SMOOTH SLIDING

Consulting company providing engineering services on issues related to sliding bearings

Aluminum Based Bearing Materials

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1. Introduction

Aluminum based engine bearing materials provide a good combination of a moderate fatigue strength (load capacity) with a moderate level of anti-friction properties (compatibility, conformability, embeddability).
Most aluminum based bearing materials have bi-metal structure. The manufacturing technology of aluminum based bearing materials includes continuous casting followed by bonding the alloy with a steel strip.

Aluminum base bearing materials are:

- Less expensive than copper based bearing materials;
- Contain no (or low) hazardous lead;
- Possess good corrosion resistance, low wear rate;
- Do not require (in most cases) overlays.

Typical microstructures of bimetallic aluminum bearing materials are depicted in Fig.1, 2 (scanning electron microscope).

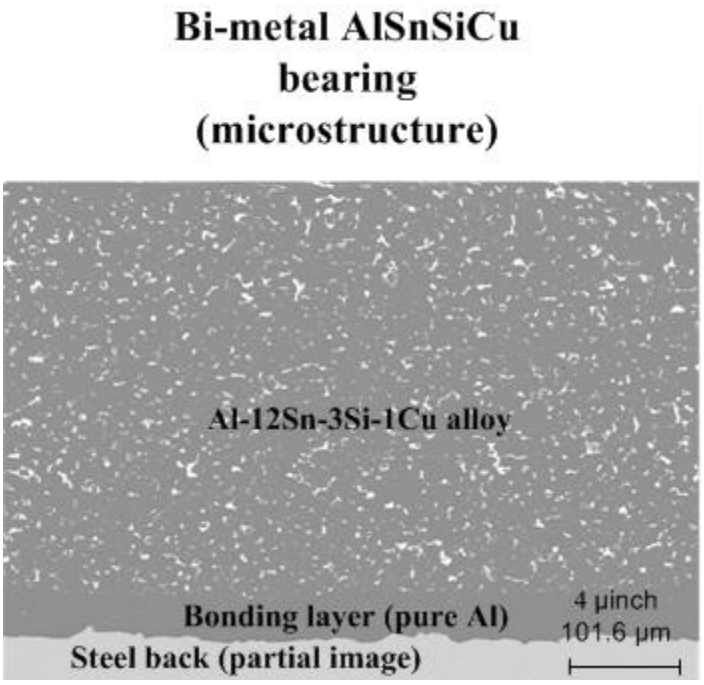
Bi-metal AlSnSiCu
bearing
(microstructure)
Al-12Sn-3Si-1Cu alloy
Bonding layer (pure Al)
Steel back (partial image)
4 µinch
101.6 µm

Fig.1

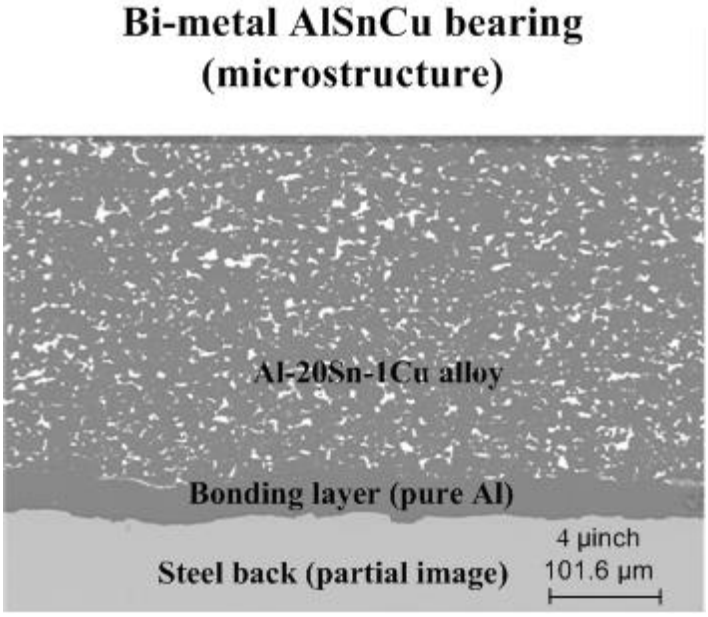
Bi-metal AlSnCu bearing
(microstructure)
Al-20Sn-1Cu alloy
Bonding layer (pure Al)
Steel back (partial image)
4 µinch
101.6 µm

Fig.2

2. Composition of Aluminum Based Bearing Alloys

- **Tin (Sn)**. Aluminum based bearing alloys commonly contain tin (6-40%) as a soft component. Tin is distributed in aluminum matrix as a separate phase in form of a reticular (network) structure along the edges of aluminum grains.

Tin imparts to the material anti-friction properties (compatibility, conformability, embeddability).

- **Silicon (Si)**. Some aluminum based bearing alloys contain silicon. Silicon has very high hardness and its inclusions distributed over the aluminum matrix serve as an abrasive particles polishing the mating journal surface.

The abrasive effect of aluminum based bearing alloys containing silicon is particularly important for the crankshafts made of nodular (ductile) cast irons consisting of spheroid nodular Graphite particles within the ferrite matrix. Grinding of the shaft surface causes formation of burred caps of ferrite surrounding the graphite nodules. These sharp edges scratch the bearing surface and decrease its seizure resistance. During the engine operation microscopic silicon particles included in the aluminum matrix remove the ragged edges from the shaft surface. Silicon also hardens the aluminum alloy and increases its fatigue strength.

- **Strengthening elements**. Aluminum matrix of engine bearing alloys may be strengthened by addition of copper, nickel, chromium, manganese, magnesium, zinc.

Most aluminum based alloys are solid solution hardened – strengthening by dissolving an alloying element. However some of the alloys may be dispersion hardened (heat treatable alloys) – strengthening by addition of second phase into metal matrix (Al_2Cu, Mg_2Si).

Aluminum based bearing alloys are manufactured by continuous casting technology.
In contrast to the copper based bearing alloys aluminum based tin containing alloys may be used without soft anti-friction overlays.

Most aluminum based engine bearings have bi-metal structure consisting of two layers: a steel back and an aluminum-tin alloy of about 0.01” (0.25 mm) thick.
Load carrying capacity of bi-metal Al20Sn1Cu bearing is 5800 psi (40 MPa).
Load carrying capacity of bi-metal aluminum-tin-silicon-copper bearing is 7250-8700psi (50-60 MPa).

The bearing materials not containing tin or containing low content of tin (less than 6%) are overplated with a thin soft overlay (tri-metal structure and multi-layer structures). The overlay parameters are like those used for tri-metal copper based bearings.
Load carrying capacity of tri-metal (overplated) aluminum based bearings is determined by the fatigue strength of the overlays:

- Lead based overlays: 7250-10150psi (50-70 MPa)
- Sputter overlays: 14500-17400 psi (100-120 MPa)

3. Characteristics of Some Aluminum Based Engine Bearing Materials

Composition	Structure	Hardness, HV	Overlay	Applications
Al20Sn1Cu	Bi-metal	35	no	Low loaded bearings
Al40Sn1Cu	Bi-metal	30	no	Low loaded bearings, excellent seizure resistance
Al8Sn2Pb2.5Si0.8Cu0.2Cr	Bi-metal, no bonding layer	40	no	Low and medium loaded bearings, good seizure resistance
Al12Sn4Si1Cu	Bi-metal	45	no	Low and medium loaded bearings, good seizure resistance, lead free
Al4Si0.5Cu0.5Mg	Tri-metal	70 (precipitation hardened)	Pb10Sn3Cu	Low and medium loaded bearings, good seizure resistance, lead free
Al6.5Sn1Cu0.5Ni	Tri-metal	40	Pb18Sn2Cu with nickel barrier	Highly loaded bearings
Al6.5Sn1Cu0.5Ni	Tri-metal	40	MoS2 in resin	Racing car engine bearings
Al6.5Sn1Cu0.5Ni	Solid	40	no	Thrust washers
Al11Si1Mg1Cu1Ni	Solid	100 (precipitation hardened)	Pb18Sn2Cu with nickel barrier	Small end bushes
Al4.5Zn1Pb1Cu0.5Mg	Tri-metal	55	Al20Sn (sputter) with NiCr barrier	Highly loaded conrod bearings