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INCREASING THE RESOURCE OF PLASTICITY OF ALUMINUM ALLOY AMG6 BY THERMOMECHANICAL TREATMENT UNDER UNIAXIAL TENSION CONDITIONS

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ABSTRACT

Increasing of the plasticity resource by thermomechanical treatment by using intermediate annealing in the deformation process is investigated. Tensile tests were performed on the specimens. The elongation of the plasticity of the aluminum alloy AMg6 by thermomechanical treatment during tensile tests was determined. It is established that the decrease in the efficiency of intermediate annealing at individual transitions is explained by the accumulation of metal damage during previous deformation. The assessment shows that intermediate annealing provides an increase in the resource of plasticity of the material in 1.5… 1.6 times.

INTRODUCTION

In recent years, intensively developing processes that extend the resource of plasticity due to thermomechanical treatment, which is a parallel or sequential action of load factors and temperature effects [1-6]. Such methods include the use of intermediate annealing, as well as high-temperature isothermal molding of complex structural materials. Important rheological characteristics can be considered the ultimate elongation and their features of resistance to deformation. Due to the emergence of new hard-to-deform materials and alloys since the 70s of the last century, the task of the theory of plasticity is to determine the possibility of technological operations of plastic formation of samples from different materials without destruction. At the same time, the assessment of the plasticity resource becomes a difficult and sometimes unsolvable task.

The aim of the work is to study the elongation of the plasticity resource by thermomechanical treatment through the use of intermediate annealing in the deformation process.

EXPOSITION

The method of work determines the procedure for uniaxial tensile experiments with intermediate annealing. The total elongation of the samples during the experiments is determined in accordance with the above algorithm.

The procedure for the experiment is as follows:

1. Divide specimens into five groups (1, 2, 3, 4, 5), their marking.
2. Measurement of the exact sizes of specimens by an electronic caliper.
3. Annealing of all groups of specimens.
4. Tensile tests before the destruction of the 1st group of specimens (1.1, 1.2, 1.3) and determination of their δ_{max1}
5. Tensile tests of specimens of group 2 (2.1, 2.2, 2.3), group 3 (3.1, 3.2, 3.3) and group 4 (4.1, 4.2, 4.3) to the value $\delta_1 = 0{,}5\delta_{max1}$.
6. Annealing of specimens of groups 2, 3, 4 and 5.
7. Tensile tests before the destruction of the 2nd group of specimens and determination of their δ_{max2}.
8. Tensile tests of specimens of groups 3 and 4 to size $\delta_2 = 0{,}5\delta_{max2}$.
9. Annealing of specimens of groups 3, 4 and 5.
10. Tensile tests before destruction of the 3rd group of specimens and determination of their δ_{max3}.
11. Tensile tests of specimens of the 4th group to the value $\delta_3 = 0{,}5\delta_{max3}$
12. Annealing of specimens of groups 4 and 5.
13. Tensile tests before the destruction of the 4th group and determination of their δ_{max4}.
14. Tensile tests before destruction of specimens of the 5th group (5.1, 5.2, 5.3) and determination of their δ_{max5}.

Here:

$\delta_1, \delta_2, \delta_3$ – used the resource of plasticity of the workpiece at the appropriate transition;

δ_{max0} – the maximum resource of plasticity of the source material of the workpiece after heat treatment - annealing;

δ_{max1}, δ_{max2}, δ_{max3}, δ_{max4} – the maximum value of the resource of plasticity (relative elongation) at the corresponding transition;

δ_{max5} – control value to determine the effect of heat treatment on the properties of the material.

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According to the following dependence, the total plasticity resource was determined:

$$\delta_{\Sigma} = \delta_1 + \delta_2 + \delta_3 + \delta_{max\,4} \quad (1)$$

This plasticity resource reflects the effect of intermediate heat treatment (annealing) operations on the ductility of the alloy.

Temperature modes of heat treatment (annealing) for the experiment:

- heating temperature of workpieces– 325 ˚C;
- exposure time in the heated state – 30 min;
- type of final cooling – in air.

The method of conducting studies on uniaxial tension was performed according to ISO 6892-1:2016 «Metallic materials — Tensile testing — Part 1: Method of test at room temperature».

In Fig. 1 shows the dimensions of the experimental specimens for uniaxial tension.

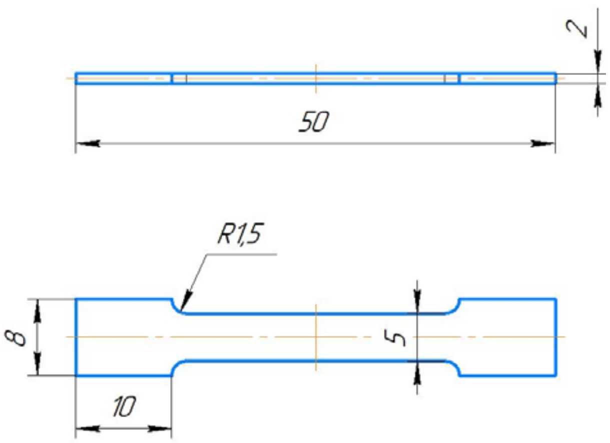

Fig. 1. Specimen drawing

To conduct an experimental study to determine the elongation of the ductility by thermomechanical treatment, 15 samples of 2 mm thick sheet of aluminum alloy AMg6 were used for uniaxial tensile tests.

The total plasticity resource after the experiment was determined by the values of the used plasticity resources at each transition:

$$\delta_{\Sigma} = 13{,}1 + 10{,}6 + 7{,}9 + 9{,}7 = 41{,}3\%$$

Therefore, $\delta_{\Sigma} > \delta_{max\,1}$ in 1,58 times.

The graph of dependence of the maximum value of relative elongation (plasticity resource) on quantity of annealing is shown in fig. 2.

As a result, it is established that the preliminary plastic deformation of 50% of the plasticity resource gives an increase in the plasticity resource following:

a) on the IItransition:

- the residual plasticity resource is 13,1 %;
- the recovered resource of plasticity is 21,3 %.

Therefore, the plasticity resource was increased 1.6 times.

b) on the III transition:

- the residual plasticity resource is 10,7 %;
- the recovered resource of plasticity is 15,9 %.

Therefore, the plasticity resource was increased 1.5 times.

c) on the IV transition:

- the residual plasticity resource is 7,9 %;
- the recovered resource of plasticity is 9,7 %.

Therefore, the plasticity resource was increased 1.2 times.

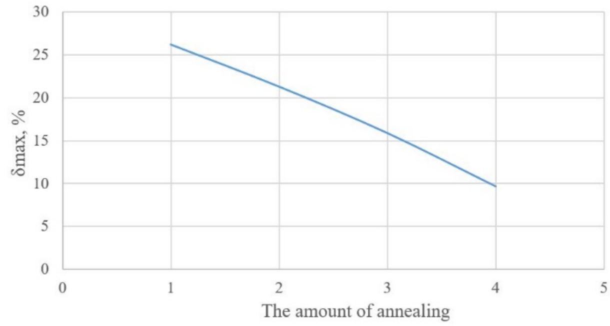

Fig. 2. Graph of the dependence of the maximum elongation on the amount of annealing

We introduce for the ratio of the reduced plasticity resource to the residual coefficient K - the recovery factor of the plasticity resource:

$$K = \frac{\delta_{max}}{\delta_i} \quad (2)$$

here δ_{max_i} - restored plasticity resource;

δ_i – residual plasticity resource.

The dependence of the coefficient K on the amount of annealing is shown in Fig. 3.

The group of specimens 5 indicates that the plasticity resource is not affected by the amount of annealing, as:

$$\delta_{max\,1} = 26{,}2 \approx \delta_{max\,5} = 26{,}1$$

Therefore, we can conclude that the annealing efficiency decreases due to the accumulation of metal damage during pre-deformation.

In Fig. 4 shows the dependence of the total plasticity resource on the amount of annealing.

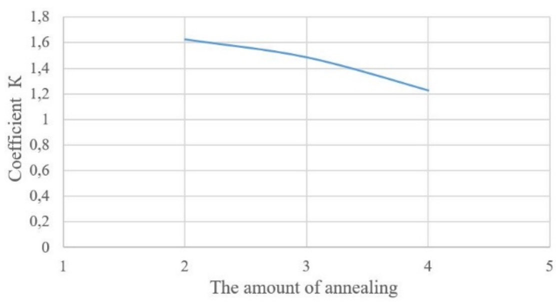

Fig. 3. Dependence of the coefficient K on the amount of annealing

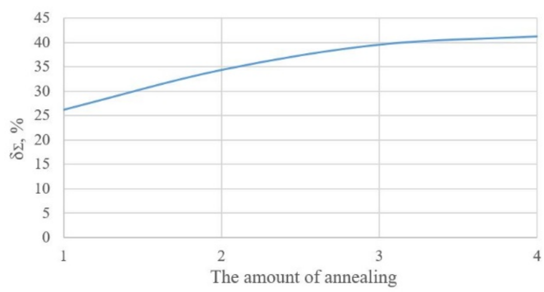

Fig. 4. Dependence of the total plasticity resource on the amount of annealing

CONCLUSION

The elongation of the plasticity resource of the aluminum alloy AMg6 due to thermomechanical treatment during tensile tests is determined. As a result, it was found that after one annealing the total plasticity resource was 26.2%, after two annealing - 34.4%, after three annealing - 39.6%, after four annealing - 41.3%. Therefore, as the number of anneals increases, the total plasticity resource increases.

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