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Effect Mg Addition on Microstructure and Hardness of Al_{2024} Alloy after Thermo-Mechanical Treatments

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Al alloys possess many favorable characteristics which make them useful in a wide variety of application. Particularly, the Al_{2024} alloys are extensively used as structural materials in commercial airplanes owing to their good balance of properties including high specific strength, good damage tolerance, formability and corrosion resistance [1, 2]. Precipitation-hardening is often employed to improve alloy strength and is one of the most important strengthening mechanisms in Al_{2xxx} alloys.

Has been reported an increment on strength and hardness by Mg addition (< 2 wt. %); however, this is accompanied by a decrease in ductility and impact resistance [3]. By another hand, the mechanical properties of this alloy can be influenced by artificial aging and by plastic deformation, such as equal channel angular pressing, high pressure torsion and cold rolling. However, only few of thermo-mechanical treatments have been practically applied to Al alloys, like heat treatment T8 of Al_{2024} and T9 of Al_{2A12} alloys [4], in which the applied deformation is relatively small. The reason is to avoid the introduction of the non-uniform distribution of dislocation cell structures which may act as nucleation sites of heterogeneous precipitation [4]. Although, it should be mentioned that a significant increase of the strength was achieved by relatively large cold deformation after solution treatment in others studies [5]. The aim of this work is evaluate the effect of Mg addition on microstructure and hardening of the Al_{2024} alloy after thermo-mechanical treatments (hot-cold rolling).

The Al_{2024} alloy fabrication with Mg additions (0.25, 0.50 and 0.75 wt. %) was made by conventional direct casting, the melt was degassed with argon gas (20 psi) for 5 min period and AlTiB was added as grain refiner (0.13 % wt.). Modification with Mg was performed with addition of pure Mg (99.99 %). The hot-plastic-deformation treatment consisted of 50% of thickness reduction by hot-rolling at 490°C, and solubilization (495°C) with different times. The cold-plastic-deformation treatment involved 5 to 10% thickness reductions by cold-rolling and a final aging step (195°C) at several times. 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; XRD analyses were performed in a Panalytical X'Pert PRO diffractometer. The mechanical properties were evaluated using hardness test in accordance with the ASTM standards.

The Fig. 1 shows the effect of hot-plastic-deformation on microstructure of Al_{2024} alloy and those modified with Mg. The microstructure change of equiaxed grains in as-cast condition to elongated grains after hot-rolling. The Fig. 2 shows age-hardening curves of Al_{2024} alloy and those modified with Mg after cold-plastic-deformation (5 and 15% cold-rolling) and aging step. It is evident highest hardness value in samples with plastic-deformation and an increase in precipitation kinetics in the same samples, the $Al_{2024\text{-}0.25\ Mg}$ present higher hardening values in all conditions. The Fig. 3 shows optical micrographs of Al_{2024} and $Al_{2024\text{-}0.25\ Mg}$ alloys, it is evident the presence of pores in undeformed samples and the formation of intermetallic phases in deformed samples.

It is concluded from results that the effect of age-hardening due to Mg addition and thermos-mechanical treatments improve the hardness of the Al_{2024} alloy. Furthermore, the Mg additions directly affect the type of precipitates and intermetallic phases in Al_{2024} alloy after aging process.

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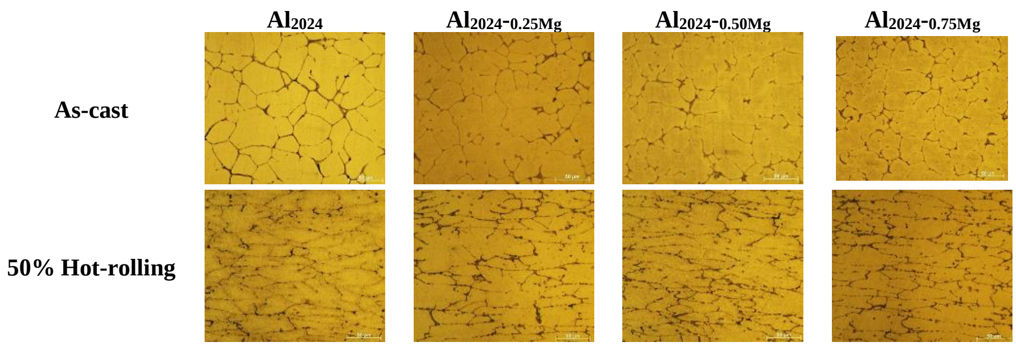

Figure 1. Optical micrographics of Al_{2024} alloy and those modified with Mg.

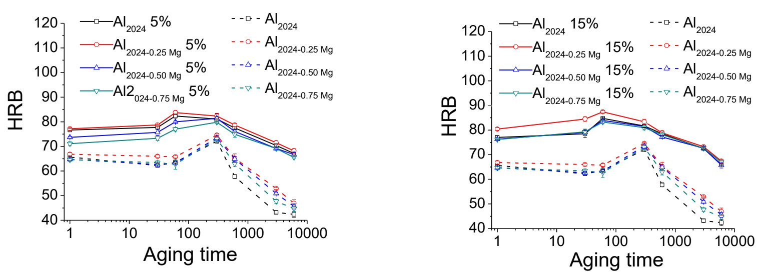

Figure 2. Age-hardening curves of Al_{2024} alloy and those modified with Mg after cold-rolling (5 and 15 %).

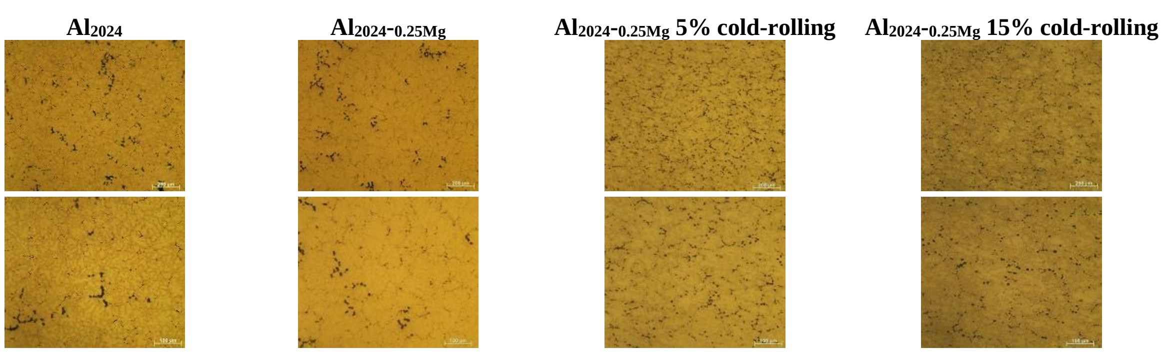

Figure 3. Optical micrographics of Al_{2024} alloy and those modified with Mg in peak age-hardening.