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ALUMINUM-LEAD COMPOSITE MATERIALS

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A process of fabrication of aluminum-lead sliding bearings is suggested on the basis of impregnation of foam aluminum with lead or lead-base alloys. The results of tests of physical, mechanical and operating properties of the composite materials are presented.

Key words: composite materials, foam aluminum, sliding bearings, aluminum-lead alloys, babbit, wear resistance.

INTRODUCTION

We are witnessing a tendency to replace commercial antifriction alloys based on lead and tin with aluminum alloys. Aluminum alloys possess a good enough fatigue resistance, corrosion resistance in oils, not bad scoring resistance, good antifriction properties and high thermal conductivity [1].

The appearance of heavily loaded engines in automotive, tractor, transport and other industries has stimulated demand for aluminum bearings with enhanced scoring resistance. Aluminum-lead bearings can serve successfully for the purpose. Such alloys possess a good scoring resistance under ultrathin lubrication layers, but this capacity is the highest at ≥ 14% Pb in the metal [2]. The Al – Pb system is a monotectic one and is characterized by a wide range of immiscibility of aluminum and lead, which makes the traditional methods of production of sliding bearings inapplicable [3].

Methods based on rapid cooling of the melt from the temperature exceeding that of separation by 100 – 200°C have been developed for making sliding bearings [3, 4]. Preliminary granulation of the melt at a rate of $10^2 – 10^4$ K/sec followed by pressing of the granules is a widely applied technique [3]. However, the methods mentioned are laborious and low-efficient.

An alternative is a method of manufacturing aluminum-lead sliding bearings where the blank is obtained from porous aluminum with open porosity by filtering the aluminum melt through water-soluble granules [5 – 7] and then filling the pores with molten lead or a lead-base alloy [8].

The aim of the present work was to study the mechanical and operating properties of composite aluminum-lead sliding bearings obtained by impregnation of foam aluminum with lead of lead-base alloys.

METHODS OF STUDY

To estimate the possibility of implementation of this method for fabricating sliding bearings were first obtained foam aluminum blanks 100 × 80 × 25 mm in size (Fig. 1) by casting molten aluminum of grade A7 or aluminum alloy AM5 into a metallic mold filled with granules of sodium chloride (Fig. 1). When the granules dissolved and the gate system was removed, the block of foam aluminum was placed into the same mold, heated, and filled with molten lead or babbit B16.

To study the physical and mechanical properties of the composite materials we fabricated blanks with different pore sizes, i.e., 2 – 4 mm, 4 – 6 mm, and 6 – 8 mm (Fig. 2).

To test the mechanical properties of the composite materials and of babbit B16, we fabricated specimens 25 × 25 × 25 mm in size (Fig. 3). The tests were performed in a N50KT testing machine. We plotted the compression diagram and determined the yield strength and the ultimate compressive strength.

The wear resistance was evaluated in terms of the change in the linear size of the specimens of the composite material and of the babbit (Fig. 6). The abrasive tests of the composite material and of the babbit were performed in a special facility (Fig. 5) at a constant speed of rotation (200 rpm) of the roll 25 mm in diameter from steel 45 and a constant force of

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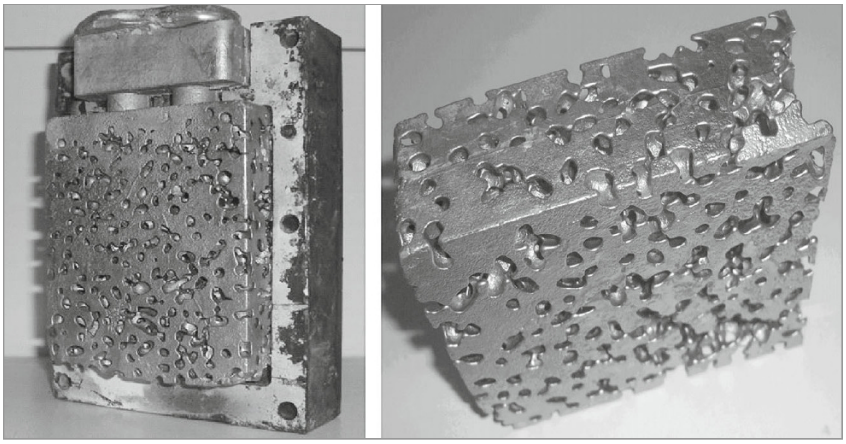


Fig. 1. A blank from foam aluminum.

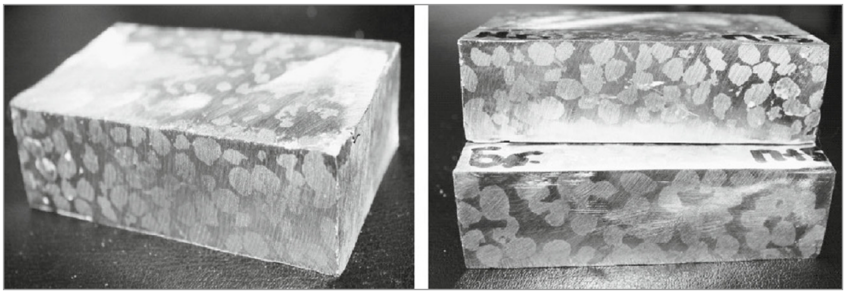
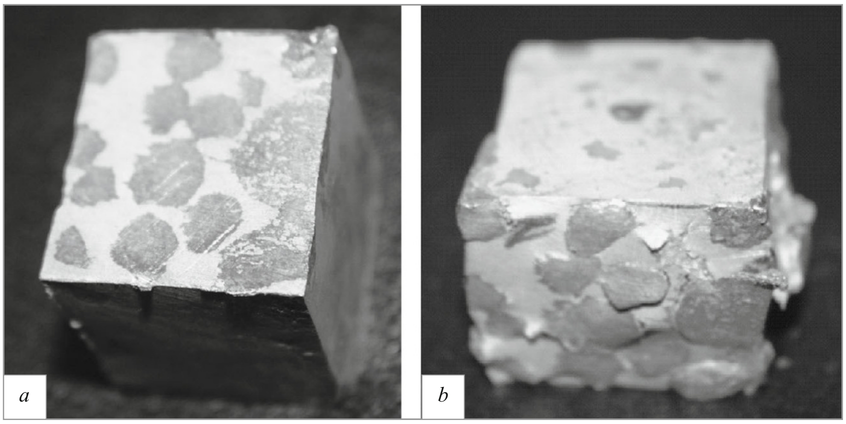


Fig. 2. Blanks for aluminum-lead bearings.



a *b*

Fig. 3. Specimens for testing for ultimate compressive strength: *a*) prior to testing; *b*) after testing.

pressing of the specimen to the roll (50 N). The specimens were preliminarily fit to the roll and tested for 2.5 h.

The wear intensity was calculated from the formula

$$I = h/L, \tag{1}$$

where h is the size of the worn layer and L is the friction path.

The force of pressure of the specimen to the roll and the constancy of the force in the testing process were controlled with the help of a BP-05 resistance strain gage, a PLK-73 controller and a SMSD 4.2 step drive with AD 200 motor.

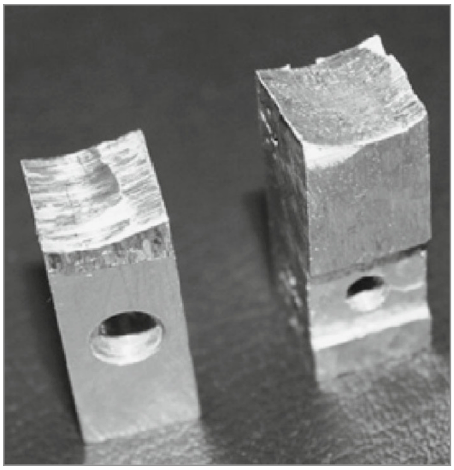


Fig. 4. Specimens for testing the composite material (on the left) and babbit B16 (on the right) for wear resistance.

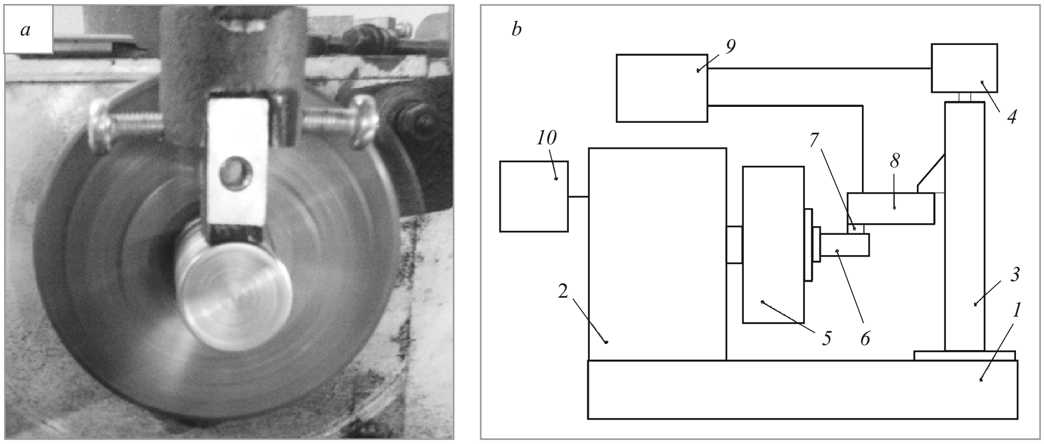


Fig. 5. Facility for testing the composite material and babbit B16 for wear resistance: *a*) appearance; *b*) diagram: *1*) bed; *2*) geared motor; *3*) screw pair; *4*) engine; *5*) holder; *6*) rider; *7*) specimen; *8*) strain gage; *9*) control unit; *10*) frequency converter.

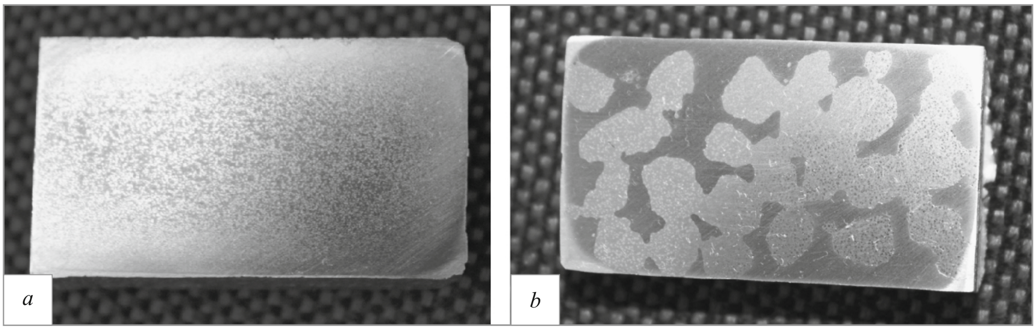


Fig. 6. Specimens for determining sliding friction coefficient: *a*) babbit B16; *b*) composite material AM5 + B16.

The friction coefficient of the composite material was evaluated under sliding of polished specimens with a size of 50 × 28 × 14 mm against steel without lubricant (Fig. 6).

RESULTS AND DISCUSSION

The study of the processes of formation of the composites has shown that the filling of the foam aluminum with lead or babbit is satisfactory without discontinuities and visible defects of the composite material at a pouring temperature of 450 – 500°C with preliminary heating of the foam aluminum at 200 – 350°C (Fig. 3).

TABLE 1. Properties of the Composite Material after Compressive Tests

Material	Density, g/cm^3	$\sigma_{0.2}$, MPa	σ_{r}, MPa
Babbit B16	9.3	86	147
Aluminum A7 + lead C0 composite	8.15 – 8.25	25 – 40	52 – 62
Aluminum alloy AM5 + babbit B16 composite	6.10 – 6.45	110 – 120	170 – 180

The ultimate compressive strength of the aluminum-lead composite material was 52 – 62 MPa; the yield strength was 20 – 40 MPa. The use of aluminum alloys instead of aluminum and of lead alloys instead of lead in the composite material increased the mechanical properties of the composite. For example, the ultimate compressive strength of the aluminum alloy AM5 + babbit B16 composite material was 160 – 180 MPa depending on the size of the pores; the compressive yield strength was 100 – 120 MPa (see Table 1).

The density of the aluminum-lead composite material was 8.15 – 8.25 g/cm^3, which is 30% lower than the lead density; the density of the AM5 + B16 composite was 6.1 – 6.45 g/cm^3, which is 30% lower than the density of the babbit (see Table 1). With allowance for the density of the composite material, the content of lead or of the lead alloy is 55 – 65 vol.%.

The wear tests showed that the wear intensity of the specimens of the AM5 + B16 composite material was 3.4×10^{-8} mm/mm; that of the B16 babbit was 2.1×10^{-7} mm/mm. The growth in the wear resistance of the composite material as compared to the babbit is a result of the presence of a harder aluminum phase.

The values of the sliding friction coefficient of the AM5 + B16 composite ranged within 0.155 – 0.287, which corresponds to the friction coefficient of babbit B16.

CONCLUSIONS

Aluminum-lead composite materials fabricated by impregnation of foam aluminum with lead exhibit higher mechanical and operating properties than lead and lead-base alloys at a lower density of the material.

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