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Influence of thermo-mechanical treatments on the microstructure and hardness of the Al-2024 alloy

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The Al-2024 alloy as a heat-treatable material, exhibits certain excellent properties, such as high tensile strength, good damage tolerance and creep resistance. With the excellent thermal stability, these alloys are considered to be candidate materials for future applications in the aerospace industry [1]. Actually, recent demand for weight reduction in structural component calls for further enhancement of strength of commercial structural alloys. Increasing recognition has been given to the thermos-mechanical treatments recently as important techniques for improving the properties of metallic materials [2]. The plastic deformation process may be useful in the effect of aging process and helpful to improve the mechanical properties of Al-2024 alloy. Some studies have shown that the plastic deformation process may be useful in the effect of aging process, which is helpful to improve the mechanical properties of aluminum alloy and refine the precipitated phase of alloys notably [3]. However, there are few studies available concerning the effect of the pre-deformation degree on the microstructure and precipitation kinetics.

The Al-2024 alloy was melted in a LINDBERG BLUE electric furnace at 740°C, degassed for 5 minutes with Argon gas (20 psi), using a graphite propeller at 490 rpm and finally 0.33 wt% of Al-5Ti-1B as grain refiner was added. The alloys were cast into steel molds preheated at 260°C, where specimens of approximately 101.39 mm long x 12.64mm wide x 9.57 mm height were obtained. Later these specimens were machined to obtain samples of approximately 97 mm long x 10 mm wide x 8mm high. Subsequently, hot rolling (pre-deformation) at ≈460 °C was carried out to reduce the thickness of the sample 50% and erase the as-cast microstructure. Subsequently, solution treatments at 495°C for 3, 5 and 7h were done in a LINDBERG-BLUE electric furnace followed by a quenching in water at 60°C. Thereafter, a cold rolling was carried out to reduce the thickness of the sample 5 and 15%. Finally, samples were cut approximately 19.46 mm long to be treated by aging in a FELISA furnace at 195°C for different periods of time. The microstructural evolution was studied by optical microscopy (OM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

The effect of homogenization-solubilization treatment time (3, 5 and 7h) on microstructure in Al-2024 alloy is shown by SEM micrographs in Fig. 1. It is observed from the results that in all homogenization-solubilization treatment times, segregation decrease compared with as-cast conditions, but samples treated for 5 and 7h shown lower segregation.

The Fig. 2 shows HRB and HV harness results as a function of aging time in the 2024 alloy, after 5 (a) and 15% (b) cold-working, additionally, the reference sample value is included. It is observed as the hardness in cold-working samples is greater than the reference samples. It is observed a direct effect of cold-working in hardness, high deformation - high hardness. Additionally, the cold-working affects the precipitation kinetics; it is observed that the time required to reach peak hardness in deformed samples is shorter than that observed in not deformed samples, it is expected a noticeable effect on the morphology,

size and distribution of precipitates. In addition, the precipitation kinetics is faster in the samples 15% cold-working compared to 5% cold-working and reference sample, which is in agree with reported in other studies [5].

References

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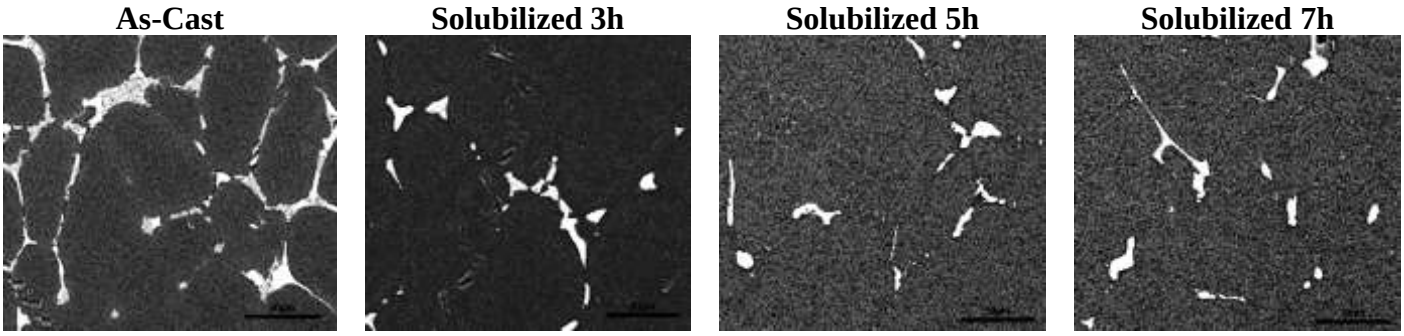

Figure. 1 Images obtained by SEM in Al-2024 alloy as function of homogenization-solution treatment time.

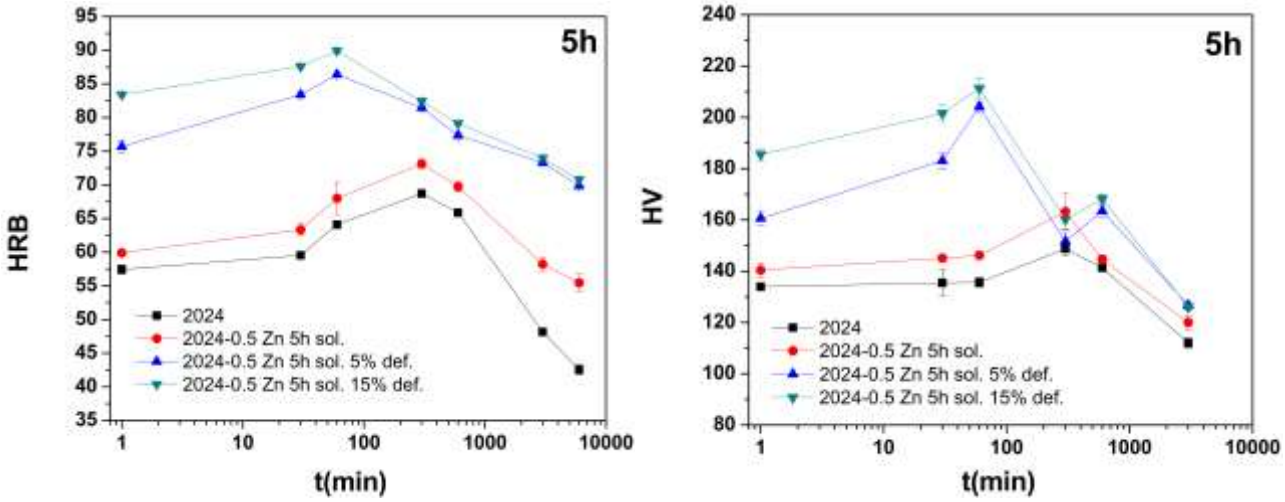

Figure. 2 Hardness HRB and HV curves as a function of aging in Al-2024 alloy solubilized for 5h . Hardness of 5% and 15% cold-working and reference samples are shown.