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ANALYSIS OF BEARING MATERIALS

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ABSTRACT

This article analyzes the types of materials used for bearings. Each bearing material is sorted and selected according to the location and type of use of the bearing. The bearing part consists of several parts, for each part of which the appropriate material is selected. It is expedient to choose materials for the types of plain bearings, rolling bearings, bending bearings, couplings, etc.

The advantages and disadvantages of each analyzed material are studied, and these advantages and disadvantages are of great importance when choosing a bearing material.

KEYWORDS: bearing, babbitt, anti-friction, run-in, fluid lubrication, eutectic

I. INTRODUCTION

Bearings and their parts are subjected to static and dynamic loads during operation. But they can also be affected by moment, shock and vibration loads, high, low and rapidly changing temperatures, aggressive media - water, alkalis, acids,solvents, solid particles. Obviously, bearing materials must meet such conditions.

In order for a bearing to perform under the specified conditions, suitable materials must be used for its manufacture. Speaking of bearing materials, we mean the chemical composition, mechanical and heat treatment and other properties of its parts - all or part.

II. Materials and methods

Bearing materials are ductile (< HB 50), soft (HB 50-100) and hard (> HB 100).

The plastic ones include babbitt, lead bronzes, aluminum alloys, silver; to soft ones - tin, tin-lead, tin-lead-zinc bronzes; to solid ones - aluminum-iron bronzes and cast irons.

For highly loaded high-speed bearings designed for operation in the field of liquid lubrication, ductile alloys are used almost exclusively in the form of thin layers applied to steel (rarely bronze) bushings and liners. Soft and hard alloys are used to make boundary and semi-fluid lubricated bearings operating at moderate speeds.

III. Literature Review

Babbitt. Babbitt are alloys of soft metals (Sn, Pb, Cd, Sb, Zn), characterized by the presence of solid structural components in a plastic matrix. Babbittare characterized by low coefficient of friction, ductility, good run-in and wear resistance. Babbitt can be paired with normalized or improved steel shafts (HRC 25-35), but to increase bearing life, it is more advisable to heat-treat the shafts to a hardness > HRC 50.

Plasticity ensures uniform distribution of the load over the bearing surface: it becomes relatively safe for small solid particles (metal dust, solid products of oil oxidation) to enter the bearings, which are pressed into the babbitt and neutralized.

The disadvantage of babbitt is their low fatigue resistance, especially at elevated temperatures.

The highest antifriction qualities are possessed by high-tin Babbitt, which are alloys of tin with antimony with small additives of copper (introduced to prevent segregation); Babbitt structure - solid SnSb crystallites interspersed in a plastic eutectic. The main brands of high-tin Babbitt are B89, B83 (the numbers indicate the tin content as a percentage). Melting temperature of tin babbitt: beginning 240-250°C, end 400-420°C. Babbittare poured at 450-480°C on liners, preheated to 250°C. The best results are obtained by centrifugal casting. Apply also pouring into molds and under pressure.

In order to save scarce tin, low-tin Babbitt have been developed and introduced into industry, which are more or less full-fledged substitutes for high-tin Babbitt.

Lead-tin Babbitt B16, B6, BN, BT consist of 60-75% lead, 5-20% Sn, 10-20% Sb with small additives of Cu, Cd, Ni, Fe. As modifiers, 0.3-1% As is introduced.

The antifriction qualities of lead Babbitt under conditions of semi-fluid lubrication are lower than those of high-tin Babbitt. Hardness and mechanical properties are about the same as those of tin Babbitt. Corrosion resistance is much lower. Under liquid lubrication conditions, the difference between lead and tin Babbitt is little noticeable.

Tin-less Babbitt BK1, BK2 consist almost entirely of lead with ~1% Ca and Na additives. The antifriction properties and corrosion resistance of lead Babbitt are improved by introducing small amounts of Sr, Ba, Li, Te.

Cadmium Babbitt contain 90-97% Cd with additives of Cu, Ni, Ag and other metals that form solid structural components in a plastic cadmium base. The hardness of cadmium Babbitt is HB 30-40. Antifriction qualities are high. The disadvantage of cadmium Babbittis their low corrosion resistance.

In bimetallic thin-walled liners, aluminum-tin alloys containing up to 20% Sn are used. The most common are alloys of the AO20-1 type (20% Sn; 1% Cu; the rest is Al) and the AO6-1 alloy (6% Sn; 1% Cu; 0.5-1% Ni; 1-1.5% Si; the rest AI). The hardness of antifriction aluminum alloys HB 35-45; Aluminum alloys have high fatigue resistance and can operate at specific loads up to 50 MPa. Tends to enveloping on the shaft. Enhanced oil pumping and the use of hardened shafts (> HRC 50) are required.

For non-critical bearings, cheap zinc-aluminum alloys such as SAM 10-5 (10% Al; 5% Cu, the rest are Zn) and SAM 9-1.5 (9% Al; 1.5% Cu) are used. Their hardness is HB 60-80; The antifriction qualities of zinc-aluminum alloys are mediocre. It is necessary to use shafts with a hardness of more than HRC 50. Non-standard high-aluminum zinc alloys (30-40% Al; 5-10% Cu; the rest are Zn) have the best qualities. Their hardness is HB 50-60.

Lead bronzes are alloys of Cu (40-70%) and Pb (30-60%) with additives of small amounts of Sn, Zn, Ni, Ag. B - the most common bronzes are BrC30 (30% Pb; the rest is Cu) and BrO5C25 (5% Sn; 25% Pb; the rest is Cu). High lead nickel bronze BrS60N2.5 (60% Pb; 2.5 Ni) is also used.

Lead is practically insoluble in copper and is present in alloys in the form of rounded inclusions, more or less evenly distributed in the copper matrix. Lead bronzes are stronger and harder than Babbitt (HB 40-60). Unlike Babbitt, their hardness and strength remain practically constant up to 200°C.

The disadvantage of lead bronzes is their reduced corrosion resistance (due to the presence of free lead). In addition, lead causes accelerated oil oxidation during operation.

The run-in and anti-friction properties of lead bronze are worse than those of babbitt. Bearings filled with lead bronze require particularly low roughness of friction surfaces, elimination of distortions, increased rigidity of the shaft-bearing system, increased oil pumping and thorough filtration, as well as increased surface hardness of the shaft (>HRC 50). Clearances in bearings filled with lead bronze make an average of 30-50% more than in bearings with babbitt filling. The working surfaces of bearings filled with lead bronze are treated with a fine boring with diamond or carbide cutters with low feeds and high cutting speeds (10-13 m / s).

Lead bronze is poured onto inserts made of low-carbon steels with a layer of 0.5-0.8 mm thick at 1050°C in graphite molds. In order to avoid segregation and to obtain a uniform and finely dispersed distribution of lead in the alloy, the liners are subjected immediately after pouring to intensive cooling with water sprayed with compressed air.

Improved compositions of lead bronzes with 30% Pb with additives of Ni (up to 5%), Sn (up to 25%) and minor amounts of S and Ca have been developed. Additive Ni increases corrosion resistance, S and Ca are introduced to prevent segregation of lead.

Along with high-lead bronzes, ductile (HB 60-80) bronzes containing 5-7% Pb, 5% P and 5% Zn are used for casting bearings.

Silver. For heavily loaded machine supports produced in small series, bearings with a friction surface of silver (with small amounts of Sn and Pb) are used. Silver coatings are distinguished by plasticity, softness (in the annealed state HB 25-35), good anti-friction properties and high fatigue resistance. Melting point 960°C.

Silver is poured onto the surface of the liners with a layer of 0.1-0.3 mm or applied electrolytically on a porous bronze or copper-nickel substrate with a layer of 20-50 microns thick. In some cases, to improve the connection with the liner, silver is poured onto a fine-mesh steel base. The sections of the steel matrix protruding to the surface increase the bearing capacity of the bearing. In order to improve the running-in ability, a layer of lead or lead-antimony spleen 10-30 microns thick is applied to the surface of the silver coating, which is coated with a layer of indium several micrometers thick to prevent corrosion. Rolls with increased hardness (> HRC 50) are required.

Multilayer coating. In multilayer pouring, a thin layer of tin babbitt is applied to a substrate of an antifriction alloy with a thickness of 0.2-0.5 mm. By exploiting the valuable qualities of tin babbitt, this method drastically reduces the consumption of tin and at the same time increases the fatigue resistance and resistance of the casting to shock loads. As a substrate, lead bronzes, aluminum alloys and bronzes are used. The best results are obtained by porous substrates made of sintered Cu-Al and Cu-Ni alloys (60% Cu, 40% Ni), which provide a strong bond between the babbitt and the insert.

There are two methods of applying babbitt. When pouring, Babbittis applied with a layer of 0.3-0.4 mm. After processing, the thickness of the Babbitt layer is 0.15-0.2 mm.

More technologically advanced is the electrolytic deposition of babbitt with a layer 15–20 μm thick on the surface of a substrate that has been finished. With this method, it is necessary to use a porous substrate, which, being impregnated with babbitt, forms an antifriction sublayer that ensures the correct operation of the bearing in case of local or general wear of the surface Babbitt layer.

Sometimes lead Babbittare used as a surface layer. To prevent corrosion, they are coated with an In electrolytic layer several micrometers thick, which is then subjected to diffusion by heating at 150°C for 2-3 hours.

Bronzes. Bronzes are used for the manufacture of bearings operating in the field of predominantly semi-fluid lubrication at low circumferential speeds (auxiliary drive bearings). Due to their increased hardness, they can withstand high specific loads.

Tin bronzes of the BrOF type have good antifriction properties. Bronzes containing >0.5% Sn are cast (preferably in molds), those containing <0.5% Sn are stamped. The hardness of stamped bronzes can be reduced to HB 50-60 by softening annealing.

The introduction of lead (bronze BrOC) improves machinability, increases ductility and reduces the hardness of bronze. Bronze BrO5S25 belongs to the category of semi-plastic.

The most widely used tin-zinc-lead bronzes, in which the content of deficient tin is reduced to 2-6%. Their plasticity is higher than that of tin bronzes (elongation 6-15%); hardness HB 50-70. Tin-zinc-lead bronze BrOTsS 4-4-2.5 is used in the form of cold-rolled strips for the manufacture of thin-walled bushings.

Aluminum-iron bronzes of the BrAZh type, having increased hardness (HB 70-100), are used for the manufacture of bushings operating at high loads and low speeds in conditions of semi-fluid and boundary lubrication (guide bushings for suction valves of internal combustion engines).

Bearings operating at high temperatures, with boundary lubrication (exhaust valve guides) are made of heat-resistant iron-nickel-aluminum alloys of the BrAZhN type. Shafts operating in medium hard bronze bearings must have a hardness of more than HRC 50, and in high hard bronze bearings more than HRC 55.

In the α-phase of aluminum bronze, up to 4% of iron dissolves, with a higher content, inclusions of Al Fe are formed. Additional alloying of alloys with nickel and manganese contributes to the appearance of these inclusions at a lower iron content. Iron has a modifying effect on the structure of aluminum bronzes, increases their strength, hardness and antifriction properties, reduces the tendency to embrittlement of two-phase bronzes due to slowing down the eutectoid decomposition of the β-phase. Aluminum-iron bronzes (for example, BrAZh-4) have the best plasticity after heat treatment, which partially or completely suppresses the eutectoid transformation of the β-phase. Tempering hardened bronze at 250-300°C leads to the decomposition of the β-phase with the formation of a finely dispersed eutectoid and an increase in hardness to 175-180 HB.

Nickel improves the workability and mechanical properties of aluminum-iron bronzes at normal and elevated temperatures. In addition, it contributes to a sharp narrowing of the region of the α-solid solution with decreasing temperature. This causes in bronzes alloyed with iron and nickel (BrAZhN10-4-4) the ability to additional hardening after quenching due to aging. Aluminum-iron-nickel bronzes are used to manufacture parts that operate under severe wear conditions at elevated temperatures (400-500 ° C): valve seats, exhaust valve guides, parts of pumps and turbines, gears, etc. Aluminum alloys have high mechanical, anti-corrosion and technological properties. - iron bronze alloyed instead of nickel with cheaper manganese (BrAZhMts10-3-1.5).

Anti-friction cast irons. As cheap substitutes for bronze, antifriction cast irons are used: gray AChS with lamellar graphite, high-strength AChS with globular graphite, malleable AChK with flaky graphite, and cuprous FM. Cast iron bearings are used with shafts of high surface hardness (> HRC 55). Soft anti-friction cast irons (ACHS-3, ACHV-2, ACHK-2) can work in tandem with normalized or improved steels (HRC 25-35) under light loads.

The disadvantages of anti-friction cast irons are brittleness and high hardness (HB 160-250), which excludes the possibility of self-running. Cast iron bearings are sensitive to misalignment causing high edge pressures.

light alloys. Of light alloys, aluminum is most often used as antifriction materials. Non-critical bearings are made from cast alloys Al-Si (ALZ; AL4; AL5), Al-Mg (AL8). Al-Cu (AL10V; AL18V) preferably by casting into metal molds (HB 65-70). It is more expedient to manufacture bearings by stamping from deformable alloys such as AK4, AK4-1 (NV 80-90).

Non-heat-treated (HB 40-60) AM8 alloys (8% Cu) are widely used; AMK2 (8% Cu; 2% Si); AG6 (6% Fe); AN-2.5 (2.5% Ni), ACC6-5 (6% Sb, 5% Pb). Plastic alloys AK5M and AN-2.5 (NV 35-45) are used in bimetallic tape liners.

Tin aluminum alloys (Sn content up to 20%) have the highest antifriction properties. One of the best alloys of this type, combining ductility and high strength, has the composition; 6%Sn; 1.5% Ni; 0.5-1% Sb; 0.5% Si; 0.5-1% Mn; the rest Al.

The hardness of antifriction aluminum alloys is HB 40-80; Aluminum alloys are corrosion resistant and do not cause oil oxidation. Pressure lubrication and rolls with increased hardness (> HRC 55) are required.

Their disadvantage is the reduced running-in and the tendency to enveloping on the shaft.

The modulus of elasticity of aluminum alloys is low, therefore, for normal operation, it is necessary to increase the rigidity of the bearings (thickening of the walls, making stiffening beads, increasing the rigidity of the beds).

In the design of bearings made of aluminum alloys, their high coefficient of linear expansion must be taken into account. When heated, the gap in the bearing increases, so the "cold" gap is made minimal, compatible with the condition of reliable operation of the bearing during starting periods. In addition, when heated, the interference on the seating surface of the bearing increases. Bearings made of aluminum alloys are preferably used in housings made of the same alloys.

Magnesium alloys as an antifriction material are close to aluminum, but differ from the latter in an even lower modulus of elasticity. For the manufacture of bearings, casting alloys MLZ, ML4 and deformable MA1, MA2 are suitable. The hardness of magnesium alloys is HB 30-40. When designing bearings from magnesium alloys, the same rules must be observed as for aluminum alloys.

Despite these shortcomings, babbitt are widely used in many areas of engineering. Their positive properties allow solving complex engineering and technical problems.

Currently, the most widely used polymeric materials for plain bearings are fluoroplastics, for example, polytetrafluoroethylene (aka PTFE, Teflon, fluoroplast-4). These plastics have a low coefficient of friction, are highly wear resistant, resistant to chemicals and high temperatures. However, their rigidity is low, so they are often used in the form of a thin-walled sliding sleeve or in the working layer of rubbing surfaces on a body made of a more durable material.

Various technologies are applied in the production of bearings, including casting, stamping, rolling, extrusion and powder metallurgy.

IV. results

List of defects in materials intended for bearings

N	Material name	Disadvantages
1	**Babbitt**	Low fatigue resistance, especially at elevated temperatures.
2	**Lead-tinbabbitt**	The antifriction qualities of lead babbitt under conditions of semi-fluid lubrication are lower than those of high-tin babbitt. Hardness and mechanical properties are about the same as those of tin babbitt. Corrosion resistance is much lower. Under liquid lubrication conditions, the difference between lead and tin babbitt is little perceptible.
3	**Cadmiumbabbitt**	Lowcorrosionresistance.
4	**Leadbronzes**	Reduced corrosion resistance (due to the presence of free lead). In addition, lead causes accelerated oil oxidation during operation. The run-in and anti-friction properties of lead bronze are worse than those of babbitt.
5	**Aluminium-ironbronzes**	Iron has a modifying effect on the structure of aluminum bronzes, reduces the tendency to embrittlement.
6	**Tinaluminumalloys**	Reduced running-in and tendency to wrap around the shaft.
7	**Anti-**	Brittleness and high hardness (HB 160-250), excluding

	frictioncastirons	the possibility of self-running. Cast iron bearings are sensitive to misalignment causing high edge pressures.
8	**Graypearliticcastiron**	low loads, low operating speeds in friction units, brittleness due to internal stresses;
9	**Aluminum-zincalloys**	poor run-in leads to increased wear of the steel shaft.
10	**Powdercopper-graphite**	small dimensions, low loads, low resource and the possibility of destruction when abrasive particles enter the friction zone.
11	**Bimetallic bushings with welded babbitt -**	insufficient thermal conductivity leads to deterioration of mechanical properties at elevated temperatures, destruction of the layer filled with babbitt. Destruction of the antifriction layer in bimetallic bushings leads to scuffing and emergency failure of dynamically loaded equipment components

V. CONCLUSIONS

As a result of the analysis of the studied materials, the following conclusions can be drawn:

1. Recently, a number of scientists have been developing new types and compositions of bearing materials.

2. As a result of the analysis, it is advisable for bearing manufacturers to choose the material for the bearing depending on the application of the bearing.

3. It is reasonable to choose materials for the types of plain bearings, rolling bearings, bending bearings, couplings, etc.

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