THE MICROSTRUCTURE OF THE ANNEALED 6063 ALUMINUM ALLOY AFTER DIFERENT DEFORMATION PROCESSES

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The analysis and control working have been of the main problems in Materials Engineering due to the complexity of the processes involving dislocations and the non homogeneity of that operation inside a deformation microstructure (1 – 5).

In this work is shown briefly the influence of some deformation processes on the final microstructure, utilizing transmission electron microscope (JEOL, JEM 200C, operating on 200kV), of an initially annealed 6063 aluminum alloy, specifically cold torsion, cold extrusion and tensile deformation, individually or a combination of both of them. The principal aim is to observe the similarities and the differences in each process or in a combination of them. There are few information about it in the literature.

Several studies have shown that for many structural aluminum alloys, the combination of strength and toughness is intimately related to the work hardening. The analysis and control of work hardening has proven to be one of the problems due to the complexity of the dislocation processes involved and the non homogeneity of their operation within the deforming microstructure together with presence of a multiphase microstructure on the 6063 aluminum alloy (Al-Mg-Si-Fe).

A better way to understand the influence of the deformation processes on the microstructure in an annealed 6063 aluminum alloy is by TEM observation where there are higher magnification.

All the TEM, at 200kV, observations (bright and dark field techniques) and also identification of present precipitates (electron diffraction patterns) was made in samples obtained from the cross section of the cylindrical pieces of the wrought alloy.
Three mm discs for the TEM observation was prepared at -25°C in a double jet electropolish (30% perchloric acid + 70% ethanol).

An intense and regular cell structure is observed in the annealed 6063 aluminum alloy who was cold deformed in torsion for 20 cycles, 2.8% of reduction on thickness. There are also presence of $FeAl_3$, Fe_3SiAl_{12} and $MgSi_2$ precipitates random distributed (figure 1).

In the annealed 6063 aluminum alloy who was cold deformed in torsion (2.8%) and finally cold deformed on tensile test (2.8%) is observed a more fine and regular cell structure and presence of same identified precipitates (figure 2).

A random sub-grains structure and a dislocation network inside the grains is a typical observation in the annealed 6063 aluminum alloy who was cold extruded in two steps (2.8% each one) (figure 3).

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Several grains containing a random sub-grain structure with some cellular structure inside them and some identified precipitates is shown in the annealed 6063 aluminum alloy who was cold extruded (1 step, 2.8%) and cold deformed on torsion (20 cycles, 2.8%) (figure 4).

A fine sub-grains, dislocation tangles near each sub-boundary and some types of precipitates is shown in the annealed 6063 aluminum alloy who was cold extruded (2.8%) and cold deformed on tensile test (2.8%) (figure 5).

We can conclude that the sequence of TEM micrographs concerning the microstructure where the cell structure or sub-grain morphology, the dislocation network interaction with precipitates or grains / sub-grains, can elucidate some theoretical aspects about the possible involved hardening mechanism and consequently could enhanced the final structural properties of the wrought 6063 aluminum alloy for industrial purposes as an example.

References

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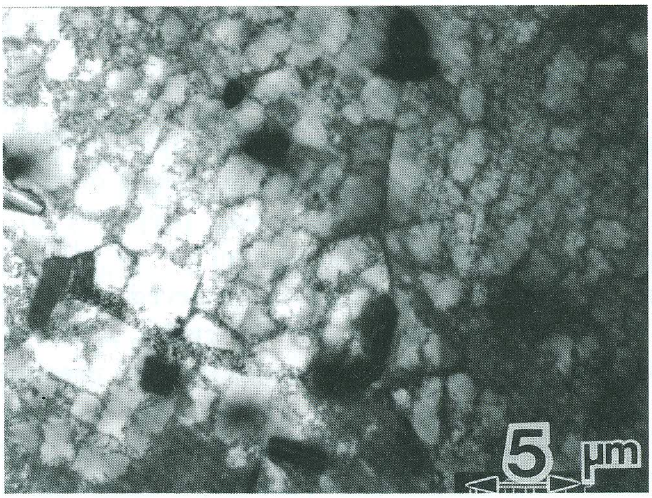


Fig.1 : TEM micrograph, 200kV, BF; shows an intense and regular cell structure in the three observed grains in an annealed 6063 Al alloy who was cold deformed in torsion for 20 cycles, 2.8% of reduction on thickness. There are also presence of $FeAl_3$, Fe_3SiAl_{12} and $MgSi_2$ precipitates random distributed. Zone axis ≈ (011).

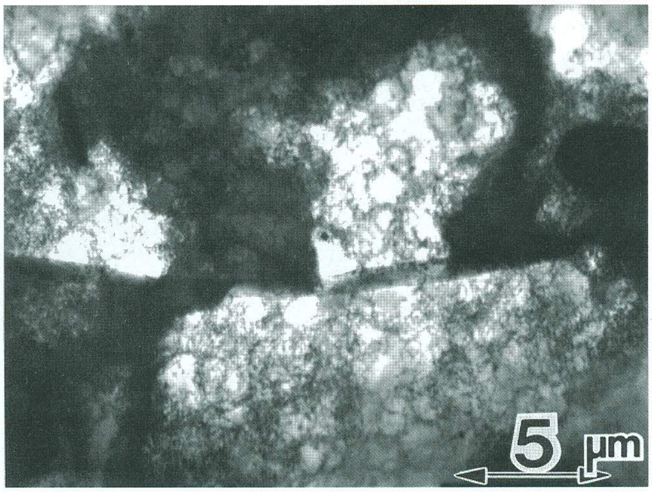


Fig.2: TEM micrograph, 200kV, BF; shows a more fine and regular cell structure and presence of same identified precipitates in an annealed 6063 Al alloy who was cold deformed in torsion (2.8%) and finally cold deformed on tensile test (2.8%). Zone axis ≈ (013).

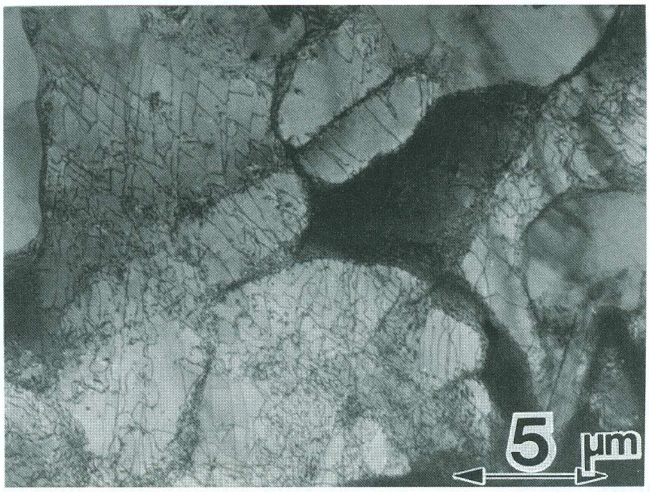
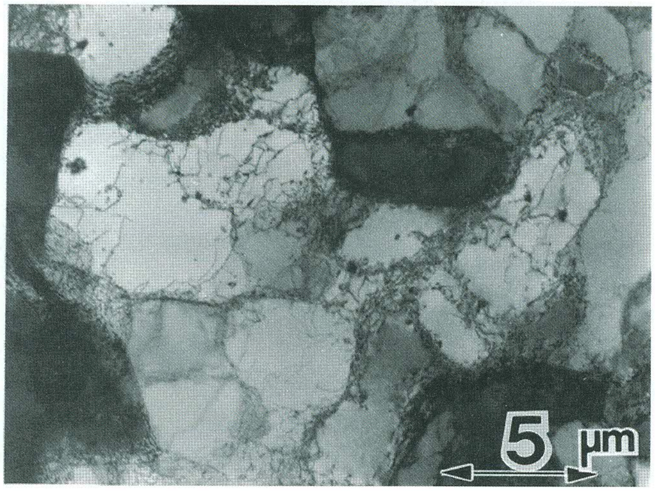


Fig.3 :TEM micrograph, 200kV, BF; shows sub-grains structure and a dislocation network inside the primary grains in an annealed 6063 aluminum alloy who was cold extruded (1 step, 2.8%). Zone axis ≈ (011).



. Fig.4 :TEM micrograph (200kV, BF) shows sub-grains containing a structure with some cellular structure inside them and some already identified precipitates in an annealed 6063 aluminum alloy who was cold extruded (1 step, 2.8%) and cold deformed on torsion (20 cycles, 2.8%). Zone axis ≈ (011).

Fig.5 :TEM micrographs, 200kV, BF; shows fine sub-grains, precipitates in grain boundary, dislocation tangles near small precipitates (Fe_3SiAl_{12}, Mg_2Si) in an annealed 6063 aluminum alloy who was cold extruded (2.8%), central region. Zone axis ≈ (011).