LEAD AND TIN BASED ENGINE BEARING OVERLAYS

Lead based engine bearing overlays

Lead based alloys are still widely used as overlay materials mainly in copper based tri-metal bearings. However in many applications the alloys containing toxic lead are replaced with new developed lead-free materials.
Lead based overlay materials have excellent soft anti-friction properties (compatibility, conformability, embedability) but relatively low fatigue strength limiting their applications in highly loaded engines (eg. direct fuel injection diesel engines). In addition to this pure lead has low corrosion resistance in acidic oils therefore conventional lead based overlay materials contain tin (not less than 10%), which inhibits corrosion attack of the alloy.
In order to impart the alloys higher fatigue strength lead-tin compositions are alloyed by copper (2-8%), indium (9-12.5%) or dispersed alumina particles (0.5-2%). Pb10Sn2Cu and Pb10Sn3Cu compositions are the most popular Pb-based overlay alloys.
Hardness of lead based overlay materials is in the range 8-20 HV depending on the content of the hardening component.
Fatigue strength of the lead based overlays is about 7250-10150 psi (50-70 MPa).

Lead based overlays compositions

Lead (Pb), %	Tin (Sn), %	Copper (Cu), %	Indium (In), %	Alumina (Al_2O_3), %
88	10	2	-	-
87	10	3	-	-
85	10	5	-	-
80	18	2	-	-
78	14	8	-	-
90	-	-	10	-
82	9	-	9	-
75.5	12.5	2	10	-
88	10	-	-	2

Lead based overlays are deposited by Electroplating methods. The same methods are used for the deposition of thin cosmetic tin flash.

Fluoborate bath formulations:
(Organic brighteners/additives - as recommended by the supplier)

Tin alloy electroplating in fluoborate solutions

	Tin		Lead		Copper		Fluoboric acid		Boric acid	
Coating	oz/gal	g/l	oz/gal	g/l	oz/gal	g/l	oz/gal	g/l	oz/gal	g/l
Pb10Sn3Cu	1.3	10	9	68	0.33	2.5	17	128	4	30
Tin flash (100Sn)	5	37	-	-	-	-	26	200	4	30

Nickel diffusion barrier (nickel dam) is deposited between the intermediate layer and tin containing overlay in order to prevent migration of tin from the overlay into the intermediate material (copper).
Diffusion of tin into copper causes formation of brittle Cu-Sn intermetallic compounds (Cu_3Sn, Cu_6Sn_5), which decrease the adhesion strength of the overlay to the intermediate layer. In addition to this decrease of the tin content in the overlay due to migration into intermediate material deteriorates the Corrosion resistance of the lead-based overlay alloy.
Thickness of nickel diffusion barrier is about 0.00004”-0.00006” (1-1.5 µm).
Nickel electroplating methods (Watts nickel plating solutions or nickel sulfamate solutions) are used for the diffusion barrier deposition.

Tin based engine bearing overlays

Tin based overlays contain copper (3-6%) as a hardening component.
The alloys are developed to replace toxic lead based overlays.
Tin based overlays possess excellent corrosion resistance and cavitation resistance.

Overlay multilayer system of Sn6Cu alloy deposited on the bi-layer diffusion barrier Ni-SnNi allows to create a microhardness gradient across the overlay thickness due to varying content of copper (soft top layer and hard bottom layer of the overlay). Such multilayer bearings are capable to withstand alternating loadsup to 11600-13000 psi (80-90 MPa).
Hardness of tin-copper overlays is 20-30 HV.

Tin-copper overlays are deposited by the electroplating methods.

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