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Effect of the Age-hardening Time on the Microstructure of Cold Rolled Al_{2024} Alloy

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Al_{2024} alloy is widely used in the aerospace industry however their mechanical properties still need to be improved to be used in critical applications as fuselage structures, wing tension members, shear webs and ribs [1-2].The Al_{2024} alloy is strengthened by microstructure evolution during aging, but the heat treatment time and initial condition of the alloy could influence on mechanical properties due to static precipitation phenomenon. For the above, the aim of this work is evaluate the effect of the age-hardering time on the microstructure of cold rolled Al_{2024} alloy to identify microestructural changes and phases formed during the static precipitation that originate increase of Vickers microhardness.

Commercial Al_{2024} alloy was used as raw material and was melted in a Lindberg Blue™ electric furnace at 740 °C. Degassing of molten aluminum was carried out with argon gas (20 psi) for 15 min followed by addition of 0.62 g of Al-5Ti-1B as grain refiner. The alloys were casted into steel molds and the specimens obtained were extruded at 465°C. Later, was performed a solution heat treatment (SHT) at 495 °C for 420 min followed by quenching in water at 60 °C. The specimens were deformed by cold rolling (CR) to 30% reduction thickness. Aging heat treatments (AHT) were performed in a Felisa™ furnace for all deformed samples. The conditions of AHT were 195 ºC for 30, 60, 300, 600, 3000 and 6000 min, followed by quenching in water at room temperature. Before and after heat treatment Vickers microhardness test were performed and the microstructure evolution was characterized by X-ray diffraction (XRD), scanning electron microscopy and mapping by energy dispersive X-ray spectroscopy (EDS). Vickers microhardness tests were performed in a LECO LM300AT hardness tester using 50g load and 10s of dwell time. Analyses by XRD were performed in a Panalytical X'Pert PRO diffractometer operated at 40 kV and 30 mA using Cu K_α radiation (λ = 0.15406 nm). X-ray mapping by EDS were carried out by scanning electron microscope Hitachi model SU3500 operated at 10 kV and equipped with Oxford Microanalysis System model AZtec X-Max^N.

Fig.1 shows the results of Vickers microhardness to different aging time of the deformed and not deformed samples. The curve of microhardness for deformed samples indicates that double-peak age strengthening was achieved to aging time of 30 min (248 HV) and 600 min (226 HV), respectively. Fig.2 shows the diffraction patterns of the compared samples. The results showed that to different aging time the phases formed are AlCu, Al_2Cu, Al_2CuMg, AlCuMg and $Al_{18}Mg_3Mn_2$. In the case of samples with the highest microhardness values, the results suggest that Al_2Cu and Al_2CuMg are the main phases that originate increase in this property. Fig.3 shows the EDS mapping of the deformed and not deformed samples at 30 min and 600 min of aging time. The results suggest that for those samples also consists in the uniform distribution of Cu semi-spherical particles to the 30 minutes of aging. Moreover to 600 min of the heat treatment, Cu agglomerated particles, Fe, Si and AlFeMn were observed in the microstructure.

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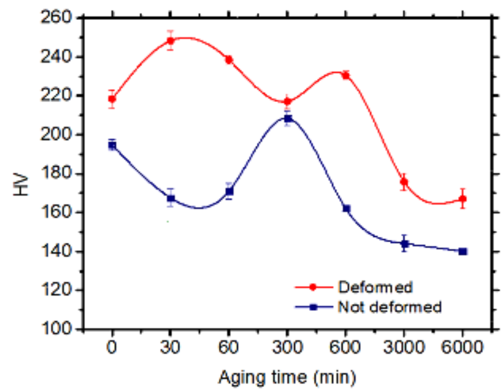

Figure 1. Vickers microhardness graph to different aging time for not deformed and deformed samples.

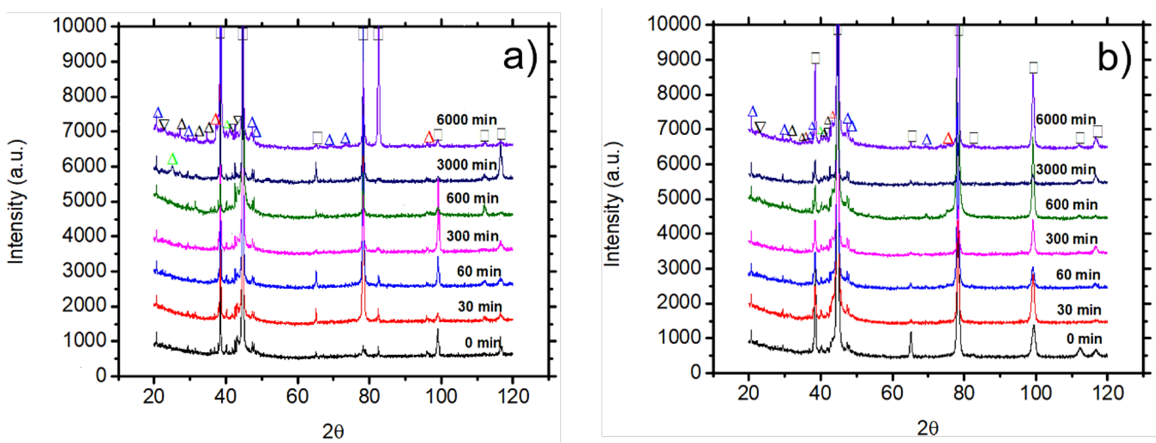

Figure 2. X-ray diffraction patterns for different aging time for the Al_{2024} alloy samples: a) not deformed; b) deformed (cold rolled-30 % ε). Symbology represents the following phases: □ Al, Δ AlCu, Δ Al_2Cu, Δ Al_2CuMg, ∇ AlCuMg, Δ $Al_{18}Mg_3Mn_2$.

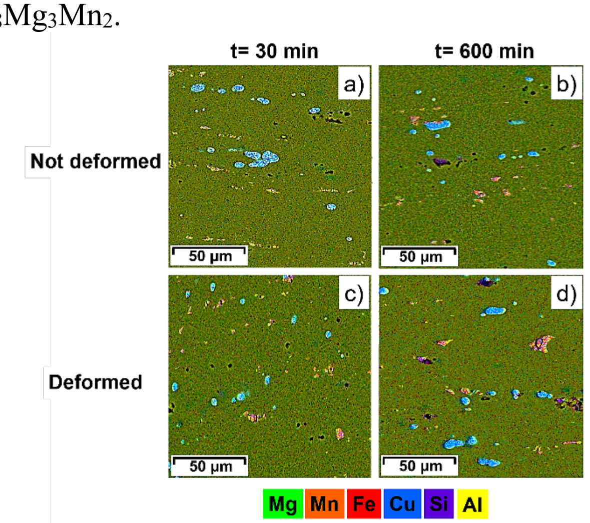

Figure 3. EDS mapping of the Al_{2024} alloy samples in condition not deformed and deformed (cold rolled-30 % ε) at 30 min and 600 min of aging time.

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