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Microstructure and Mechanical Properties of Al_{2024} Alloy Modified with Mg and Zn Additions after Hot-Extrusion and Aging Processes

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The use of Al alloys in industry is increasing owing to their high strength/density ratios and other advantage properties; in addition, standard extrusion technology for high-strength Al alloys in T6 temper allows producing profiles of simple geometrical shapes. Because of its high yield strength and good fatigue resistance, the Al_{2024} is a commercial alloy used in the aerospace industry principally. The precipitation-hardening is the main strengthening mechanism due the precipitation of Al_2Cu (θ) phase. Additional alloying elements are being used seeking an increment on mechanical properties. Have been reported that Mg additions have a positive effect on the strength and hardness, However, has been reported a decrement in ductility and impact resistance [1]. On the other hand, by Zn additions, aluminum could be hardened by solid solution [2].

The aim of this work is evaluate the effect of Mg and Zn addition on the microstructure, precipitation kinetics and mechanical properties of Al_{2024} alloy after hot-extrusion and aging processes.

The Al_{2024} alloy fabrication with Mg and Zn additions (0.25, 0.50 and 0.75 wt. %) was made by conventional casting, the melt was degassed with argon gas (20 psi) for 5 min. 0.13 wt % of AlTiB was added as grain refiner. Modification with Mg was performed with addition of pure Mg (99.99 %). Modification with Zn was performed with the addition of a Zn-Al master alloy (Zn72.7-Al27-Cu0.2 Mg-0.1), commercially known as ZA27. The microstructural characterization was done using an optical microscope ZEISS model Scope A1, a SEM Hitachi model SU3500 and a TEM PHILIPS model CM-200. The mechanical properties were evaluated using tensile and hardness test in accordance with the ASTM standards.

The Fig. 1 shows representative images of Al_{2024} alloy and those modified with Mg and Zn (0.5 wt. %) after hot extrusion process (HEP) and solution heat treatment (SHT). In this figure it can be seen different microstructure in each characterized section (cross-equiaxed grains and longitudinal-elongated grains).

The Fig. 2 shows the effect hardening due Mg and Zn addition to the Al_{2024} alloy after HEP, it is evident the increase in the hardness by the addition of Mg and Zn. In addition, the age-hardening curves in the Al_{2024} alloy and those modified with Mg and Zn show a higher effect of age-hardening with Mg addition. The alloys modified with 0.50 wt. % (Mg-Zn) shown higher values of hardness.

The Fig. 3 shows TEM micrographics of Al_{2024} alloy and those modified with Mg and Zn (0.50 wt. %) after SHT and at the peak age-hardening (PAH). It is evident the difference between number density, size, spatial distribution and type of precipitates in the PAH of all samples.

It is concluded from results that, *i)* Mg and Zn additions directly affect the number density, size, spatial distribution and type of precipitates in Al_{2024} alloy after aging process; and *ii)* the hardening effect of Mg is more important than Zn, in both, age-hardening and hardening by solid solution.

References:
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[2] Ž. Skoko, S. Popović and G. Štefanić, Croatica Chemica Acta **82** (2009), p. 405.

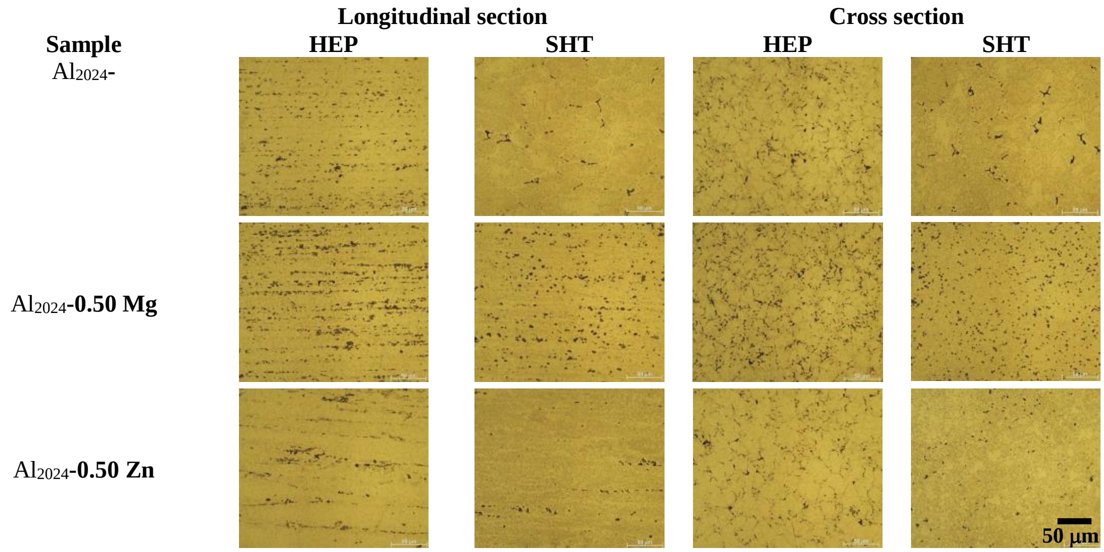

Figure 1. Optical micrographics of Al_{2024} alloy modified with Mg and Zn.

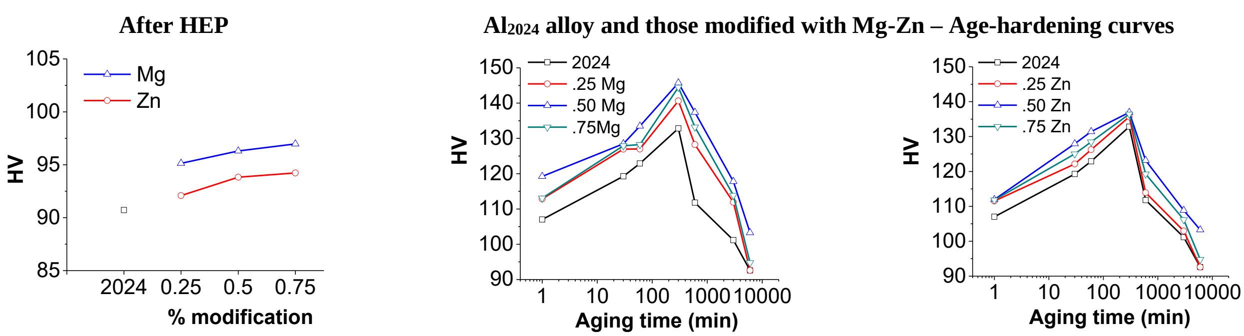

Figure 2. Age-hardening curves in Al_{2024} alloy and those modified with Mg and Zn.

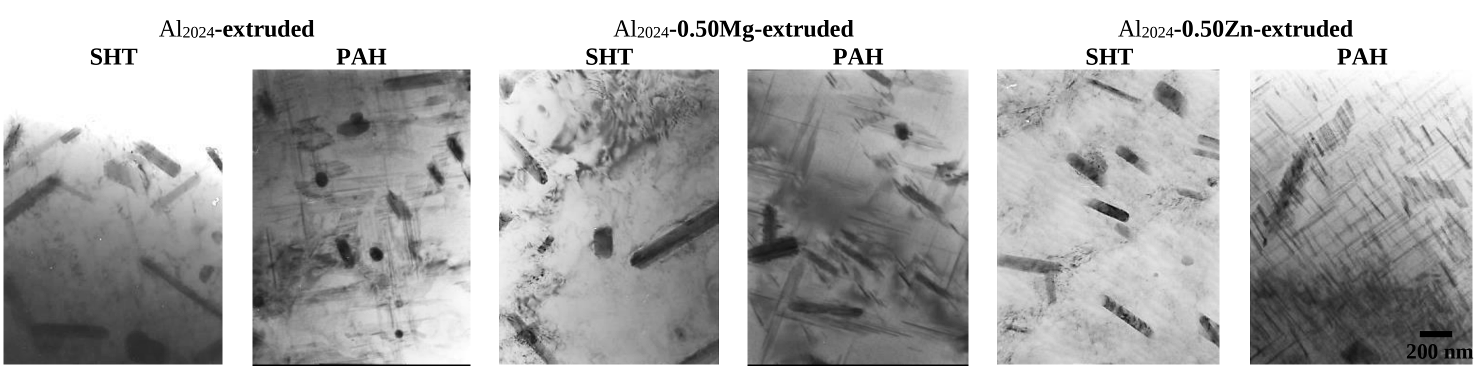

Figure 3. TEM micrographics of Al_{2024} alloy and those modified with Mg and Zn.