Effect of germanium oxide on the properties of aluminum casting details in agricultural machinery

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Abstract. The article presents research aimed at improving the properties of aluminum alloy by changing its composition when developing a pump housing part that can be made of aluminum alloys in agricultural machines. In the studies, germanium oxide was included in the composition of aluminum-manganese and aluminum-copper alloys, its effect on the alloy structure and hardness was studied. Scientists from all over the world have conducted many similar studies. In the experiments, the composition of the aluminum alloy included Germanium oxide in the charge in the state of coating with a special aluminum coating. Germanium oxide is part of the alloy in an amount from 0.1% to 0.3%, depending on the weight of the charge and taking into account the Germanium content in the oxide. Microscopic analysis of the cast samples was carried out using an optical metallographic microscope. In addition, the hardness of the samples was measured using an ITV-1-M hardness tester. Based on the results obtained, a graph of the dependence of Germanium oxide in the alloy on hardness was developed. Based on the conducted research, the authors draw their conclusions at the end of the article.

1 Introduction

Aluminum alloys have better mechanical and technological properties compared to pure aluminum. Therefore, aluminum alloys are widely used in mechanical engineering, aircraft construction, shipbuilding, construction and agricultural engineering. Aluminum stands out among engineering materials for its important properties (specific strength, electrical and thermal conductivity, as well as corrosion resistance). Aluminum forms solid solutions of variable composition, which look the same as alloying elements. Research aimed at improving its properties as a result of increasing industrial demand for aluminum alloys has been conducted by scientists around the world. In particular, studies aimed at improving the properties of an aluminum alloy by including various alloying elements in its composition were conducted by the Iranian S.G. Shabestari and others investigated the influence of the state of copper and hardness on the microstructure and mechanical properties of Al-Si-MG alloys [1, 2]. The researchers used a356 grade aluminum alloy with a copper content of 0.2 to 2.5% and cast various hard alloys (sand, graphite, copper and cast iron, iron molds). The highest tensile strength of the alloys was determined by heat treatment (T6), the degree of cooling of the mold (graphite), as well as with a copper content of up to 1.5%. The best mechanical properties were manifested in graphite forms when Al Si dissolved in Mg alloy about 1.5% Cu. Tajik researchers S.S. Gulov, I.N. Ganiev, A.E. Berdiev, R.H. Saidzoda, J.T. Ashurmatov in the scientific study "The influence of germanium and strontium on the mechanical, technological and strength structure of aluminum alloy grade AK9M2" analyzed that Germanium changes its properties by including it in the aforementioned aluminum alloy [3]. In studies carried out, it can be seen that the inclusion of germanium in the alloy increased its fluidity property by up to 30%, and the porosity in the inlet decreased by 10-12% [4-6]. In this case, the researchers included germanium in the alloy by 0.1-0.3 % (relative to the amount of mass). In this article, the authors studied the effect of germanium oxide on its hardness from its mechanical properties by introducing it into aluminum.

2 Material and method

The research was carried out in alloys of aluminium-copper and aluminium-magnesium systems. These alloys included Germanium oxide [7, 8]. As a result of the introduction of this compound, the oxygen contained in it is absorbed by germanium from the alloy.

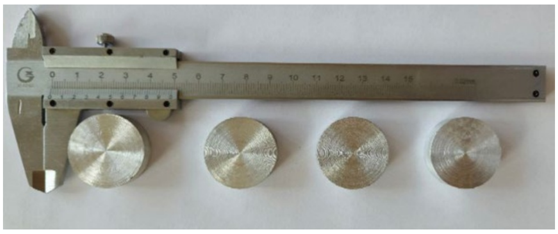

Fig. 1. Processed samples.

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Germanium is an intermediate optics of gray-white color, shiny like metals. Like silicon, it is a semiconductor. Germanium is usually extracted from nickel and tungsten ores as a semi-metallic mixture. It is also obtained from silicates. After very complex ore processing processes, Germanium oxide is released in the form of GeO2. In experiments, aluminium alloys were melted in a resistance furnace in a state with the addition of Germanium oxide. At the same time, samples were first poured into aluminium alloys for comparison without the addition of Germanium oxide. At the next stage, Germanium element oxide was added to the composition of the alloys of the selected grade in relation to the charge in the range from 0.1% to 0.3%. Samples of 3 different compositions were cast from alloys of each brand. The cast samples were processed on a lathe to the desired size and shape. The cut awl samples are shown in Fig. 1.

3 Results and discussion

The cut samples were ground and the hardness was measured [9]. Hardness was measured on the Brinell scale. A hardness tester of the ITV-1-m brand was used to measure hardness (Fig. 2).

Fig. 2. ITV-1-M hardness tester.

The hardness of the samples was measured at 3 different points on the surface [10]. The results of the hardness measurement are shown in Table 1 below.

Table 1. Results of hardness.

Element	Aluminium-manganese	Aluminium-copper
0% GeO_2	24.27	25.5
0.1 % GeO_2	22.53	22.43
0.2 % GeO_2	22.43	15.93
0.3 % GeO_2	22.22	13.90

After measuring the hardness of the samples, they were sanded to make micro slips. The structural analysis of the prepared samples was carried out using an optical metallographic microscope. The microstructures of the samples are shown in Fig. 3 and Fig. 4. Fig. 3 shows the microstructure of the added sample, calculated in such a way that “a” is an alloy of aluminum and copper without the addition of Germanium oxide, and "b" is an alloy containing 0.1% Germanium. Fig. 4 shows the microstructure of the added sample, calculated in such a way that Germanium oxide “a” is an aluminum-copper alloy added in 0.2%, and "b" is so that 0.3% Germanium remains in the alloy.

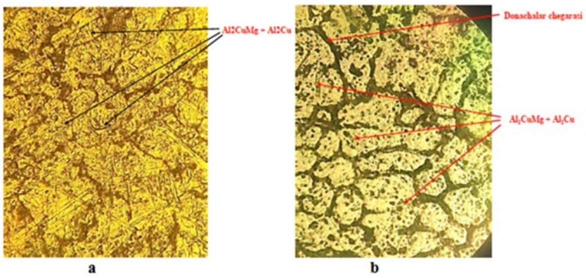

Fig. 3. Microstructure of samples: a - AlCu; b - AlCu+ 0,1% GeO.

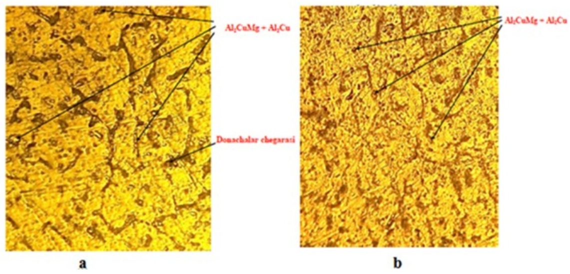

Fig. 4. Microstructure of samples: a - AlCu+0,2% GeO; b - AlCu+ 0,3% GeO.

4 Conclusion

The following conclusions can be drawn from the above studies: In general, germanium oxide did not have a positive effect on the hardness of aluminium alloys. Germanium oxide did not have a significant effect on the hardness of the alloy in the aluminium-manganese system. But it sharply reduced the hardness of the alloys in the aluminium-copper system. Therefore, Germanium oxide is recommended to be included in the composition of the alloy together with another element. For example, that its introduction in combination with strontium, silicon, increases the hardness of the alloy. The microstructure of the Al-Cu alloy is a base metal, where the main component is a solid solution of miss and magnesium in aluminium, as well as the intermetallic phases Al2CuMg and Al2Cu. Intermetallic foci of flow and eutectic located near clusters of intermetallides were not visually detected. 5639-82 grain size according to standard No. 7-8. Intermetallic grains are columnar, elongated 9-10x3 microns. From the results of the study, it was found that when the Germanium aluminium alloy is liquefied in Germanium oxide, it remains in it, destroying the microstructure of the alloy. When Germanium is added in an amount of 0.3% relative to the charge, the alloy granules are crushed to 2-3 microns. From this it can be concluded that the Germanium element improves the microstructure of aluminium alloys.

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