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EFFECT OF THE THERMOMECHANICAL TREATMENT ON CHARACTERISTICS OF THE Al-Mg-Si ALLOYS

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Abstract: *It has long been known that it is possible to strengthen AlMgSi alloys by means of theat treatment and plastic deformation. Investigations in that directionresulted in the discovery of very interesting alloys with high physicomechanical parameters.In the paper are given the results of researches of composition and treatment parameters effects on hardening rolled sheets of the AlMgSiCu alloys. It is found that the hardening value depends on degree of deformation, deformation programmed and copper content. It is shown that alloys subjected to less intensive deformation and those with larger copper concentration display a characteristically larger hardening effect.*
Keywords:*thermomechanical treatment, hardening*

INTRODUCTION

It has long been known that it is possible to strengthen AlMgSi alloys by means of theat treatment and plastic deformation. Investigations in that direction, such as [1, 2], resulted in the discovery of very interesting alloys with high physicomechanical parameters.

Although thermmechanical treatment is widely used, ther are still many questions associated with the influence of cold plastic deformation, and particularly of a deformation programme combined with alloying, on hardening of AlMgSiCu alloys which remain unanswerwd. One would expect a change in the cold rolling programme to affect not only hardening but also the structure and residual stresses in the material [3].

Investigation made on copper [4], steel [5] and AlMgSi alloys [3,6,7] show that the distibution of stress at the deformation centre during rolling resulting from defferent deformation programmes gives rise to local changes at the deformation centre.We know [8] that the stress distribution at the deformation centre during rolling is determined by a set of geometric parameters; for instance, the pressure distribution depends on the ratio l/x_m (l is the length of the deformation centree; x_m- mean thickness of deformed specimen). The deformation is inhomogeneous at the centre and that has a strong influence on turn of the crystallites and on hardening [9, 10].

EXPERIMENTAL

We have investigated two AlMgSiCu alloys. The first (denoted L_1) contained 0-57%, the second (L_2) 1-0,4% copper. The two alloys contained the same quantity of Mg_2Si phase – 1-5%. The aluminium used in preparation of the alloys was 99-99,5% pure.

After homogenization for a day at 520 ^{0}C and preliminary rolling with annealing (15 min, 520^0) and quenching in cold water, sheets of the alloys were deformed to different degrees: 15, 30, 50, 70 and 80%. After preliminary annealing for 30 min at 520^0 in salt bath and quenching in water the specimens were aged for 10 min at 160^0.

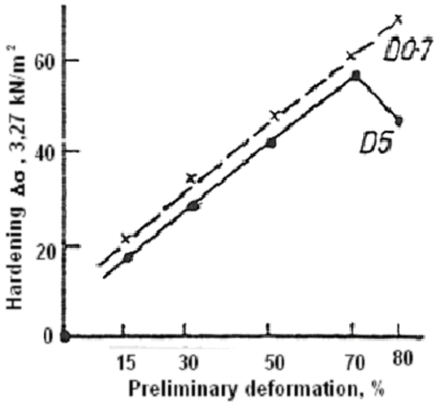

Figure 1. *Relative hardening of alloy L_1, as a function of degree of deformation and deformation programme: • - D5; × – D0,7; □ - IA; $\varphi=40^0$*

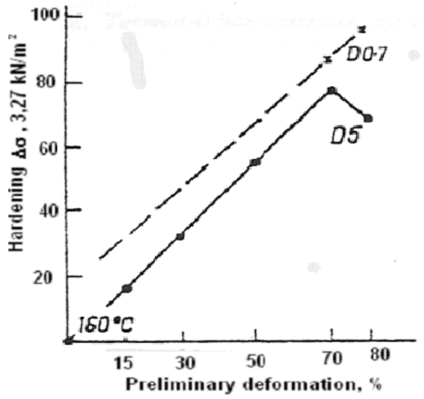

Figure 2. *Dependence of relative hardening of alloy L_2 on degree and programme of deformation.● - D5; × – 0,7; ■ - IA; $\varphi=40^0$*

The aged specimen was deformed in twee programmes. The first, with $l/x_m \geq 5$, involved a small number of passes, and will be denoted *as programme D5. The second, D0-7, with $l/x_m \cong 0\text{-}7$, involved a large number of passes. In both cases the rate of deformation was constant – 0,73 sec^{-1}. Hardening of the specimen was examined after initial ageing (IA) and initial ageing and deformation (IA+D).*

In order to determine hardening, the specimens were subjected to variable deformation by bending with a given maximum angle of bend [10].

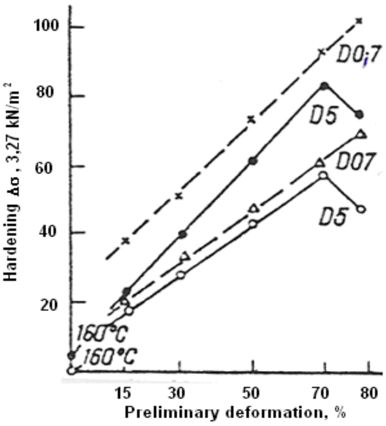

***Figure 3.** Relative hardening of alloys L_1 and L_2 as function of degree and programme of deformation separately: alloy L_1: △ – D 0,7; □ - IA; ◆ - D5; alloy L_2: ■ - IA ; × - D0,7; ○ - D5; $\varphi=40^0$*

The increment of flow stress $\Delta\sigma$ was determined relative to the flow stress for specimens after IA with angle bending $\varphi=40^0$. In order to eliminate the contribution of bending to hardening, the angles of residual bending φ_r were verified to be the same for the same instantaneous angle of bend φ.

RESULT AND DISCUSSION

The results are shown in Figures 1, 2 and 3. Figures 1 and 2 shows the dependence of relative hardening of the alloys as a function of degree of deformation and programme. The dependence of hardening of the alloys on copper content and degree of deformation and programme.

The dependence of hardening of the alloys on copper content of deformation and programme is shown in Figure 3.

For both alloys, maximum hardening is obtained at 15% deformation (see Fig. 3). Hardening continues to grow with further increase in degree of deformation, but at a lower rate relative to the initial increment at 15%. A difference is first seen in the curves for the IA+D specimens after 70% deformation: for the less intensive deformation programme (Fig. 3, D0,7) hardening is greater than that achieved at 70%, while for the more intensive programme (Fig. 3, D5) it is lower.

The $\Delta\sigma$ value for programmes D5 and D0,7 can be compared with the hardening value after IA+D.

It turns out that the hardening effect is greater for programme D0,7 than for D5, and greater for alloy L_2 than L_1.

The results show that, other conditions being equal, the copper content in AlMgSi influences hardening of the alloys (see Fig. 3). The hardening value of specimens of alloy L_2 after IA and IA+D is higher than for similar specimens of alloy L_1 (see Fig. 3). We assume that copper is responsible for higher dispersion of the inclusions, increasing the number of nucleation centres [11, 12] and thereby improving corrosion resistance and the mechanical parameters of the AlMgSi alloy.

CONCLUSION

All the specimens had identical treatment before deformation, that is, they had identical structure, and identical thickness after rolling. We can therefore say that the observed differences in hardening of AlMgSi alloys are due to: a) difference in copper content and b) use of different deformation programmes.

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