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Microstructural Behavior of AA319 Aluminum Alloy Modified with Nickel

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Aluminum presents several advantages over steel. With an improved thermal conductivity and excellent machinability, it offers a versatility highly appreciated by engineers when considering its application in prototyping, structural applications and casting processes [1]. These characteristics make of aluminum and its alloys valuable resources when considering the current issues related with low energy consumption. A route to overcome this challenge is the modification of their chemical composition by adding elements capable of generating intermetallic compounds with high thermal stability.

Commonly used in low-pressure die casting processes for automotive parts, the 319-aluminum alloy (AA319) is a heat treatable alloy, which hot mechanical behavior improvement is of interest when considering the manufacturing of lighter automotive components [2]. From the different alloying elements with high thermal stability, nickel is an excellent candidate to for using in aluminum alloys with positive reported results in modified aluminum alloys, regarding to hardness and tensile strength tested at elevated temperatures [3, 4].

This work reports the microstructural behavior of the AA319, modified with Ni additions and tested at elevated temperatures. For this purpose, the AA319 modified with the Al-20Ni master alloy in order to obtain an AA319 modified with 1.0 wt.pct of Ni (AA319-1.0Ni). The Al-20Ni was added to the melted AA319 and degassed with Ar. Specimens were T6 heat treated under solution (495°C/5h) and artificial aging (220°C/3h). The mechanical evaluation was carried out at room (25°C) in the as-cast (AC), T6 and after a second stage heating of 250°C for 45 min (OH). The microstructural characterization was carried out by electron microscopy. The mechanical evaluation was carried out by hardness (Rockwell-B) and tensile tests. Samples were machined according to the E8-ASTM standard test.

Fig. 1a-c shows backscattered SEM micrographs of the microstructural evolution under different thermal conditions. The microstructural changes observed in the AA319-1.0Ni due to the thermal heat treatments show the presence of intermetallic phases mainly containing Cu, Fe, Mn and Ni. The coarsening and roundness of the Si phase present minimal variations in the T6 and the OH stages. It was observed that the addition of Ni does not noticeable affect the amount Cu dissolved the aluminum matrix. A deeper study of the microstructural evolution is presented in Fig. 1d,e, by means of bright field TEM micrographs. Dark phases with an irregular morphology (Fig. 1d) correspond to Si-rich precipitates. Needle-pairs phases with a relative angle of 90° are observed in the T6 and the OH condition. The microstructure observed in the Fig. 1e show the degradation of the AA319-1.0Ni after and overheating condition. The OH sample present a representative area where θ´ needles have been coarsened, retaining a small portion of the in the Al matrix. Even though, θ´ needles retain their morphology and high aspect ratio, as well as spatial distribution, these phases were largely coarsened in comparison to the previous thermal stage.

Results from the mechanical evaluation of the AA319 and the AA319-1.0Ni at different thermal conditions are displayed in Fig. 2. It can be observed a noticeable increment in the mechanical performance of the modified alloy after 1.0 wt.pct of Ni. However, after an overexposure of the specimens at a second thermal stage a mechanical degradation is presented. Even though a detriment in the mechanical behavior of the modified AA319 alloys is observed after overheating conditions, the effect of different Ni additions on their mechanical and thermomechanical must be considered must be further studied.

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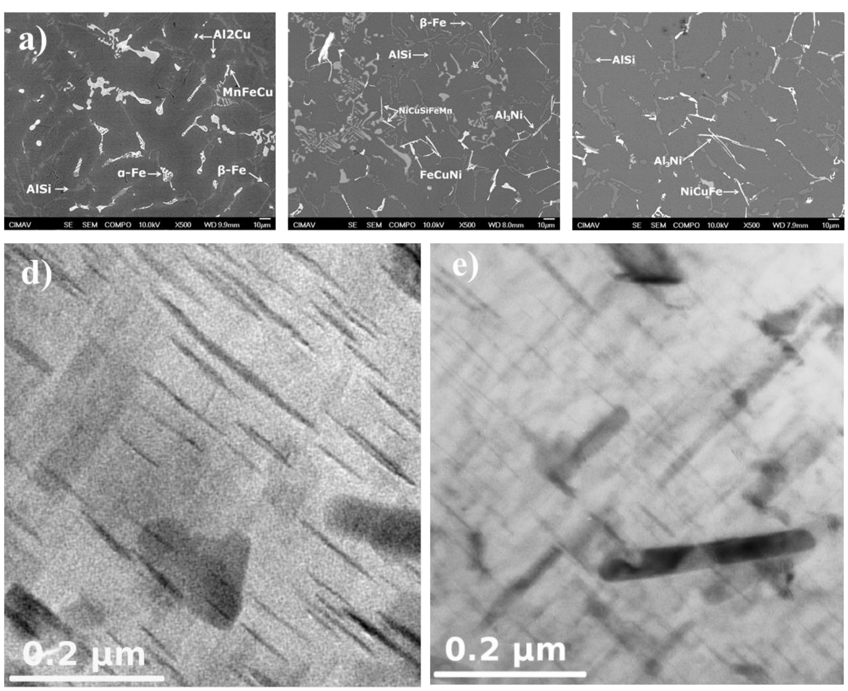

Figure 1. Figure 1. Results from electron microscopy. (a-c) Backscattered SEM micrographs and (d,e) bright field TEM micrographs of the AA319-1.0Ni evaluated in the AC, T6 and OH condition respectively.

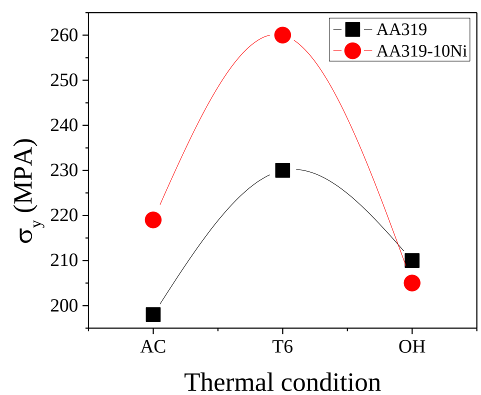

Figure 2. Tensile behavior of the AA319 and the AA319-1.0Ni in the as-cast, T6 and overheating condition.

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