ЛИТЕЙНОЕ ПРОИЗВОДСТВО

Antifrictional silumin which excels traditional bronzes in mechanical and tribotechnical properties is developed. Ecologically safe casting technology of billets of 30–300 mm in diameter of antifrictional silumin is created. Their cost is 2–3 times lower than that of similar bronzes. The new technology is introduced in manufacture in the Republic of Belarus.

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PROPERTIES AND APPLICATIONS OF ANTIFRICTION SILUMIN

Nowadays the most antifrictional alloys in mechanical engineering are bronzes. Bronze AL9Fe4 and bronze Sn5Pb5Zn5 are used the most extensively. Together with steel they possess high frictional wear resistance and low friction coefficients. At the same time, antifrictional bronze possess a number of essential disadvantages: high specific weight, big cost, low ecological compatibility of alloying. It is known that the copper content in earth crust makes only 0,01% [1]. Therefore the prices of antifrictional bronze will rise. It forces to search for new antifrictional alloys which could replace traditional bronzes.

The most perspective are aluminum-silicon alloys (silumins) with the maintenance of silicon more than 12%. The aluminum content in earth crust makes 9%, and silicon – 28% [1]. In process of perfection of technology of silumin preforming, the prices of it will decrease. It is a material of the future. Silumin, as well as bronze, possesses excellent foundry properties, but it is three times easier than bronze. Casting of aluminum-silicon alloys is less energy-consuming, than bronze casting and it is relatively environmentally safe technological process. Silumin is a natural composite in which firm crystals of silicon are distributed in a plastic aluminum preform. Usually castings of aluminum-silicon alloys have dendritic crystal structure. It considerably impairs mechanical and tribotechnical properties of billets.

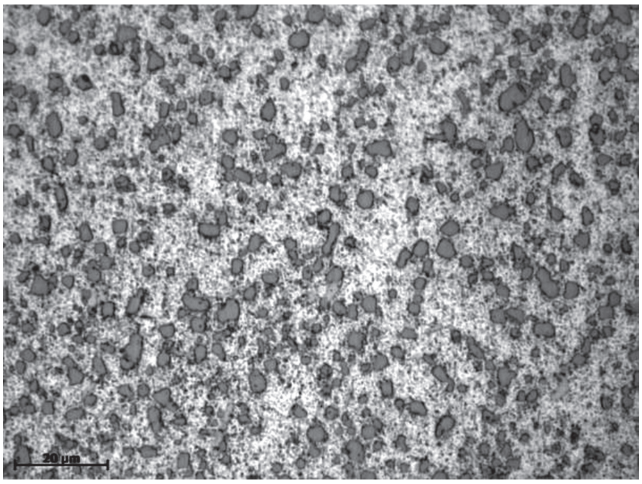

Fig. 1. Microstructure of billets with diameter of 120 mm of antifrictional silumin with average diameter of silicon globular crystals of 4 μm

Special foundry technology of antifrictional silumin preforming with silicon content of 13–15% and copper content of 3% is developed. It is based on casting in a crystallizer with increased solidification rate and on effect of a metallurgical heredity [2]. With increase of solidification rate of silumin castings concentration of crystallization centers increases, structure breaks up, and silicon crystals get globular form (Fig. 1). The developed technology allows to receive casting with diameter up to 300 mm with globular crystals of silicon with diameter 2–5 μm.

Such microstructure is inverted, and it completely corresponds to Sharpey's principle that defines high mechanical and antifrictional properties of this silumin. After heat treatment on mode T5, castings of antifrictional silumin have following mechanical properties: hardness – 125–145 HB, time rupture strength – 350–450 MPa, extension coefficient 6–10%. Pilot plant of iterative casting in a crystallizer with jet system of cooling (Fig is created. 2). The given plant allows to receive measured cylindrical casting from antifrictional silumin in diameter 75–200 mm and up to 300 mm high with productivity of 1–1,5 tons per hour.

Pilot plant of continuous horizontal casting of ingots is created on the basis of the method of crystallizer jet cooling (Fig. 3). The given plant allows to receive ingots of antifrictional silumin with diameter up to 100 mm with productivity equal to 0,5–0,7 tons per hour.

Using effect of structural heredity, hollow castings of antifrictional silumin with diameter up to 300 mm were obtained by rotational casting (Fig. 4).

Comparative tribotechnical tests were carried out at dry friction of antifrictional silumin and of bronze

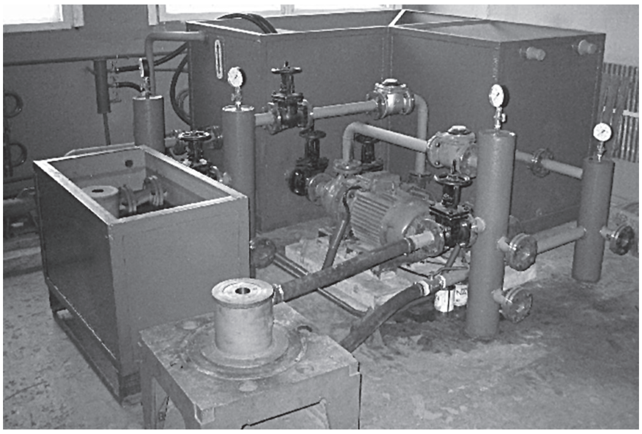

Fig. 2. General view of pilot plant of iterative casting of antifrictional silumin billets

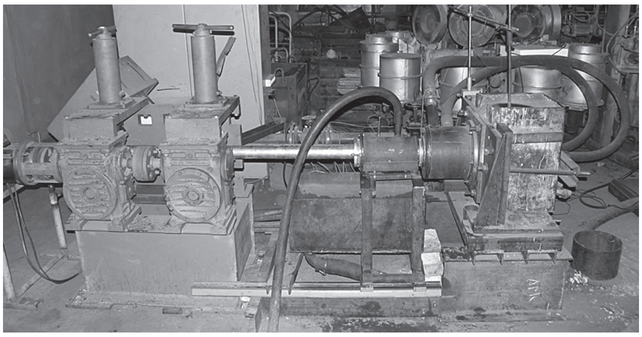

Fig. 3. General view of pilot plant of continuous horizontal casting of antifrictional silumin ingots

Sn5Pb5Zn5 on front friction machine at normal pressure equal to 12,8 H and at rotation of steel 45 sample with a speed of 60 rad/s. Tests were carried out at the Saint-Petersburg State Engineering Institute. Results are presented in table 1.

According to table 1, in the conditions of dry friction antifrictional silumin exceeds bronze Sn5Pb5Zn5 on wear resistance with steel 45 in 7 times.

Comparative tribotechnical tests were carried out in the conditions of greasing of antifrictional silumin and bronze Sn5Pb5Zn5 on friction machine at normal pressure 200 H and at rotation of sample of steel 45 at a speed of 30 rad/s. Tests were carried out at the Saint-Petersburg State Engineering Institute. Results are presented in table 2.

According to table 2, in the conditions of greasing antifrictional silumin exceeds bronze Sn5Pb5Zn5 on wear resistance in 7 times.

At comparative tests friction coefficient of antifrictional silumin on steel 45 is lower, than friction coefficient of bronze Sn5Pb5Zn5, both at dry friction and in the conditions of greasing (Fig. 5, Fig. 6). Besides, in absence of greasing bronze curing was observed, and antifrictional silumin was devoid of such phenomena (Fig. 5). It means that last can work in the most extreme conditions.

Fig. 4. Hollow castings of antifrictional silumin

Worm gears of antifrictional silumin have successfully passed industrial tests instead of similar of bronze on RUPE «Machine-tool plant «Krasny borets» (Orsha, the Republic of Belarus) and on OJSC «Plant Optic» (Lida, the Republic of Belarus). Work resource of worm gears of antifrictional silumin is 4–6 higher, than those of similar of bronze AL9Fe4. Sliding bearings of antifrictional silumin have successful-

Table 1. **Comparative wear-resistance of samples under the conditions of dry friction**

Sample	Material	Weight before test, g	Weight after test, g	Mass wear, g	Size before test, g (H1/H2), mm	Size after test, g (H1/H2), mm	Linear wear, mm
Roller-sample № 1	Steel 45	141,182	141,607	0,005 (growth)	11,76	11,77	0,01 (growth)
Roller-sample № 2	Sn5Pb5Zn5	182,507	180,832	1,675 (loss)	11,97	11,76	0,21 (loss)
Roller-sample № 1	Steel 45	139,840	139,841	0,001 (growth)	11,27	11,27	0
Roller-sample № 2	Antifrictional silumin	56,669	56,646	0,023 (loss)	11,99	11,96	0,03 (loss)

Table 2. **Comparative wear-resistance of samples under the conditions of greasing**

Sample	Material	Weight before test, g	Weight after test, g	Mass wear, g	Size before test, g (H1/H2), mm	Size after test, g (H1/H2), mm	Linear wear, mm
Roller-sample № 1	Sn5Pb5Zn5	161,241	156,837	4,404 (loss)	50,05	46,09	3,96 (loss)
Roller-sample № 2	Steel 45	157,437	157,434	0,003 (loss)	50,05	50,05	0
Roller-sample № 1	Antifrictional silumin	48,957	48,948	0,009 (loss)	49,94	49,77	0,17 (loss)
Roller-sample № 2	Steel 45	157,191	157,190	0,001 (loss)	50,06	50,06	0

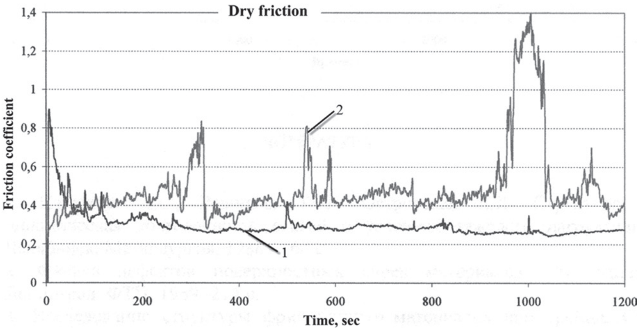

Fig. 5. Comparative changes of friction coefficients of the test time at dry friction on steel 45: *1* –antifrictional silumin; *2* – bronze Sn5Pb5Zn5

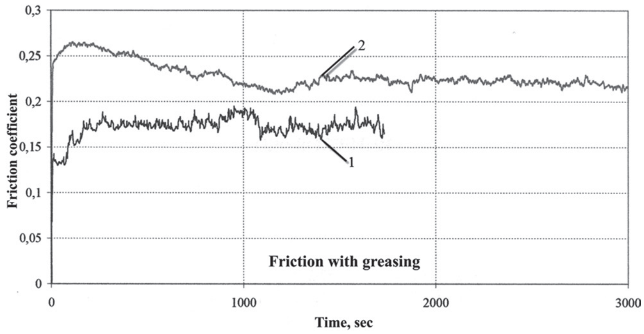

Fig. 6. Comparative changes of friction coefficients of the test time at friction with greasing on steel 45: *1* – antifrictional silumin; *2* – bronze Sn5Pb5Zn5

ly passed industrial tests instead of similar of bronze Sn5Pb5Zn5 in friction couples of assembly machines tools on OJSC «Belshina» (Bobruysk, the Republic of Belarus). It was established that for 6 months of work linear wear of plugs of antifrictional silumin made no more than 0,04% that is the best indicator, than for bronze. On mating parts of steel shaft guide marks and wear traces were absent. All these tests show that antifrictional silumin can replace with success traditional bronze in friction units of machines and mechanisms.

Now billets of antifrictional silumin are introduced in manufacture and they are delivered to the following enterprises of Belarus: OJSC «Plant Optic» (Lida), OJSC «Belshina» (Bobruisk), RUPE «Machine-tool plant «Krasny borets» (Orsha), OJSC «Bobruiskselmash» (Bobruisk). Cost of billets of antifrictional silumin is 2–3 times lower, than that of similar of bronze.

Thus, antifrictional silumin is rather perspective antifrictional alloy which is recommended for replacement of traditional bronzes.

References

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