STRENGTHENING MODEL OF ALUMINUM ALLOYS DURING IMPULSE COMPRESSION

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The possibility of strengthening of some aluminum alloys during impulse treatments was shown in several papers. After explosive loading we also proved impulse strengthening of aluminum alloys. Microstructure changes during and after impulse explosive loading are discussed and the strengthening model is proposed.

INTRODUCTION

Deribas proved strengthening phenomenon after explosive compression of aluminum alloy D16 (1). Tensile strength σ_{TS} was increased from 240 to 450 MPa, hardness increased 1.1-1.23 times, elongation δ decreased from 18-23% to 5-8%. Kylesza and Dabrowska discovered strengthening effect, formation of stacking faults and dislocations structures, after impulse treatment Cu-Al alloys (2). Strengthening effect of aluminum alloys during high rate deformation was shown also in (3,4).

EXPERIMENTAL RESULTS

Two aluminum alloys were investigated, B95 (Zn 6.1, Mg 2.2, Si 0.1, Mn 0.4, Cr 0.16, Fe 0.15%, Al-bal.) and D16 (Cu 4.3, Mg 0.6, Mn 0.6%, Al-bal.), thermally treated at 500°C and aged. Scheme of an impulse explosive loading is given in Fig.1.

Explosive treatment for B95 alloy increased σ_{TS} from 490 to 600-880 MPa. HM_{50} decreased from 100-115 to 100, δ decreased from 13-14% to 5-6%. In initial condition, structure of alloy B95 had

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mechanical texture and consisted of solid solution plus second phase inclusions η ($MnZn_2$), T ($Al_2Mg_3Zn_3$). Explosive treatment practically eliminated a texture, and second phase particles had more round form after than before the treatment. Explosive treatment for alloy D16 increased σ_{TS} from 220 to 350 MPa. Yield strength σ_{YS} changed from 110 to 190 MPa, HM_{50} from 93 to 112, δ from 18% to 10.3%. For pure aluminum AD1 (Al-99.6%) σ_{TS} was the same (70 MPa) before and after treatment, δ decreased from 32% to 17%. Explosive treatment increased porosity for several percents.

STRENGTHENING MODEL

In 1980 Polyakov (5) presented a character of stress distributions near second phase particles before and after explosive treatment (Fig.2-4) and gave a formula of impulsive strengthening due to changing of second phase configuration

$$\sigma_m = \sigma_m^M - \frac{1}{S_o}\int_{S_{sp}} \sigma_{sp} dS \qquad (1)$$

where σ_m^M denotes strength of material's matrix with inclusions, S_o cross-section, S_{sp} - second phase particles cross section, σ_{sp} - stresses near second phase particle.

In the case of large and irregular second phase particles the second term of right side of expression (1) is very large. But when the second phase particles are comparatively round and small, this term is negligible. If one takes into account a porosity a strength estimation formula will be

$$\sigma_m = \sigma_m^M - \frac{1}{S_o}\int_{S_{sp}} \sigma_{sp} dS - \frac{1}{S_1}\int_{S_p} \sigma_{sp} dS \qquad (2)$$

where S_p denotes cross-section of the pores, $S_1 = S_o - S_p$, σ_p -stresses near pore zones.

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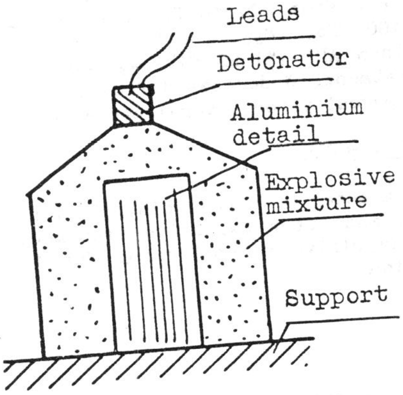

Figure 1 Scheme of contact explosive compression

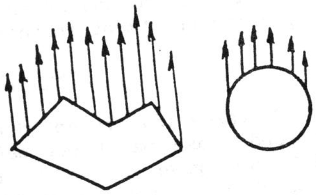

Figure 2 Scheme of stress distribution near particle

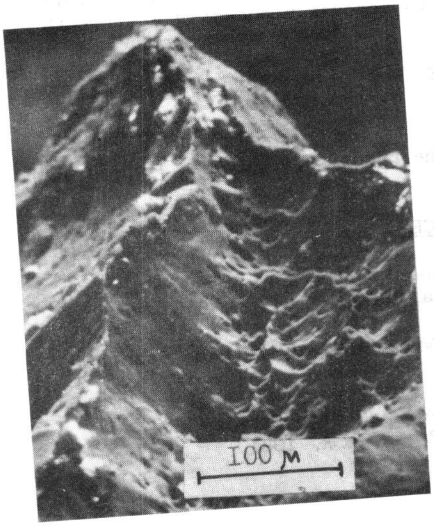

Figure 3 Fracture surface Al AD1 treated specimen

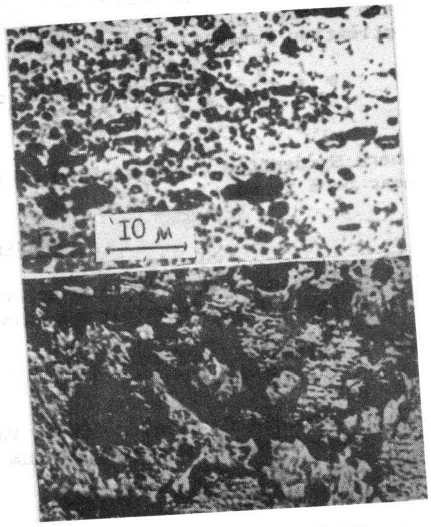

Figure 4 Microstructure before and after treating