



Increasing the Strength of Casting Parts of Agricultural Machinery Made of Aluminum Alloys under the Influence of Modifying Elements

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Abstract. Currently, aluminum alloys are widely used in the production of agricultural machinery parts. This article discusses the technology of increasing the tensile strength of aluminum alloys under the influence of various modifying elements. Samples were cast and tested. The studies were conducted on aluminum-copper and aluminum-magnesium alloys from aluminum alloys. As a result of the tests, the tensile strength of aluminum alloys was increased by 5%-7%. Based on the results obtained, a graph was constructed showing the dependence of the number of modifying elements on the tensile strength. At the end of the article, the authors present their conclusions based on the results of the studies.

Keywords: aluminum, agricultural machinery, modification

1 Introduction

Aluminum alloys are widely used in the production of mechanical parts due to their lightness, strength and corrosion resistance [1-5]. In this regard, scientific research aimed at improving the mechanical properties of aluminum alloys is carried out by the world's leading research institutes [6-8]. One of the methods for improving the properties of aluminum alloys is the introduction of micro alloying elements into their composition [10-13]. In this research work, germanium oxide and silicon elements were introduced into aluminum alloys, aluminum-copper and aluminum-magnesium alloys as modifiers, and their effect on tensile strength was studied. Testing materials for tensile strength of alloys is a scientific experiment. The purpose of this is to determine the strength of materials under the influence of external forces. Tensile strength is one of the main characteristics of alloy deformation [14].

2 Materials and methods

Elongation or compression of a rod occurs under the action of forces acting along its longitudinal axis. Central elongation of a rod occurs under the action of two equal and oppositely directed forces F directed along the axis of the rod. The rod experiences central compression under the action of two forces F directed towards each other. In this case, a longitudinal tensile force - N occurs in the cross-section of the rod. If the longitudinal force causes elongation, then it is considered positive, if compression, then it is considered negative. Elongation or compression deformation consists of a change in the length and dimensions of the cross-section of the rod. The strength of metal alloys is one of its main characteristics. In addition, deformation (elongation) is the main characteristic for assessing the strength of a material. Tensile tests are carried out with a standard sample of the material in a state of uniaxial tension. To determine the strength of materials, the force applied to the sample is gradually increased until the solid sample breaks [15]. The ultimate strength σ_m of the test specimen is determined, and the specimen fails when the maximum loading force F_m occurs during the process. The ultimate strength σ_m is equal to the ratio of the maximum force F_m to the cross-sectional area of the specimen [16].

$$\sigma_m = F_m / A_o \quad (1)$$

Here: σ_m is the maximum stress created in the section; F_m is the maximum force; A_o is the cross-sectional area.

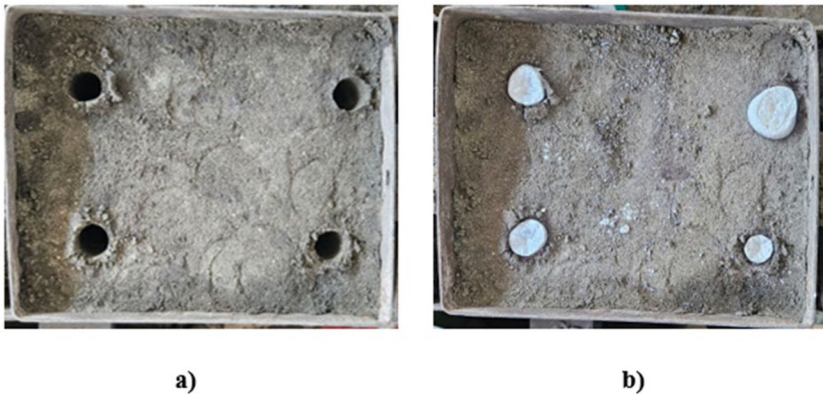


Fig. 1. a-sand-clay mold; b- cast samples.

For the experiments, germanium was added to the samples at 1%, 2% and 3% concentrations, and silicon was added to each sample at 5% concentration in combinations. Germanium oxide and silicon were added to aluminum-copper and aluminum-magnesium alloys, the samples were melted in resistance furnaces and cast into sand-clay molds (Figure 1).

Cast specimens (Figure 2) were processed for tensile testing [17]. The specimens were processed to the dimensions of DIN 50125. The tests were carried out on a universal tensile testing machine model WP 300 (Figure 3).



Fig. 2. Cast samples.

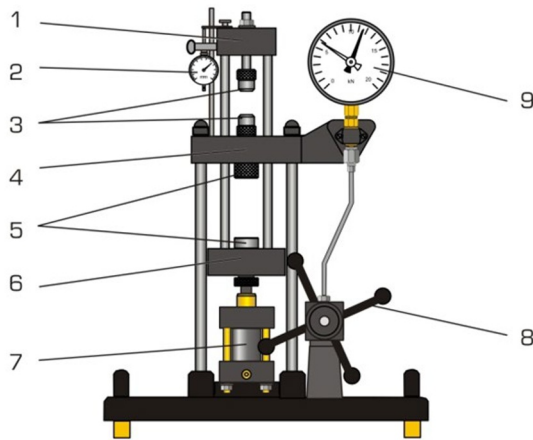


Fig. 3. 1 - upper crossbar, 2- indicator, tension sensor, 3- shape and expansion lock, 4- column, 5- compression part and pressure plate, 6- lower column, 7- hydraulic cylinder, 8- control wheel, 9- dynamometer.

3 Results

Based on the obtained results, the ultimate strength σ_m was calculated. In this case, the cross-sectional area of the sample was taken as $A_0 = 6 \text{ mm}^2$. The calculation results are given in the tables below.

Table 1. Results for aluminum-magnesium alloy.

№	Sample composition	The value of the maximum load force F_m	The value of the cross-sectional area of the sample A_o	Calculation formula	The value of the strength limit σ_m
1	Al-Mg	$6.284 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$22.23 \cdot 10^2$
2	Al-Mg-1%Ge-5%Si	$6.306 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$22.31 \cdot 10^2$
3	Al-Mg-2%Ge-5%Si	$6.653 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$23.54 \cdot 10^2$
4	Al-Mg-3%Ge-5%Si	$6.280 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$22.22 \cdot 10^2$

Table 2. Results for aluminum-copper alloy.

№	Sample composition	The value of the maximum load force F_m	The value of the cross-sectional area of the sample A_o	Calculation formula	The value of the strength limit σ_m
1	Al-Cu	$10.111 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$35.78 \cdot 10^2$
2	Al-Cu-1%Ge-5%Si	$10.138 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$35.87 \cdot 10^2$
3	Al-Cu-2%Ge-5%Si	$10.386 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$36.75 \cdot 10^2$
4	Al-Cu-3%Ge-5%Si	$10.082 \cdot 10^3$	0.2826	$\sigma_m = F_m / A_o$	$35.67 \cdot 10^2$

Graphs were developed to correlate the tensile strength values σ_m in the tables above with the germanium content of the aluminum alloy (Figure 4).

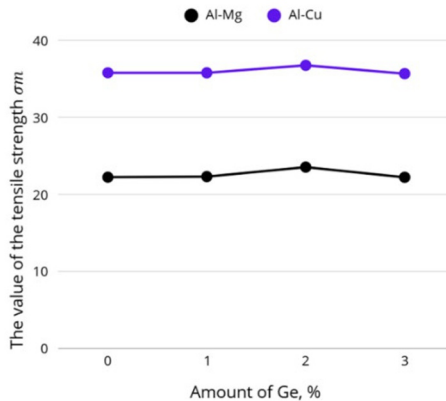


Fig. 4. Graph of the dependence of the values of the tensile strength σ_m on the amount of germanium in the aluminum alloy.

4 Conclusion

As can be seen from the graph in Figure 4 above, the germanium and silicon in the aluminum alloy served to increase the tensile strength of the alloy. The values of the tensile strength σ_m varied from $22.23 \cdot 10^2$ for the Al-Mg alloy to a maximum of $23.54 \cdot 10^2$. For the Al-Mg alloy, it varied from $35.78 \cdot 10^2$ to a maximum of $36.75 \cdot 10^2$. The maximum values of the samples were achieved when 2% germanium and 5% silicon were added to the alloy. Increasing the germanium content led to a decrease in its tensile strength.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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