HARDENED ALUMINUM WITH OXIDE PARTICLES

Florentina POTECASU, Octavian POTECASU, Elena DRUGESCU
"Dunarea de Jos" University,
e-mail: fpotec@ugal.ro

ABSTRACT

The paper presents the effect of size and dispersion degree of the particles of aluminum oxide, on structure, mechanical characteristics and phenomena that take place when heating at different temperatures for recrystallization, for some samples obtained through deformation of superficially oxidized aluminum powder.

The powder necessary for research had a grain size smaller than 40 μm and it was obtained in lab on a pulverization installation with air-jet. The fine film dispersion of oxide in the metallic matrix was obtained as an effect of extrusion with high degrees of the compressed products of superficially oxidized powder (from compressed with diameter of 20 mm to tests with diameter of 3 and respectively of 4 mm). For comparison reasons semi-products of cast aluminum were deformed under the same conditions.

The maintaining temperatures of thermal treatment ranged from 350-550^{o}C. At heating the oxide particles are stable and have a role of barrier against dislocations, therefore delay the interactions among dislocations and thus maintaining high mechanical resistances for the hardened aluminum matrix as compared to cast aluminum (without particles). The hardening effect through dispersion is as much higher as the deformation degree of tests from superficially oxidized powder increased, which determined o more pronounced finishing of the oxide particles and a greater dispersion of the fine oxide particles in aluminum matrix.

KEYWORDS: aluminum, oxide, dispersion, hardening

1. Introduction

The enhanced mechanical resistance, including at high temperatures, for a hardened material through dispersion with non-metallic particles is due to interactions among matrix dislocations and the fine precipitates, interactions that diminish the dislocations mobility. The obstacles that the particles create for moving the dislocations in the alloy's matrix are made on the one hand by the presence of these disperse phases, and on the other hand by the existing stress fields around these ones.

Starting from these reasons, the paper presents the influence of stable Al_2O_3 particles, hardening on structure, mechanical characteristics and the phenomena that take place at heating done at different temperatures for recrystallization, in the case of some deformed tests of superficially oxidized aluminum powder with a grain size smaller than 40 μm.

2. Experimental conditions

The aluminum powder used for experiments was obtained in the lab on a pulverization installation with air-jet. The oxide dispersion in the metallic matrix, was realized through extruding the compressed products of superficially oxidized powder with the grain size of < 40μm, initially compressed and sintered at 550^{o}C. When passing by the calibration zone of the matrix, it occurs a profound deformation due to initial diameter reductions of 20 mm to final diameters of the extruded tests of 4 and respectively of 3mm.

As an effect of this deformation, the particles of fragile oxide that cover the aluminum powder particles, are crumbled and controlled carried along in the aluminum matrix of the extruded tests. Under the same conditions of extrusion the blank tests were obtained of cast aluminum with identical deformation degree, similar to the cases of hardened.

tests with oxide, of ε_1 =25 and respectively of ε_2 = 44. The deformation degree « ε » was determined as a report of the initial section, before deformation and the final section of the extruded test ($\varepsilon = S_0/S_f$).

3. Experimental results

In fig.1 it is presented the microstructure of oxidized powder tests and of cast aluminum, extruded at the diameter of 3 mm (ε_2 = 25).

The cold-hammered tests were heated at different temperatures within the range of 350- 550^{o}C and the structural changes and mechanical properties for applied conditions were analyzed.

In fig. 2 it is presented the graph with the temperature influence of thermal treatment on mechanical resistance and elongation determined at the tensile breaking test both for the samples of aluminum extruded through dispersion and for those of aluminum hardened through dispersion with fine oxide particles.

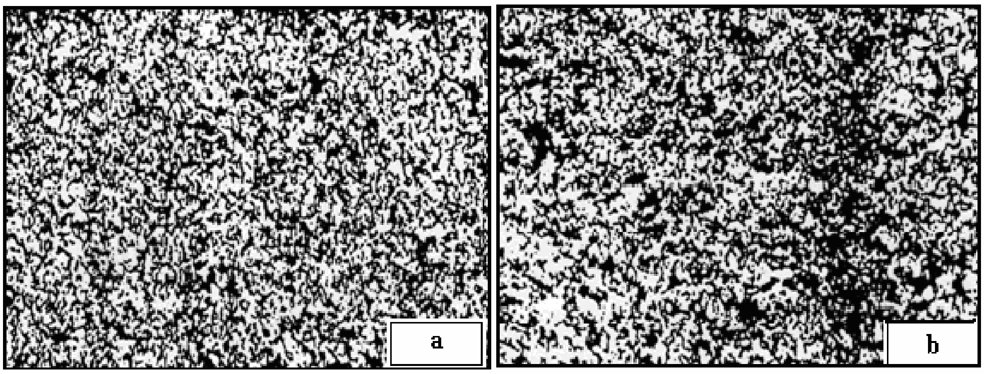

Fig. 1. *Microstructure of cold-hammered samples with ε_2 = 44: a-aluminum hardened through dispersion with oxide particles; b-aluminum (increase: x 250: metallographic attack: 10% HF)*

Experiments highlighted the importance of oxide particles in blocking the dislocations thermodynamic activated by heating. Thus, superior values of mechanical resistance were obtained, for extruded samples with the same deformation degree in the case of aluminum hardened with oxide (curve 3) as compared to those not hardened (curve 1).

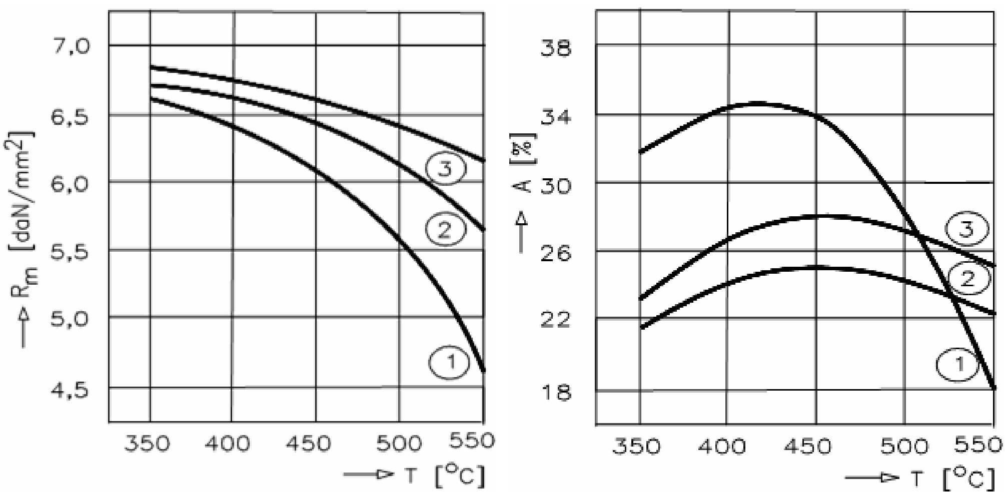

Fig. 2. *The temperature influence of thermal treatment on mechanical resistance and elongation on extruded samples: 1-aluminum (ε_2 = 44); 2 - aluminum hardened through dispersion with oxide particles (ε_1 = 25); 3 - aluminum hardened through dispersion with oxide particles (ε_2 = 44).*

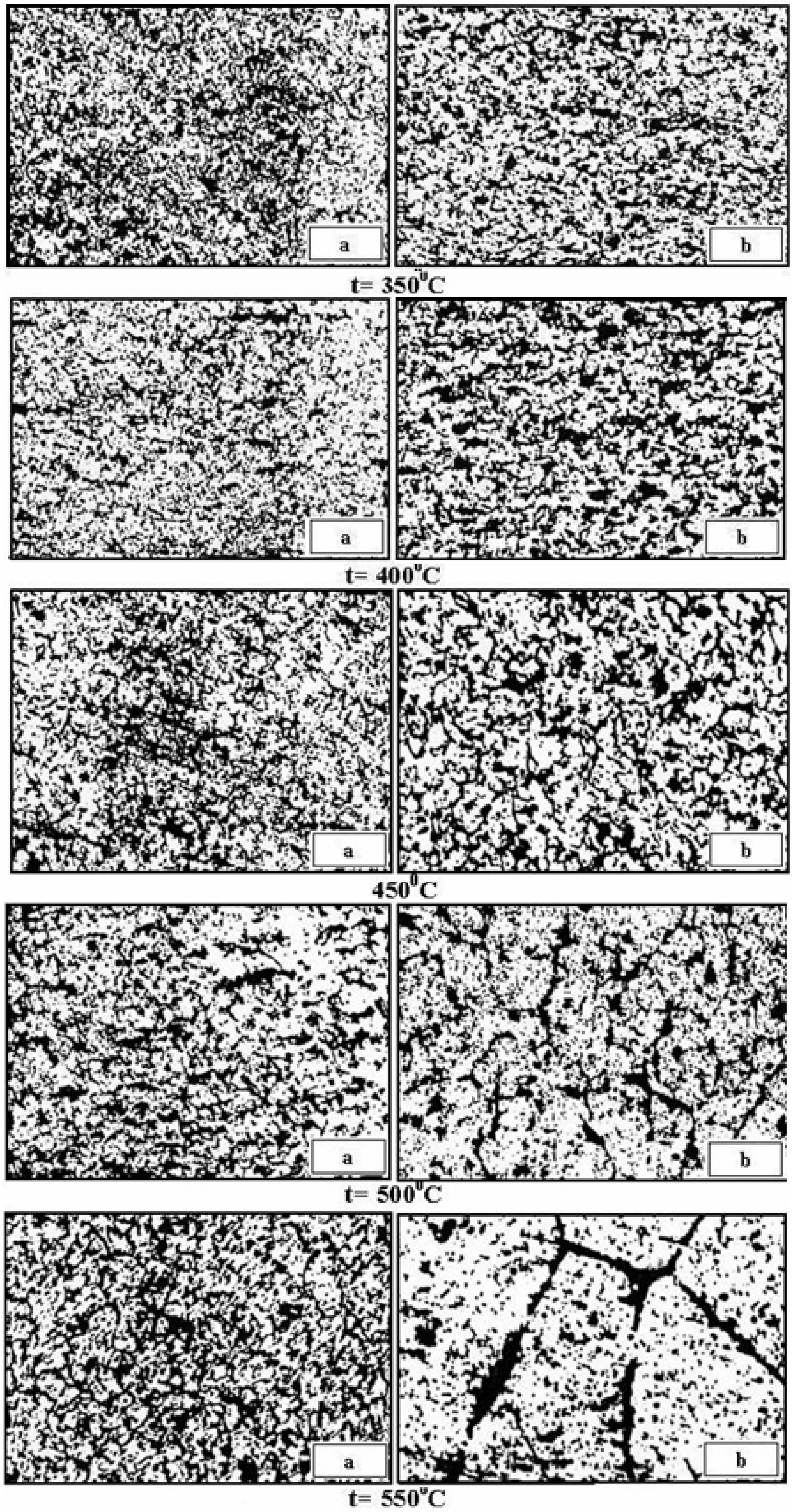

Fig. 3. Microstructure of extruded samples with ε_2 = 44 and maintained for 1 hour at different temperatures of annealing thermal treatment: a – aluminum hardened through dispersion with oxide particles; b – aluminum (increase: x 250 ; metallographic attack: 10% HF)

One can notice also, that when increasing the deformation degree (curve 3) the more pronounced finishing of the dispersed particles (as compared to curve 2) lead to higher number of obstacles against dislocations, which determined a more pronounced hardening of the metallic matrix associated with a better plasticity.

If above 450 ^{o}C the aluminum softening is speeded, for the hardened aluminum the decrease is diminished.

The results of the mechanical tests are confirmed also by the microstructural analysis presented in fig. 3 for cold-hammered samples, thermically treated at different temperatures within the range of 350-550 ^{o}C with maintain periods of 1 hour.

4. Conclusions

The experiments presented in the paper showed that the metallic matrices get hardened by extruding with high degrees of the compressed products of superficially oxidized powders.

The hardening of extruded materials through dispersion with fine particles is obtained as a result of crumbling the fragile films of oxide that clothe the powder particles. The dispersed oxide particles are barriers against dislocations and, thus, when heated, the metallic matrix keeps itself a high density of dislocations. This brakes the increase of the grains at thermal treatment of recrystallization and it gives to the extruded products superior characteristics of mechanical resistance and one can notice a good creep behavior also. Products hardened through dispersion of hard and stables particles, can be obtained by deforming from superficially oxidized powders. They have superior mechanical characteristics that can work under higher temperature conditions as compared to the same metallic matrices without hardening phases.

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