THE INFLUENCE OF MODIFICATION ON THE STRUCTURE AND MECHANICAL PROPERTIES OF ALUMINUM ALLOYS

Tetiana Nosova
ORCID: https://orcid.org/0009-0009-1591-8811
Oles Honchar Dnipro National University, Dnipro, Ukraine

Stella Mamchur
ORCID: https://orcid.org/0009-0004-1600-6068
Oles Honchar Dnipro National University, Dnipro, Ukraine

INTRODUCTION

Requirements for objects are determined by the conditions of their operation. Two main groups of influences can be distinguished: mechanical and climatic. Mechanical impacts associated with the operation and transportation of products include overloads, vibrations, shocks, and acoustic loads. Climatic influences are characterized by the following components: temperature, pressure, humidity, dust.

In addition to climatic and mechanical influences, chemical, biological, radiation, magnetic, electrical, and electromagnetic influences are possible [1]. Ensuring resistance to mechanical, climatic, and other influences is necessary for the normal functioning of mechanisms, components, and parts. Atmospheric humidity causes corrosion of metals, swelling and loss of strength of non-metals.

OBJECTIVE AND TASKS

The work examines the choice of corrosion-resistant material for the brake housing of the wind power plant VEU-250, which is installed in areas with appropriate wind load. When developing this unit, it is necessary to consider climatic influences - temperature, dust, sand, sea water. The ambient temperature range during operation of the VEU-250 is usually (+60 ...- 60) C. The VEU consists of a foundation, a power cabinet including power contactors and control circuits, a tower, a ladder, a rotating mechanism, an electric generator, a system for monitoring the direction and speed of the wind, a brake housing, transmission, blades, and a rotor cap. The wind power plant is located at a high altitude (24-36 m), it is necessary that the structure has minimal weight.

Therefore, it is necessary to select a material for this part that would combine minimum density and high strength. Aluminum alloys fully

satisfy these requirements. This paper examines aluminum alloys.

MATERIALS AND METHODS

When comparing aluminum alloys, for example AL4S, AL5, AL9, the AL4S alloy has the best manufacturability (high ductility). The necessary plasticity is needed so that when drilling holes for the bolts (alternating and fatigue loads occur), thanks to which the housing is attached to the gearbox, the part does not collapse. In AL9, the ductility is the same as in AL4S, but the yield strength is significantly lower. Exposure to sea water and fog leads to the formation of a conductive medium on the surface of the part, and in the case of a potential difference caused by structural heterogeneity, corrosion destruction may occur (due to the appearance of a liquid conductive film of a salt solution).

The current sharply increases, leading to the dissolution of the anodic areas and the formation of pitting, which causes corrosive destruction. Therefore, the material and its manufacturing technology must provide the highest possible corrosion resistance [2, 3].

An analysis of methods for producing parts from aluminum alloys shows that for the part under development, made from AL4S material, it is better to use chill casting. This type of casting is cost-effective and significantly improves the mechanical properties of products. The economic feasibility of producing castings in a mold is determined by their serial quantity and the cost of manufacturing and the stability of the molds.

The work proposes a technology for modifying an aluminum alloy to improve mechanical properties, since in this alloy the mechanical properties change slightly because of heat treatment. Since the additions of modifying elements are usually very small, it is assumed that they do not have a noticeable effect on the phase composition of the alloy and affect its properties, the crystallization process, and the grain size of the main structural component.

An analysis of work [4, 5] related to the modification of aluminum alloys shows that a low concentration of elements reduces the grain size of aluminum. All of the listed elements, except boron, are among the transition elements of the fourth, fifth and sixth periods. Thus, the refinement of aluminum grains during crystallization is the result of a special interaction between these metals and aluminum.

Available literature data on the effectiveness of modifying aluminum with various transition metals, as well as some other factual data regarding the modification process, show the influence of modifiers on the grain size of cast aluminum grades of alloys A99 and alloy AL7, from which it follows that the effect of transition metals is more effective (degree of

grinding grains are higher), which is due to the smaller number of electrons on the - shell of their atoms.

RESULTS

When the concentration of modifying additives increases above a certain value, the modification effect does not increase, and in some cases even decreases, which is explained by the enlargement of particles of chemical compounds due to their coagulation. The results of changes in the microstructure after modification are shown in Fig. 1, 2.

Figure 1 - Microstructure of not modified silimunes

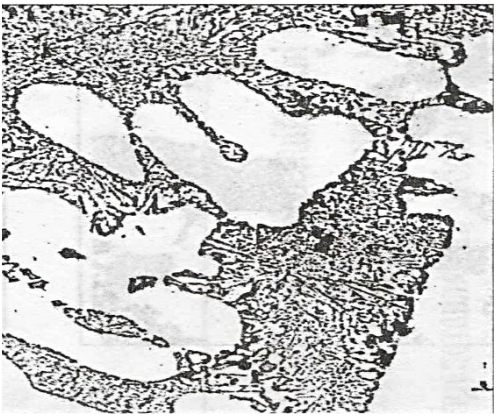

Figure 2 - Microstructure of modified silimunes

The microstructure of modified silumin is a solid solution and fine eutectic.

Silumin AL4 is additionally doped with 0.2-0.3%. In this case, a phase is formed in the alloy, which is an effective hardener during heat treatment, therefore silumin AL4 is a thermally hardenable alloy [6]. AL4 alloy is used to cast large, medium-load parts that operate at temperatures up to 200 C. Aluminum-silicon alloys with 10-13% Si (AL2 alloy) are used for castings of complex shapes, which do not require high mechanical properties. With higher requirements for strength properties, special silumins are used - hypoeutectic silumins with 4-10% Si with the addition of copper, magnesium and manganese (AL3, AL4, AL5, AL6 and AL9 alloys).

Metallographic analysis was carried out on a sample cut from the part. The production of a metallographic section was carried out in concentrated acid. The microstructure consists of: - Al solid solution, + Si eutectic, AlSb intermetallic phases.

Tests carried out to determine the mechanical properties showed that after modifying the aluminum alloy, the tensile strength increased from 240 MPa to 270 MPa, hardness - from 70 HB to 85 HB, ductility - from 4% to 6%.

CONCLUSIONS

1) Research was carried out on modifying the AL4S alloy with sodium and antimony. The microstructure after modification consists of: -Al solid solution, +Si eutectic and AlSb intermetallic phases. The AlSb intermetallic phase is located in the center of the solid solution grains and contributes to the strengthening of the alloy after quenching and aging.

2) The basic principles of changes during aging and factors influencing changes in the structure of a material during aging have been studied. It has been shown that the performance properties of materials can be changed by appropriate heat treatment regimes. To improve the properties of the AL4S alloy, it is proposed to quench in heated water at a temperature of 535 C for 5 hours. After hardening, as in the basic process, there will be no 2-hour interval; we perform aging immediately at a temperature of 160 C for 12 hours and thereby save 6 hours in time. Cooling during hardening is carried out in water, and during aging in air. This mode is proposed to increase corrosion resistance, weldability and satisfactory machinability.

3) Tests for mechanical properties according to GOST 1497-84 showed that the tensile strength increased from 240 MPa to 270 MPa, hardness - from 70 HB to 85 HB, ductility - 4% to 6%.

4) Economic effect: from reducing heat treatment time, as well as from replacing equipment with cheaper ones.

5) The results obtained make it possible to use the AL4S alloy for the manufacture of parts for more critical purposes, as well as to increase the service life of the brake housing. Combining high casting and mechanical properties, AL4S is one of the best aviation casting alloys based on aluminum.

REFERENCES

1. Kalinina, N., Davydyuk, A., Kalinin, A., Nosova, T., Mamchur, S., & Savchenko, I. (2022). Advanced structure and power of aluminum alloys modified by dispersed compositions. *System Design and Analysis of Aerospace Technique Characteristics*, *26*(1), 80-84. https://doi.org/10.15421/471912

2. Kalinina, N., Davydyuk, A., Tsokur, N., & Nosova, T. (2023). Development of technology for modification of cast aluminum alloys with nanocompositions. *Journal of Rocket-Space Technology*, *31*(4), 76-80. https://doi.org/10.15421/452310

3. Kalinina, N., Nosova, T., Kalinin, A., Mamchur, S., Shakhov, A., & Mamchur, I. (2019). Welding aluminium alloys refractory modifiers treatment – the effective method for characteristics increasing. *Journal of Rocket-Space Technology*, *27*(4), 74-78. https://doi.org/10.15421/451912

4. Kalinina , N., Kalinin , V., NosovaT., Mamchur, S., Serzhenko I., & Neznaiko, S. (2021). Interaction of structure and properties in modified aluminum alloys. *Journal of Rocket-Space Technology*, *28*(4), 96-102. https://doi.org/10.15421/452013

5. Dzhur, E., Kalinin, O., Dzhur, O., Nosova, T., & Mamchur, S. (2021). Advances in power of deformed aluminum alloys modified with nanocompositions. Space science and technology, 27(6), 98-104. https://doi.org/10.15407/knit2021.06.098

6. Nosova, T., Mamchur, S., Tsokur, N., & Komarov, M. (2021). Investigation of the process of modification of liquid aluminum alloys. *Visnik of Khnadu*, 94 (2), 55-59. https://doi.org/10.30977/BUL.2219-5548.2021.94.0.55