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# Kompozitsion Materiallar

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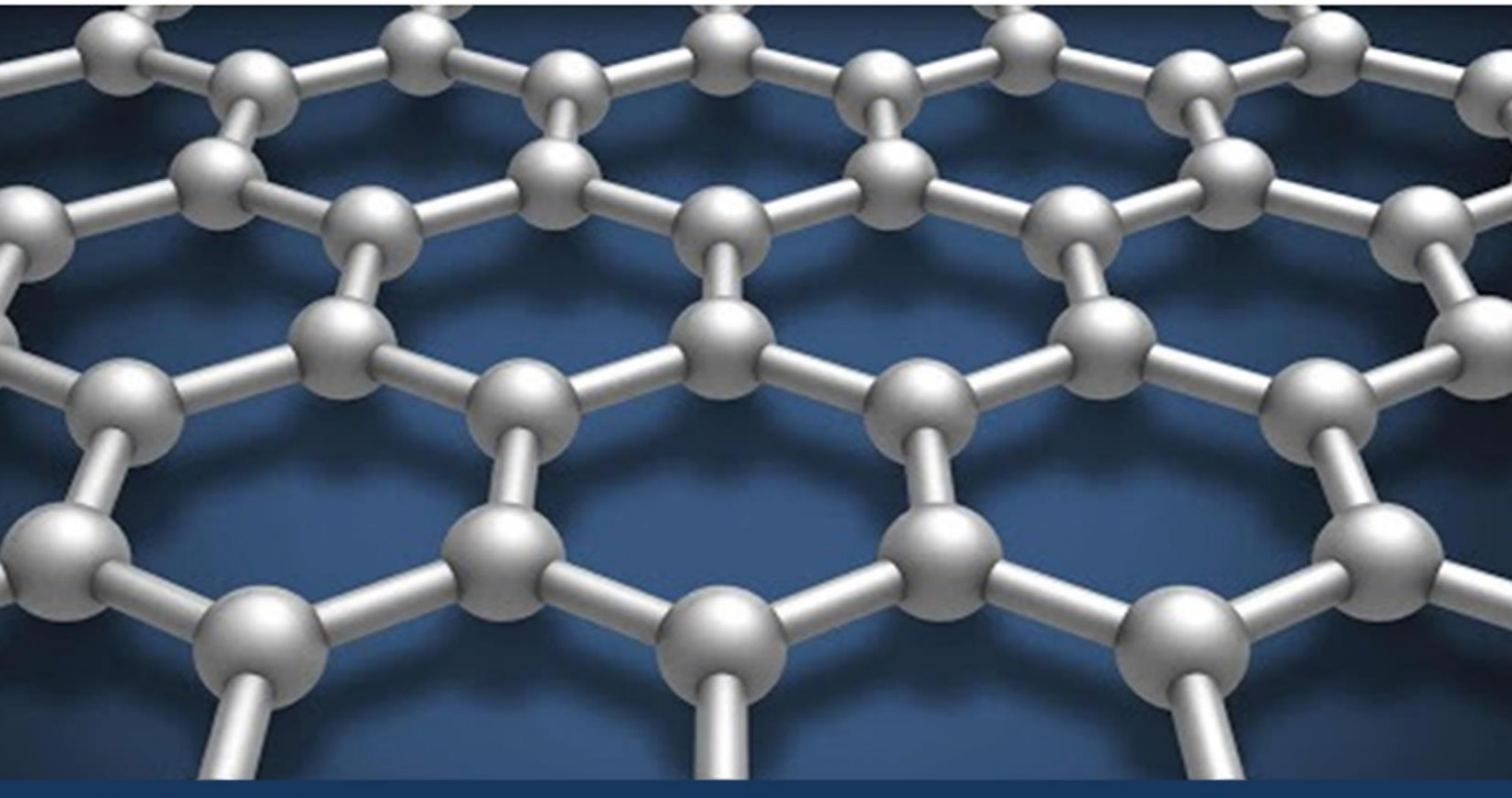

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## Композиционные материалы

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# THE CHANGE IN THE FLUIDITY PROPERTIES OF THE AL-CU ALLOY UNDER THE INFLUENCE OF MODIFYING ELEMENTS

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**Abstract:** The paper investigates the fluidity properties of aluminum-copper alloys with the inclusion of germanium oxide and silicon. The experiments show that when the germanium element is added in the amount of 1% in the aluminum alloy composition, the fluidity properties are improved. However, it can be observed that increasing the amount of germanium in the composition reduces its fluidity properties.

**Keywords:** fluidity, aluminum, copper, alloy, temperature, oxide.

**Introduction.** The aluminum-copper alloy has several significant advantages compared to pure aluminum. These key properties include: High strength – The addition of copper enhances the mechanical properties of aluminum alloys, particularly improving strength and hardness [1-4]. Good thermal and electrical conductivity – Aluminum naturally has excellent thermal and electrical conductivity, and copper further enhances these properties. High corrosion resistance – Aluminum-copper alloys have good resistance to corrosion, especially when treated with special coatings. Lightweight – Aluminum is a lightweight metal, and its alloys with copper are used in applications where weight and strength are crucial. Ease of processing – These alloys are easy to weld, machine, and shape into different forms. Heat resistance – The presence of copper increases the alloy's ability to withstand high temperatures. Due to these properties, aluminum-copper alloys are widely used in aviation, automotive, electronics, construction, and shipbuilding industries [5-8]. Many scientists worldwide have conducted research on aluminum-copper alloys, achieving significant advancements in metallurgy and materials science. Alfred Wilm (1903) – The German metallurgist Alfred Wilm accidentally discovered in 1903 that aluminum-copper alloys become stronger over time after undergoing heat treatment. This discovery led to the development of duralumin, a new alloy that became widely used in the aviation industry. Paul Héroult and Charles Martin Hall (1886) – The French scientist Paul Héroult and the American scientist Charles Martin Hall independently developed the electrolysis process for extracting aluminum in 1886. This method significantly reduced the cost of aluminum production and expanded the possibilities for using its alloys with copper in industry [9,10]. Apart from the contributions of these successful scientists, modern research institutes and large metallurgical companies continue to conduct studies on this topic today.

**Materials and Experimental.** In this study, the effect of alloying elements on the fluidity of aluminum-copper alloys was investigated. During the experiment, the mass of the aluminum-copper alloy was measured and initially melted in a special electric furnace, then cast into a spiral shape. After the first process, the same procedure was repeated three times, with the aluminum-copper alloy being remelted. During these subsequent melting processes, germanium oxide powder ($GeO_2$) was added to the charge in amounts of 1%, 2%, and 3%. As a result, the oxygen in the charge was released, and the germanium oxide was absorbed (Figures 1a and 1b). Germanium is a chemical element in period 4, group 14 of the periodic table, with atomic number 32 and is denoted by the symbol Ge. In addition, similar to germanium oxide, silicon (Si) was also added to the charge in a fixed amount of 5%. Silicon is located in period 3, group 14 of the periodic table, with atomic number 14. In the experiment, the aluminum-copper charge was melted in an electric resistance furnace (Figure 1c).

a b c

Figure 1. Weighing the charge on a scale (a, b) and the resistance furnace (c).

During the melting process of the aluminum-copper alloy, the temperature of the electric furnace was set to 750°C using special control buttons. This temperature was chosen because if the alloy is not sufficiently melted, it may not react properly with the added elements. Therefore, adjusting the electric furnace to the required temperature is crucial during the charge preparation process.

To obtain an aluminum-copper alloy charge in a spiral shape, a special two-layer mold was prepared. The mold composition consisted of:

- 85% quartz sand
- 11% bentonite clay
- 4% water

The mixture was prepared using a special mixer. After one to one and a half minutes of mixing, the mold mixture reached the ready-to-use state, and the two-layer mold for the spiral shape was created (Figures 2a, 2b).

Since this type of mold could be used only once, a separate two-layer mold was prepared for each of the four casting stages. The casting process of the aluminum-copper alloy into the prepared mold is shown in Figure 2c.

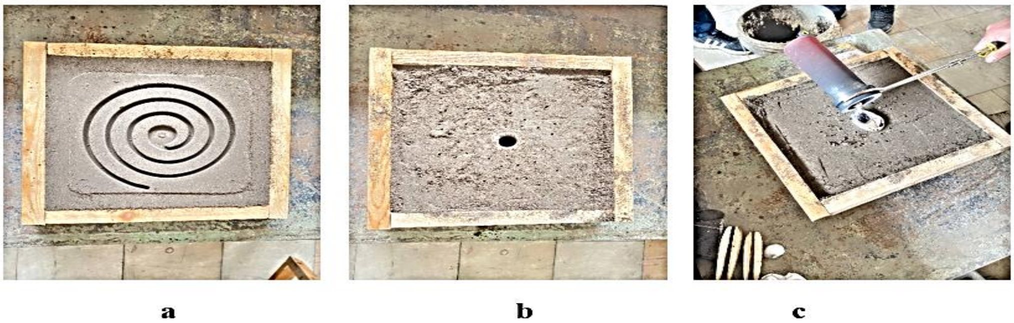

Figure 2. Molds (a, b) and the process of pouring the molten alloy into the mold (c).

**Results.** The spiral length of the aluminum-copper alloy charge was measured and compared at each of the four casting stages with the addition of different elements.

1. First stage: The initial aluminum-copper alloy was cast without any additional elements, resulting in a spiral length of 48.2 cm.
2. Second stage: 1% germanium oxide and 5% silicon were added to the aluminum-copper charge. The resulting spiral length was 45.8 cm.
3. Third stage: 2% germanium oxide and 5% silicon were added, leading to a spiral length of 42.5 cm.
4. Fourth stage: 3% germanium oxide and 5% silicon were added, and the measured spiral length was 40.5 cm.

From these results, we can conclude that adding germanium oxide and silicon to the aluminum-copper alloy reduced its fluidity instead of increasing it, as observed in the decreasing spiral lengths: 48.2 cm > 45.8 cm > 42.5 cm > 40.5 cm. (Fig. 4.)

Figure 3. Casted samples

**Conclusion.** Based on the conducted experiments, the following conclusions can be drawn:

1. The addition of silicon to aluminum-copper alloys results in a stronger bond formation after casting. Compared to the unmodified cast alloy, the silicon-modified alloy exhibited increased hardness and durability, suggesting better resistance to friction and wear.

2. The addition of small amounts of germanium oxide to aluminum-copper alloys led to a significant decrease in fluidity as the germanium oxide concentration increased.

The research findings demonstrate that aluminum-copper alloys react well with both silicon and germanium oxides, improving the microstructure and durability of final products. However, these additions significantly affect the alloy's fluidity during casting, which must be considered in industrial applications.

### 4. Прикладные, экономические и экологические аспект применения композиционных материалов

### 5. Методы исследовании, приборов и оборудований композиционных материалов