cold work as shown Figure 1. The specimen of 50% cold rolled was recrystallized at 1050°C for 1 h. This result, the grain size was decreased from initial grain size (75 ㎛) to fine grain size (5.2 ㎛).

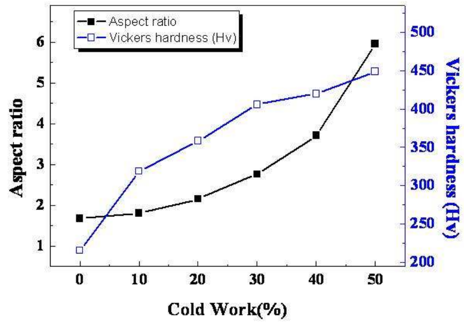

Fig. 1. Change of aspect ratio and Vickers hardness during cold work.

2.3 High Temperature Oxidation and Mechanical Property

The high temperature oxidation test (950°C) was carried out from as-received and recrystallized specimen. Figure 2 shows the cross-sectional micrographs of Inconel 617 alloy exposed at 950°C for 120 h. Both as-received and recrystallized, the external oxide scale was mainly composed of Cr_2O_3 and small amount of another oxide (Ni, Ti and Co). The internal oxide layer was observed below the external oxide scale and was presented following the grain boundaries. The internal oxide was confirmed as Al_2O_3. The internal oxide layer formed by as-received was deeper than that formed from recrystallized.

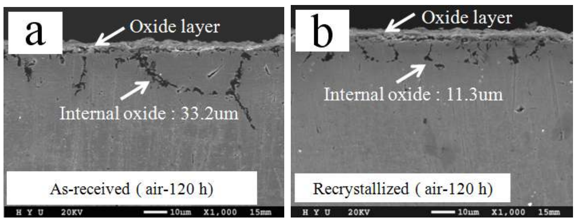

Fig. 2. Morphologies of Inconel 617 after aging 120 h in air about (a) as-received and (b) recrystallized.

The mechanical property was carried out by Vickers hardness tester. The Vickers hardness was maintained both as-received and recrystallized with exposure time as shown Figure 3. However, Vickers hardness of recrystallized was higher than that as-received. Because recrystallized specimen have fine grain size than that as-received.

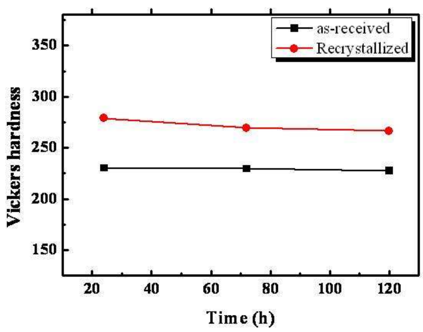

Fig. 3. Changes of Vickers hardness of as-received and recrystallized after exposure for 120 h in air.

3. Conclusions

Oxidation behavior and mechanical properties of Inconel 617 were investigated and following result were obtained;

1. After cold rolling up to 50%, Vickers hardness of Inconel 617 increased with aspect ratio. At 50% cold rolled Inconel 617, recrystallization temperature was determined by 1050^{o}C for 1h. This result, the grain size was decreased from initial grain size (75㎛) to fine grain size (5.2 ㎛).

2. Both as-received and recrystallized, the external oxide scale was mainly composed of Cr_2O_3. The internal oxide was confirmed as Al_2O_3. The internal oxide layer formed by as-received was deeper than that formed from recrystallized. Therefore, from the depth of internal oxide point of view, oxidation behavior of recrystallized specimen was more stable than that as-received specimen.

3. The Vickers hardness was maintained both as-received and recrystallized with exposure time. However, Vickers hardness of recrystallized was higher than that as-received.

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