MECHANICAL CHARACTERISTICS OF POWDERED ALUMINUM BRONZE OBTAINED FROM METALLURGICAL WASTE

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Abstract - Currently, the main materials for the manufacture of sliding bearings are cast bronze and powder bronze, where the main alloying element is tin, the graphite content in these alloys is from 2 to 4%. At the same time, sintered bronze alloys, where the main alloying element is aluminum, have an advantage over both cast and sintered tin bronze. The advantage of aluminum bronze is the low cost of aluminum powder compared to tin powder, lower weight of sintered aluminum bronze bearing compared to the tin bronze bearing of the same size.

The proposed article presents the results of studies of the mechanical characteristics of powdered aluminum bronze obtained from metallurgical waste with different percentages of aluminum powder and sulfur-containing pyrite additive (FeS_2) replacing graphite. The results of studies on the effect of sintering temperature on the hardness and strength of aluminum bronze, as well as the effect of sulfur-containing additive - pyrite (FeS_2) on the oil permeability and porosity of aluminum bronze, are presented).

Keywords: Tin, Powdered aluminum bronze, Pyrite, Sliding bearing, Hardness, Strength, porosity, Soil permeability, Sintering temperature.

1. Introduction

One of the most pressing problems of modern materials science is the development of bearing materials for work in severe friction conditions. Such conditions are the operation of friction pairs with a limited supply of lubricant, with minor loads (up to 1 kg/cm^2) and small (less than 0.1 m/sec) sliding speeds; at elevated loads (more than 100 kg/cm^2), elevated and high sliding speeds (above 4-10 m/sec); elevated and lowered temperatures [1,2]. Under these conditions, lubrication is not effective and the surfaces of the rubbing bodies come into contact.

To ensure the necessary antifriction properties when creating bearing materials, the basic principle is guided: heterogeneity of their structure in this regard, the Sharp graft has become widespread, which consists in the fact that bearing alloys consist of solid-phase inclusions distributed in a plastic metal base.

Such a structure is observed in all cast alloys: bronzes, babbits, brasses, recognized as the best bearing materials. They meet the basic conditions that antifriction materials must meet: a) the pressure is transferred to solid particles that are not able to lift the shaft neck; b) the plasticity of the binding matrix, which allows the working surface of the bearing to deform and take shape closest to the working profile of the shaft, this reduces the possibility of local pressure peaks that are a smooth cause of bearing failures.

The main drawback of these materials is their inability to work in the absence of lubrication.

The powder metallurgy method makes it possible to develop simple bearing materials based on copper and iron, which have comparable properties and significantly higher wear resistance compared to cast alloys. This determined the widespread use of metal-ceramic antifriction materials in the place of cast-bearing alloys in various friction nodes [3, 4].

The improvement of the friction characteristics of such materials is determined by the presence of pores filled with oil and ensuring the manifestation of the effect of self-lubricity at the time of termination of the supply of lubricant from the outside during the operation of the bearing.

The implementation of the self-lubricity effect, due to the release of oil from the pores and the formation of the thinnest films on the friction surface, is the basic principle of creating porous antifriction materials that ensure long-term and reliable operation of the bearing assembly.

Regulation of the composition, structure, size, and number of pores allows the direction to change the frictional characteristics of friction units.

Machines and units of modern technology are offered increasingly increased requirements for reliability, durability, simplicity of design, cheapness, and simplicity of their operating conditions.

The degree of satisfaction of these requirements determines the operability of the movable joints, the suitability, and durability of the entire unit.

2. Methods

The objects of the study were products obtained by pressing and sintering powders from local raw materials.

Copper powders were obtained by grinding fine copper chips formed during the production of copper pipes at the enterprises of the Almalyk Mining and Metallurgical Combine of the Republic of Uzbekistan. The aluminum powder obtained from aluminum chips formed during the production of aluminum profiles for various purposes was used as an alloying element. Pyrite powder, which is also a waste of mining and metallurgical production, was used as a sulfur-containing additive. Powders were obtained up to a fraction of 0.45-0.160 mm. From the obtained powders, a charge was prepared from which samples for testing were made. The samples were pressed at a pressure of 400 to 700 MPa and sintered at a temperature of 500 to 1000 ^{0}C in a vacuum at a pressure of 10^{-2} Pa.

Cylindrical samples ∅10x10 were made to determine the compressive strength. The samples were tested according to GOST26529-85 - "Powder materials". Radial compression test method

$$P_{max}*(D-a)L*a_2$$

where,

P_{max} – maximum destructive loads;

D– outer diameter of the sleeve;

L – length of the cylindrical part of the sleeve.

Density and porosity were determined following GOST 18398-73 "Powder metallurgy. Methods for determining density and strength". The hardness of the samples was determined by the Brinell method.

3. Research Results

To conduct studies of mechanical characteristics, samples were made based on copper with a content of 5 to 20% Al and from 1 to 4% pyrite as a sulfur-containing additive. Initial experiments were carried out on samples without pyrite at different percentages of aluminum to establish the nature of changes in the mechanical properties of aluminum powder bronze. The influence of the sintering temperature on the hardness and strength of the alloys was determined (Fig.1,2), at a pressing pressure of 500 MPa.

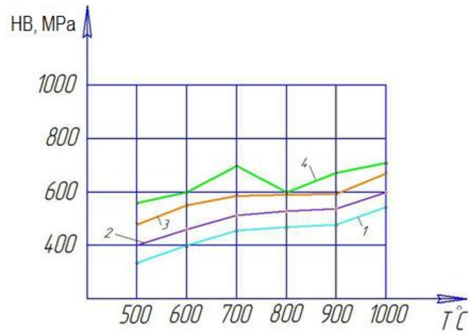

Figure 1: Changes in the hardness of aluminum bronze samples depending on the sintering temperature; 1 - 5% Al, 2 - 10% Al, 3 - 15% Al, 4 - 20% Al

Analyzing the results obtained, it can be noted that the hardness and strength of the obtained samples increase with an increase in the percentage of aluminum and with an increase in the sintering temperature. The most advantageous sintering modes are sintering temperatures from 800 to 900 ^{0}C with an aluminum content of 20%. For materials intended for friction units, the main requirement is the ability to resist the processes of setting and jamming.

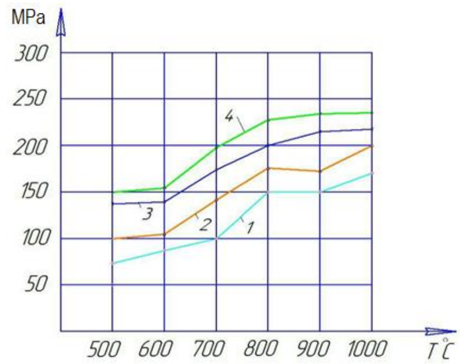

Figure 2: Changes in the strength of aluminum bronze samples depending on the sintering temperature; 1 - 5% Al, 2 - 10% Al, 3 - 15% Al, 4 - 20% Al

The introduction of substances capable of playing the role of dry lubricants into the composition of porous bearing materials makes it possible to resist the processes of setting and jamming. One of such materials is sulfides. In particular, during the production of copper, waste from metallurgical production is formed - pyrite (FeS_2). To determine the effect of pyrite content on mechanical properties, tests were carried out on the hardness and strength of aluminum bronze with an aluminum content of 20% and pyrite additives from 1 to 4% (Fig.3,4).

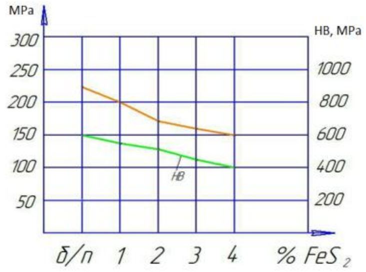

Figure 3: Changes in the hardness and tensile strength of aluminum bronze depend on the pyrite content. The sintering temperature is 850 ⁰C.

As can be seen from the graph, the highest values of hardness and strength in aluminum bronze are achieved with a minimum content of pyrite. However, for materials intended for sliding bearings, the porosity of the material and its oil absorption is of great importance.

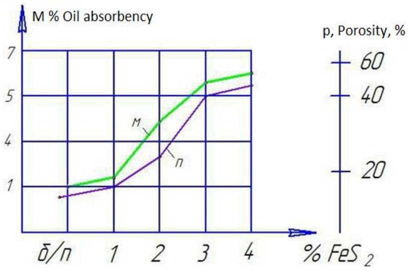

Figure 4: Changes in porosity and oil absorption in aluminum bronze depending on the pyrite content

4. Conclusions

Based on the conducted research, the following conclusions can be drawn:

1. With an increase in the sintering temperature and with an increase in the percentage of aluminum powder in aluminum bronze, the hardness and strength of the sintered alloy increase.
2. The optimum sintering temperature in terms of obtaining the desired level of hardness and strength is the temperature of 850 ⁰C with an aluminum powder content of 20%.
3. The required porosity level of 20% for plain bearings is achieved in aluminum bronze with a pyrite content of 2%.

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