METALLOGRAPHIC ANALYSIS OF AS RECEIVED AND AUTOCLAVING INCONEL 617 ALLOY

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ABSTRACT

This paper make a comparative metallographic analysis between “as received” and steam-autoclaving samples of Inconel 617 alloy (UNS N06617). The samples were tested by steam-autoclaving. Autoclaving test parameters: time 16 days, 550°C temperature and 250 atmosphere pressures. The analysis of samples consisted in metallographic examination: thickness layer measuring, microstructure modification, and Vickers microhardness (MHV0.1) determinations. The tested material was compared with the as received material. For metallographic analysis are used the Olympus GX 71 optical microscope and OPL tester by automatic cycle. Average grain size were automatic determined by linear interception method and reported as ASTM Micro Size number (G). Material microhardness was calculated with relationship of technical book of device. Average grain size for tested and “as received” samples is finer than the specification requirements (G max. 3.5). The results showed a good metallographic behavior of Inconel 617 at this steam-autoclaving test.

Key words: Inconel 617, steam-autoclaving, microstructure, microhardness

Introduction

INCONEL® alloy 617 (UNS N06617) is a solid-solution, strengthened, nickel-chromium-cobalt-molybdenum alloy with an exceptional combination of high-temperature strength and oxidation resistance. The alloy also has excellent resistance to a wide range of corrosive environments, and it is readily formed and welded by conventional techniques. The high nickel and chromium contents make the alloy resistant to a variety of both reducing and oxidizing media. The aluminum, in conjunction with the chromium, provides oxidation resistance at high temperatures. Solid-solution strengthening is imparted by the cobalt and molybdenum. The combination of high strength and oxidation resistance at temperatures over 1800°F (980°C) makes Inconel alloy 617 an attractive material for such components as ducting, combustion cans, and transition liners in both aircraft and land-based gas turbines. Inconel alloy 617 also offers attractive properties for components of power-generating plants, both fossil-fueled and nuclear, [1].

Experimental Methods

The experiment consisted in a steam-autoclaving test, in a Baskerville Autoclave, with further parameters: 16 days time, 550°C temperature and 250 atmosphere pressure.
Metallographic analysis of samples consisted in the thickness oxide layer determination and the microstructure examination (average grain size, Heyn method), [2].

Vickers microhardness were calculate with relationship of technical book of device (micro-load 0.1 kgf): $MHV= 1854.4\ F/d^2$, [kgf/mm²]
Where: F -force/charge [gf]; *d* -average diagonal of indentation [μm]; 1854.4 -device coefficient for Vickers microhardness, [3].
In Table no.1: The average grain size and hardness for cold-rolled sheet of Inconel 617 (solution treated), in conformity with prescript requirements in Table 4 of ASME SB-168, [4].

Table 1 - Inconel 617 (UNS N06617) Average grain size and hardness, [4]

Cold-Rolled Sheet, 1.42 m Wide and Under			
Thickness Sheet, mm	Calculated Diameter of Average Grain Section, Max., mm	Coresponding ASTM MicroGrain Size No.	Rockwell B Hardness, Max.
Over 1.3 to 6.4, incl.	0.110	3.5	86

Results and Discussion

Thickness oxide layer

The thickness oxide were automatic measured with "analySIS" soft of Olympus GX 71 metallographic microscope (x1000). In general, after the steam-autoclaving test the thickness oxide layer was very thin, below 0.5 μm. Figure 1: oxide layer on autoclaving Inconel 617, [5].

Fig. 1. Tested Inconel 617: oxide layer <0.5μm, [6]

Microstructure

Structure were revealed by electrolytic etching: 10% oxalic acid solution, 6V, 20-50 seconds. Average grain size were automatic determined, in cross-section (TS).
Microstructure of as-received Inconel 617, Figure 2 (TS): Austenite (*A*) with twined grains and carbide particles (dark) at grain boundaries and intragranular. Average grain size correspond of ASTM No. 5.5, [6]
Microstructure of autoclaving Inconel 617, Figure 3: Austenite (*A)* with partial recrystallized grains and uniform dispersed carbide particles (dark). Average grain size correspond of ASTM No. 7.0, [5]

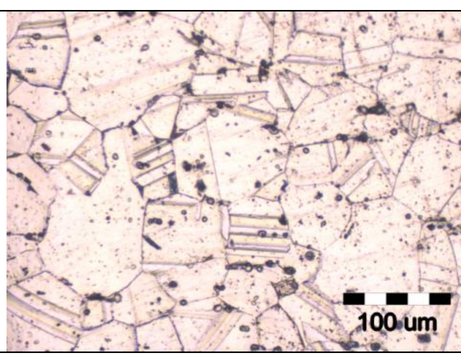

Fig. 2. As-received Inconel 617, *A*+carbides, TS

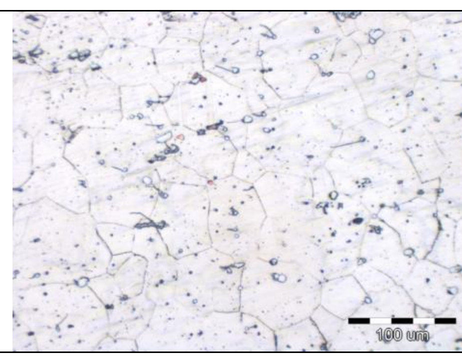

Fig. 3. Tested Inconel 617: *A*+carbides, TS

The microstructure of autoclaving samples is finer than the as-received samples, average diameter of grain decreasing with 1/3 approximate (see Figure 4).

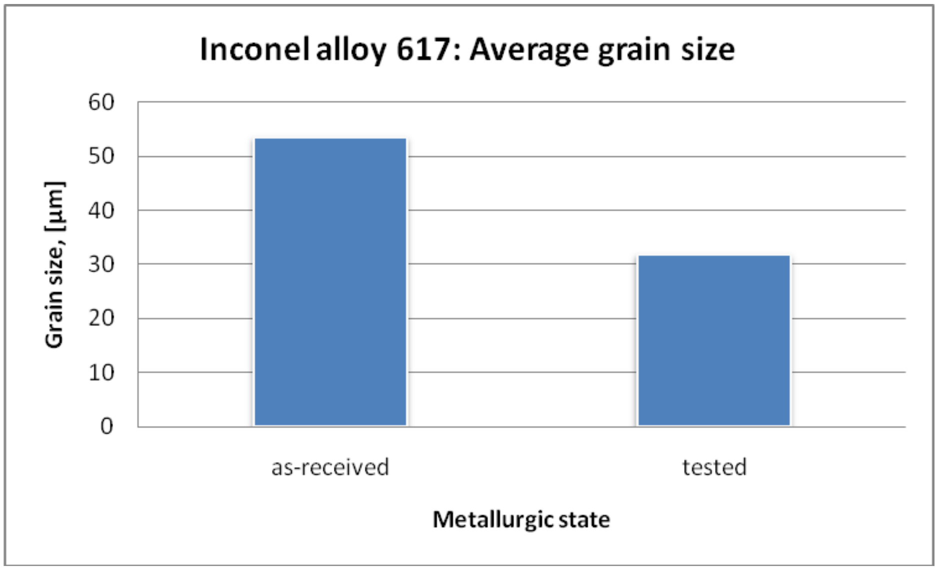

Fig. 4: Comparative diagram of average grain size

In general, average grain size of as-received and tested samples is finer than the ASTM requirements [4]: Max. ASTM No.3.5 for Alloy 617 (UNS N06617).

Vickers microhardness

In Figures 5-6: Vickers microhardness imprints (MHV0.1) on as-received and autoclaving samples, in cross-section (TS), [5]

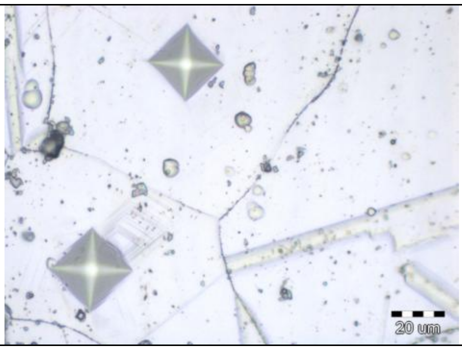	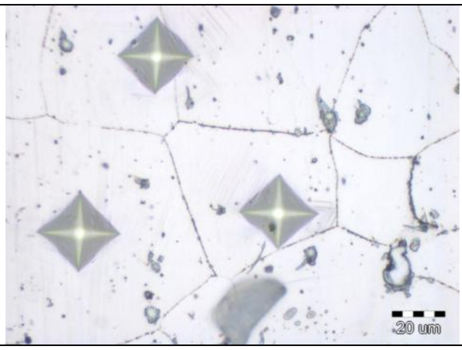
Fig.5. As-received Inconel 617: MHV imprints	Fig.6. Tested Inconel 617: MHV imprints

After steam-autoclaving test the microhardness increase with 10 units comparative with as received samples (see Figure 7)

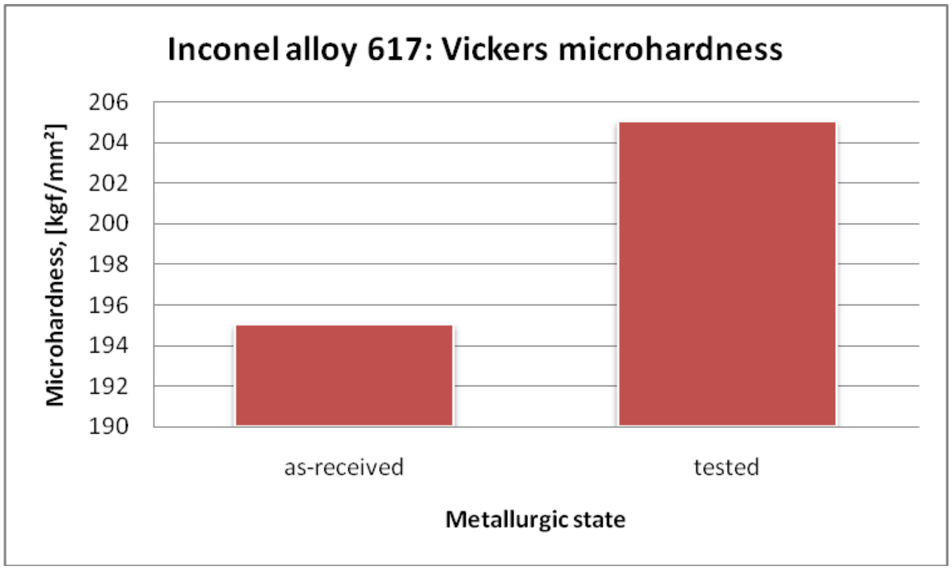

Fig. 7: Comparative diagram of Vickers microhardness

Conclusions

✓**Thickness layer.** The surface samples after steam-autoclaving covered with a very thin oxide layer.
✓**Microstructure.** The alloy after steam-autoclaving undergo some microstructure changes comparative with as-received alloy: partial recrystallization and finer grains.
✓**Vickers microhardness.** A little growth of microhardness have place after steam-autoclaving (light hardening).

The results show that Inconel 617 alloy have a good behaviour at this steam-autoclaving test.

References

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