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Effect of Ni Addition on Microstructure and Hardness of A356 Alloy after Hot Plastic Deformation

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A356 aluminum alloy is included in 3xx.x type alloys based in Al-Si system. They have excellent flow characteristics during casting due to Si content, high thermal conductivity, corrosion resistant and excellent strength/weight ratio. The most important alloying elements are Si and Mg. Excellent mechanical properties of A356 alloy are obtained after T6 heat treatment, because to precipitation of β-Mg_2Si phase and others metastable phases. The main applications are in the automotive and military industries. The typical microstructure of A356 alloy is formed by Al-α dendrites, eutectic Si particles, based-Fe intermetallics and Mg_2Si equilibrium phases [1].

By another hand, several authors have reported that some transition metals like Ni, Fe, Zr and V, which main characteristics are their low solubility in Al, have a positive effect in reduction of coefficient of thermal expansion and mechanical properties of 2xx.x and 3xx.x type alloys [2-3]. Additionally, it has also been reported than the modification of microstructure by hot plastic deformation in 3xx.x type alloy, enhances the mechanical properties [4-5]. Thus, this study evaluates the changes on microstructure and hardness generated by Ni additions, hot plastic deformation and heat treatments in A356 alloy.

A356 alloy and those modified with Ni (1 and 2 wt. %) were hot plastic deformed at 350 °C (50 %), solution heat treated (SHT) at 535 °C for different times, quenching in water at 60°C and aged at 180 °C for different times. Variations in the microstructure and hardness were characterized and evaluated by OM, TEM and micro-hardness HV.

The effect of hot plastic deformation in longitudinal (1A and 2A) and transversal (1B, 2B and 3B) zones of deformed samples in the as-cast condition and after solubilized for 7h are show in Fig. 1. The evolution in hardness values respect to Ni content, hot-plastic-deformation (D) or hot–plastic-non-deformation (ND), and aging time after solution for 7h are show in Fig. 2. It is observed increases of hardness values in function of increment of Ni content. In addition, the hardness values after peak hardness remain stable up to 10h. Furthermore, Ni addition and hot plastic deformation have important effects on precipitation hardening; mainly in morphology, size and distribution of β (Mg_2Si) precipitates (Fig. 3).

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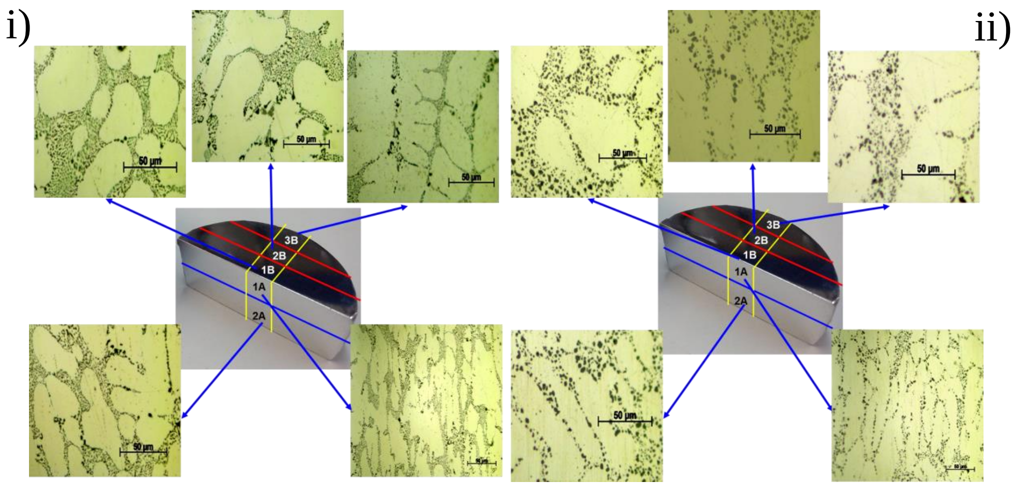

Figure. 1 Micrographs obtained by MO in longitudinal (1A and 2A) and transverse (1B, 2B and 3B) zones of deformed samples in the as-cast condition (i) and after solubilized for 7h (ii).

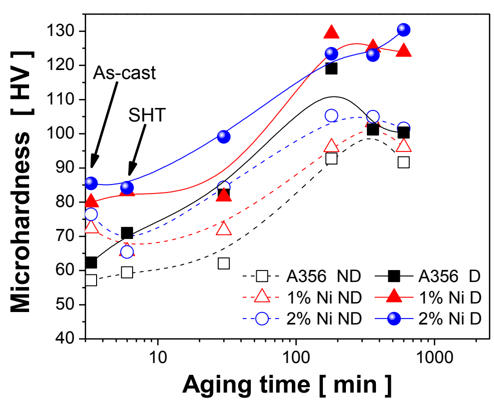

Figure. 2 Evolution in hardness values respect to Ni content, hot-plastic-deformation (D) or hot–plastic-non-deformation (ND), and aging time after 7h of solution treatment.

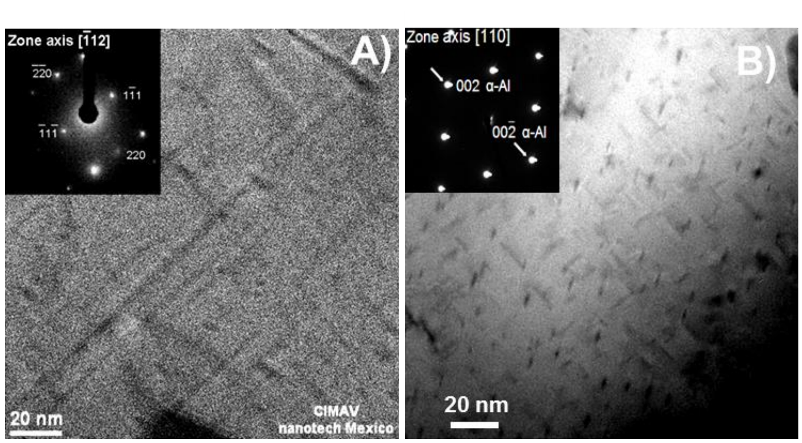

Figure. 3 Micrographs of alloy A) A356 in STEM mode, B) A356 with 2% Ni TEM mode, after hot plastic deformation and aged at 180 °C for 10 h.