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Microalloying with Cd of Antifriction Sn-Sb-Cu Alloys

In the case of bimetallic sliding linings with superior technological characteristics, the use of an antifriction ally is imposed an alloy of the type Sn-Sb-Cu, which possesses a high adherence to the steel stand and a high durability in exploitation. For this reason we use the microalloying of the antifriction alloy with cadmium.
The microalloying with Cd of antifriction alloys Sn-Sb-Cu determines an increase of the adhesion property of the antifriction alloy on the steel stand. The steel stand is previously subjected to a process of degreasing with $ZnCl_2$ and washing so that is can later be subjected to a thermal-chemical treatment of tinning.

Keywords: *rotation bearings, microalloying antifriction alloys*

1. Introduction

The proper functioning of machines and aggregates, but especially of thermal engines, that have in their unit rotary components (areas of axle stand – shafts), require the use of sliding bearings or rotation bearings that will diminish the friction between components. It is known that the friction effect between components, in many occasions, metallic components of units, may influence in a negative manner the functioning parameters of these components. At the same time, the premature wear of components due to friction leads to interruptions in functioning. The alloys destined to the realization of linings for sliding bearings used as organs of support for machines axels and machineries must present a high resistance to wear in lubrication conditions and in conditions of insufficient lubrication or even in the absence of it.

Alloys with antifriction properties must have a heterogenic structure that contains soft phases (with a low toughness and a high plasticity) that will insure the lining conformation according to the geometrical configuration of the axel shafts and rough and semi-rough phases, capable of taking mechanical demands generated by the axels supported. Also, casted antifriction alloys must by characterized by their properties to form on active surfaces of the lining networks of capillary channels which deposit lubricants and may dissipate the heat produced due to friction in order to insure thermal regimes of bearing functioning [Zecheru, Gh., Drăghici, Gh., 2002].

In order to ellaborate the antifriction alloy [www.eurostyle.ro, Cracea i., Gheorghe M., 20], presented in this study, we used a crucible furnace from graphite, with a capacity of 500 kg (Fig. 1), and for the cast on the carbon steel stand, a centrifugal casting machine (Fig. 2) [Diaconescu, Fl., 2011]. The heating of furnace charge is realized by transfer of heat produced by burning a gas (marsh gas).

The burner of marsh gas is placed on the inferior side of the metallic housing, respectively of the graphite crucible so that the flame generated by the burner by burning marsh gas to "dress" circularly the graphite crucible, wrapping in a spiral shape the crucible, starting from the inferior side.

Figure 1 Furnace - discharging

Before loading the components, he graphite crucible (well cleaned, from the anterior charge or after a period of stationary) it is preheated at a temperature of 400^0C.

In the crucible thus preheated, the blocks of pre-alloy SnSb are charged and the fondant of protection (of surface) (burnt charcoal) (1,5%). After melting the primal pre-alloy Sn-Sb-Cu, we introduce in the melting the pre-alloy CdCu15. Before introducing the pre-alloy CdCu15 in the metallic bath, the melt surface is cleaned from the layer of slag formed and it is heated at a temperature of 430^0C. After the introducing of the CdCu15 prealloy, the surface of the melt is covered with a new layer of protection flux (1,5%, of the melt quantity). The pre-alloy CdCu15 is introduced under the shape of small pieces in order to dissolve easily in the melt. In order to obtain a chemical homogenization and a proper temperature in the entire volume of the melt, this is heated at a temperature of 430^0C.

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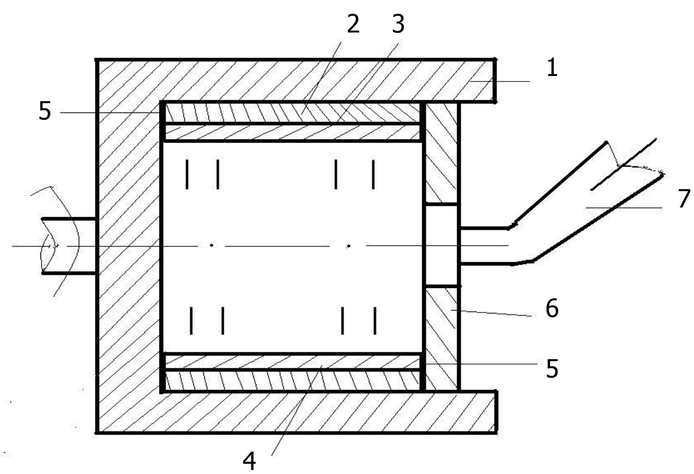


Figure 2. The scheme of centrifugal casting installation for bimetallic bearings: 1 - machine housing; 2 - steel support; 3 - metallic layer of adhesion (tin), 4 - layer antifriction alloy Sn-Sb-Cu: 5 - garreting, 6 - cover; 7 - casting funnel.

composition is no longer needed.

After the melting of the pre-alloy, the melt is preheated at a temperature of 420…430^0C. Before the discharging, the surface of the melt is cleaned from the slag formed.

The covering flow of the metallic bath of nonferrous alloy is composed of zinc chloride and sodium chloride ($ZnCl_2$ + NaCl).

In casting antifriction alloys on steel stands we may take into consideration the following prescribed chemical composition (Table 1).

Table 1. Prescribed chemical composition for antifriction Sn-Sb-Cu alloys [%]

Sn	Sb	Cu	Pb	Zn	Fe	Al	As	Bi	Cd
88...90	7...8	3...4	0,35	0,05	0,01	0,05	0,10	0,008	0,05

For the casting of the antifriction alloy, the centrifuge casting machine develops a speed of approximately 530-550 rot/min. the cooling of the antifriction alloy is realized by stpraying the cooling water on the superior semi-circumference of the steel stand.

2. Experimental results

In table 2 we can see the chemical compositions of the Sn-Sb-Cu alloy and in table 3, the chemical composition of the steel stand, for two lots of casted bearings.

Table 2. Chemical composition obtained for antifriction alloys Sn-Sb-Cu [%]

Charge no.	Sb	Cu	Pb	Cd	Ni	Sn
1	7,6	3,2	0.05	0,96	0,17	Rest
2	7,8	3,5	0,04	1,02	0,28	Rest

Table 3. Chemical composition of steel stands [%]

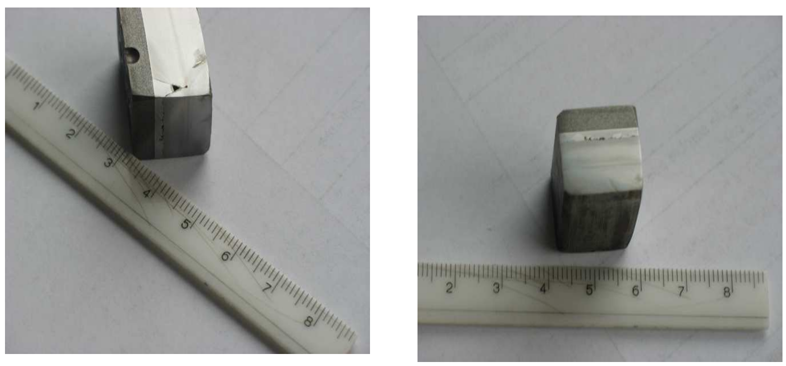
Nr. Lot	C	Mn	Si	P	S
1	0,10	0,44	0,22	0,019	0,24
2	0,11	0,43	0,21	0,018	0,20

In figure 3, we can see the macroscopic aspect of the samples removed from the bearings studied, and in fig. 4 we can observe a few defaults of material seen in the structure of the stands used.

These casting defaults underlined clearly by a microscopic analysis of the base material (Fig. 4). A part of the defaults observed seem to have been induced in the base material as a result of structural modification of the area of thermal influence generated by the realization of an adhesion by welding (realized in points) of the two parts from the bearing stand.

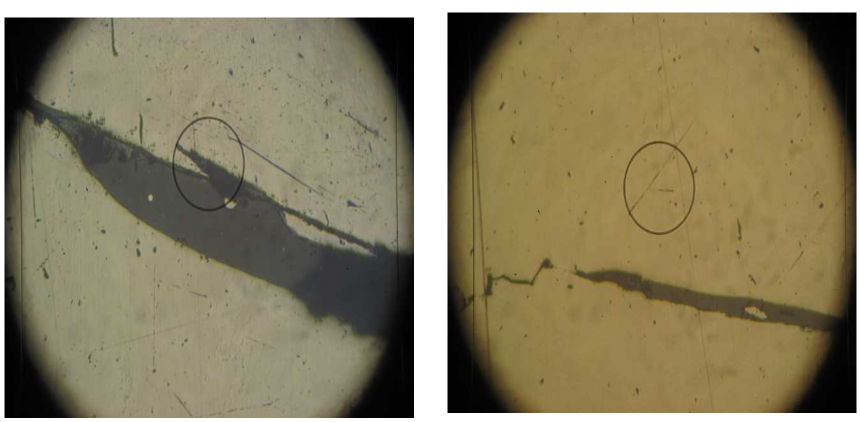
If the metallographic structure of the base material (steel) is ferrite-pearlitic, structure of the steel stand in the area of thermal influence din is pearlite-ferritic with a noncircular ferrite. In the same area we can observe the presence of material defaults (casting ones – sulphide).

In fig. 5 we can see the metallographic structure of the stand, in fig. 6 and fig. 7, the metallographic structure of the stand and that of the antifriction alloy. In fig. 6 nad 7, we can also observe the layer of adherence material applied on the active surface of the steel stand, obtained by the tinning of the surface (diving into a tin bath).

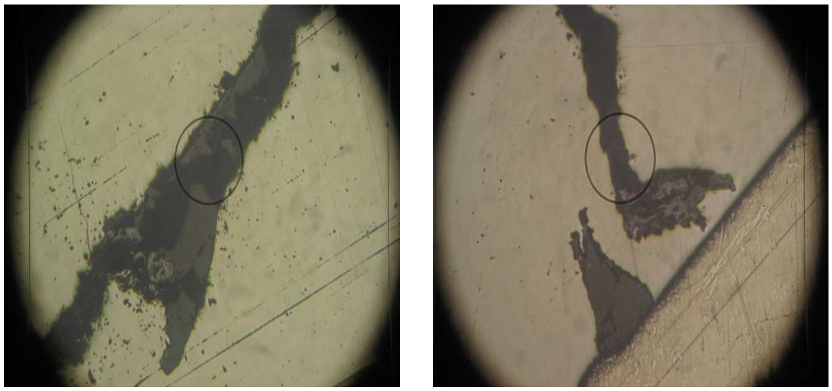


a. b.

Figure 3. Macro aspect of bearing samples:
a – transversal section; b – longitudinal section

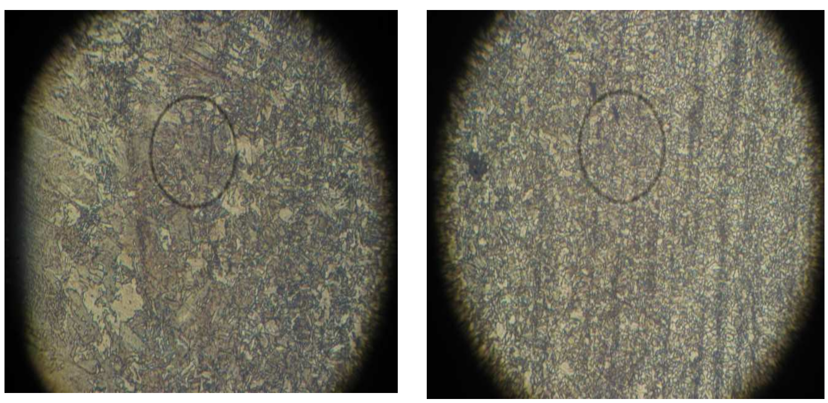


a. b.



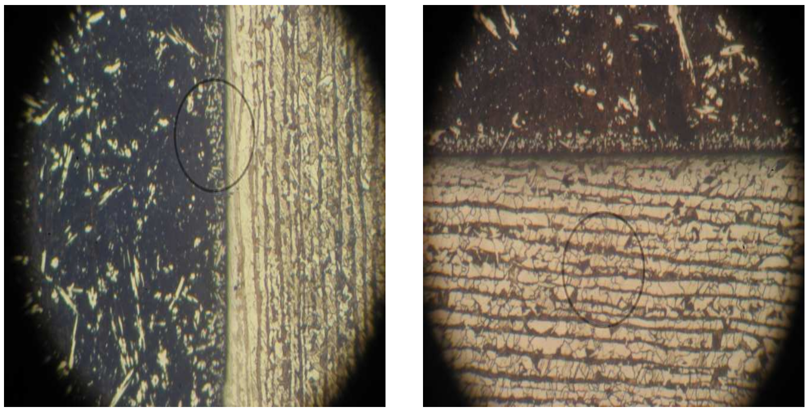
c. d.

Figure 4. Defaults of casting in the base material (steel): a, b - bearing 1; c, d - bearing 2 (100X)



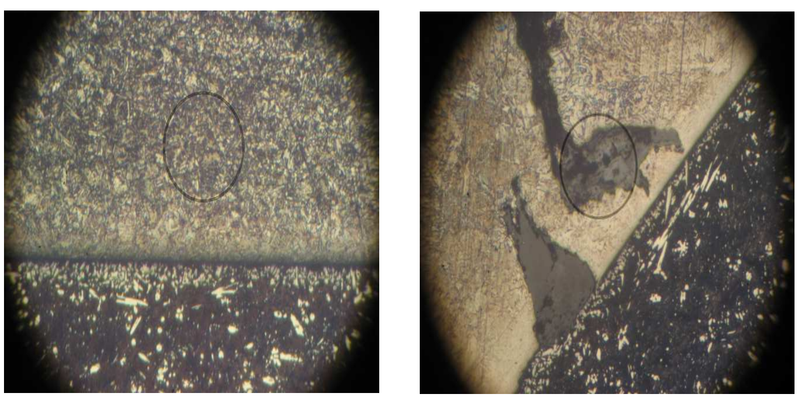
a. b.

Figure 5. Metallographic structures of the steel stand, with pearlite-ferrite matrices – area of thermal influence: a - bearing 1; b - bearing 2 (100X)



a. b.

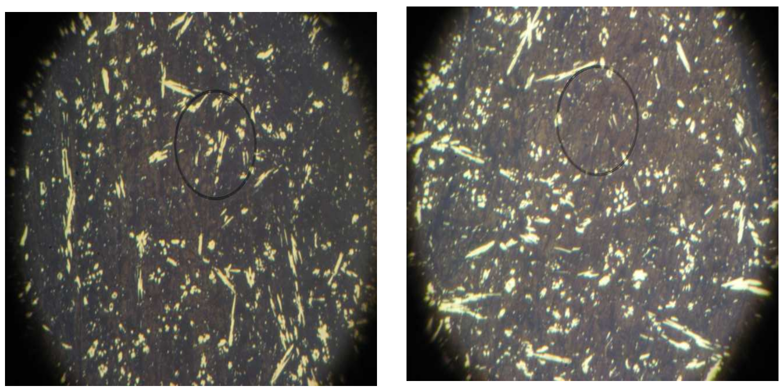
Figure 6. Metallographic structure of bearing 1 (100X)



a. b.

Figure 7. Metallographic structure of bearing 2 (100X)

The metallographic structure of the antifriction alloy Sn-Sb-Cu (Fig. 8), casted on a steel stand is characterized by a matrix of solid solution α (a fund of eutectic alloy Sn-Sb-Cu), with precipitations of the inter-metallic compound Cu_3Sn, in a noncircular shape. The globular separations of led are visible and are found at the border of grains.



a. b.

Figure 8. Metallographic structure of antifriction Sn-Sb-Cu alloy:
a - bearing 1; b – bearing 2. (100X).

In table 4 we can see Brinell hardness measured on the layer of antifriction alloy Sn-Sb-Cu, microalloyed Cd, in table 5, the same harness is measured on the layer of antifriction alloy Sn-Sb, which contains Cd as impurity (< 0,05% Cd) of the bearings and in table 6, Vickers hardness determined on the steel stands of the same bearings.

Table 4. Brinell hardness of antifriction alloys Sn-Sb-Cu, microalloyed with Sb [HB]

Bearing no.	Brinell hardness [$HB_{10/500/180}$]
1	22,3; 22,3; 22
2	22,4; 22,1; 22,3

Table 5. Brinell hardness of antifriction alloys Sn-Sb-Cu, which contains Cd as impurity [HB]

Bearing no.	Brinell hardness [$HB_{10/500/180}$]
1	26; 28; 28
2	25; 29; 24

Table 6. The hardness measured on the steel stands

Bearing no.	Area measured	Vickers hardness, HV_5 [HV]
1	Base material	175; 175; 175
	Area of thermal influence	232; 232; 195
2	Base material	175; 174; 174
	Area of thermal influence	244, 232; 239

4. Conclusion

Copper, as an alloying element in antifriction alloys Sn - Sb, in the same manner as cadmium, antimony and arsenic addings, has the role of forming new inter-metallic combinations of diminishing the content of antimony, improving the antifriction properties and it also reduces the tendency of segregation of the SnSb phase during solidification.

Antifriction alloys on a base of Sn-Sb-Cu are poured in thin layers, on a carbon steel stand in order to obtain an increase in resistance to fatigue of bimetallic bearings.

In order to obtain a growth in adherence for the antifriction alloy Sn-Sb-Cu at the steel stand, the latter one is cleaned and covered with a very thin layer of tin, by diving it in a tin bath.

For the preparing of the steel stand, for the casting, its surface is treated with solutions of HCl or H_2SO_4 (5…20%), then it is washed with hot water and neutralized with solutions of NaOH; the surface thus prepare is covered with a solution of $ZnCl_2$, with addings of NH_4Cl.

The presence of nonmetallic inclusions under the shape of sulphides, as a result of a high content of sulfur in the steel stands (sometimes even present in the interface with the adhesion material – tin), influences in a negative manner adhesion of the antifriction alloy and may lead even at its detachment from the stand, during the function of bearings.

Brinell hardness measured on the antifriction alloy Sn-Sb-Cu, microalloyed with cadmium has lower values than antifriction alloys Sn-Sb-Cu (contain cadmium under the shape of impurities). Brinell hardness prescribes of the antifriction alloy Sn-Sb-Cu is: 26...33HB

Areas of thermal influences from the steel stands, generated by the adhering by electrical welding of the two halves of bearings, have a negative influence on the durability of bimetallic bearings, being even able to lead in the detachment of the antifriction alloy layer.

Cadmium, as element of microalloying of antifriction alloys Sn-Sb-Cu enhances the capacity of adhesion of the alloy on the stand, decreases in a considerable manner its harness in comparison to antifriction alloys from the same category, but which contain cadmium as impurity.

The metallographic structure of the antifriction alloy Sn-Sb-Cu is formed of: solid solution α, solid solution β, on the basis of the inter-metallic compound SnSb, precipitated with Cu_3Sn and small spherical separations of led, at the grain borders of the α solid solution.

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