THREE LAYER SLIDE BEARINGS FOR AN IC ENGINE CRANK MECHANISM

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Abstract

A continuous effort on new design, materials and manufacturing technologies is being made in order to limit the wear and secure reliable operation of slide bearings. Following paper presents the state of the art of the three-layer bearings used for main and crank bearings of automotive engines.

1. Introduction

Hydrodynamic bearings, where the load carrying oil layer is formed as a result of journal and shell relative motion are used as crank mechanism bearings of IC engines. Thanks to the wedge lubrication gap around journal, a spontaneous hydrodynamic uplift can be created.

The main and crank bearings of modern engine crankshaft are produced as removable steel shells covered with various bearing alloys. At present, engine bearings are manufactured almost exclusively as thin two or three layer shell, shells of inhomogenous structure of bearing layer, so called Rillenlager, or shells of fine-grained bearing layer with evenly spread soft matrix (so called sputter bearings).

2. Multilayer shell structure

Nowadays produced so called bilayer shells are made of a steel strip covered with a thin layer of bearing alloy [ ]. Often they are additionally covered with another thin layer* of a soft alloy of good frictional properties (trimetal shells), separated from the basic bearing material with a nickel intermediate layer, which prevents diffusion into e.g. lead bronze and formation of new compounds at the bronze and third layer contact area. Besides, other protecting overlays are used, e.g. those made of tin or copper, placed on the outer surface of the shell, that prevent the housing seizure, ease the heat transfer and protect the shell against corrosion. Fig. 1 illustrates the construction of multilayer shell, while the cross-sections of Rillenlager and sputter bearings are presented in [6], [7], [11].

Multilayer slide bearings combine good mechanical properties of high strength bearing alloys with good slide features of soft bearing materials.

* Thin overlays show much higher fatigue strength and wear resistance in comparison to thick layers.

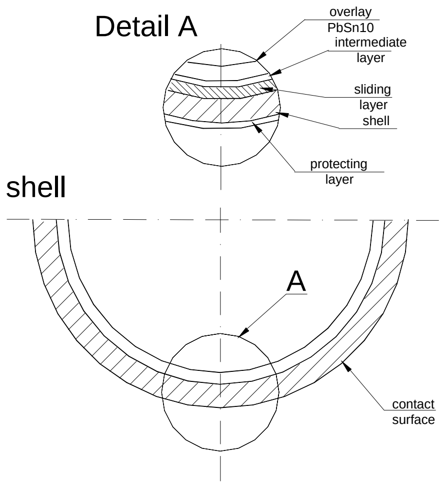

Fig. 1. *A cross-section of multilayer bearing shell*

3. Trimetal bearings

A number of layers, kind of material used and the way of production influence the total cost of bearing manufacturing. In a case of trimetal bearing the cost of production merely exceeds that for the traditional bimetal bearings – due to that this kind of bearings is most often applied to the engine crank mechanisms. Rillenlager and sputter bearings are far more expensive, therefore they are applied only to highly loaded sport car engines [11].

FM BIMET, the biggest Polish manufacturer of slide bearings, among others produces bearings of steel strip covered with an overlay. Examples of materials used for 3-layer slide bearings and information on their construction and chemical composition are presented in Table 1.

Table 1.

Some alloys for trimetal bearings made by FM BIMET S.A. [2]

Symbol*	Material		
	support	bearing material	overlay
MB45	steel	sintered bronze CuPb30	PbIn7
MB46	steel	sintered bronze CuPb22Sn4	PbIn7
MB48	steel	sintered bronze CuPb26Sn1,5	PbIn7
MB30	steel	cost bronze CuPb23Sn2	PbIn 7
MB40	steel	sintered bronze CuPb30	PbSn10Cu2
MB41	steel	sintered bronze CuPb22Sn4	PbSn10Cu2
MB43	steel	sintered bronze CuPb26Sn1,5	PbSn10Cu2
MB35	steel	cost bronze CuPb23Sn2	PbSn10Cu2
MB33	steel	statically cost bronze CuPb23Sn1	PbIn7
MB38	steel	statically cost bronze CuPb23Sn1	PbSnCu
MB39	steel	statically cost bronze CuPb23Sn2 +PbSn Cu	PbSn10Cu8

* According to FM BIMET S.A designation.

The Glacier Vandervell Europe produces slide bearings for IC engines in 6 European countries. Table 2 presents materials for trimetal bearings, however Fig. 2 presents a cross-sections of bearing materials: white metal and lead bronze [4].

Table 2.

Selected materials for trimetal bearings made by the Glacier Vandervell [4]

Bearing alloy	Material			Remarks
	Support material	Bearing material	Overlay	
White metal	steel	CuPb22Sn4,5	PbSn	sintered overlay
	steel	CuPb26Sn1,5	PbSn PbSnCu	
Lead bronze	steel	CuPb23Sn1,5	PbIn PbSnCu PbSnAl AlSn - sputtered	cast overlay
	steel	CuPb10Sn10	PbSnCu	
Aluminum	steel	AlSi4CuMg	PbSnCu PbSnAL	

a) b)

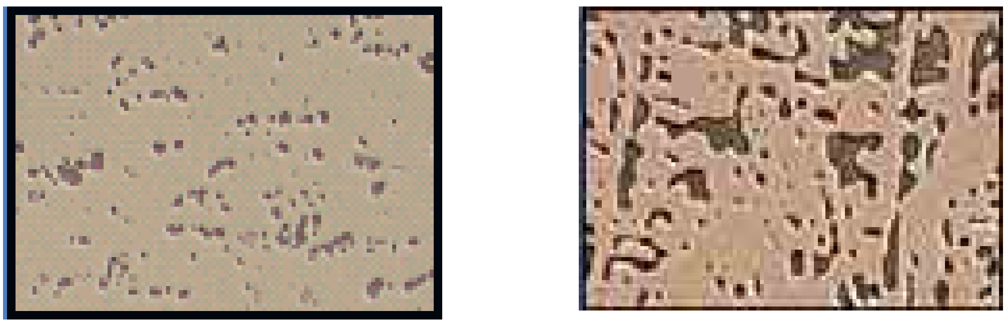

Fig. 2. *Cross section through bearing material*
a) white metal (AlSi4CuMg)
b) lead bronze (CuPb23Sn1.5)

Table 3 presents materials for trimetal bearings made by MIBA of Austria. Fig. 3 presents cross-sections of MIBA materials for trimetal and Rillenlager bearings [11].

Table 3.

Selected materials for trimetal bearings made by MIBA Gleitlager AG [11]

Bearing alloy	Support material	Bearing material	Intermediate layer	Overlay	Remarks
White metal (babbit)	steel	lgSn85CuNi	Ni	PbSn18Cu2	electroplated
Lead bronze	steel	CuPb22Sn2 CuPb20Sn4	Ni	PbSn18Cu2	electroplated
	steel	CuPb24Sn CuPb22Sn4	Ni	PbSn18Cu2	electroplated
	steel	CuPb22Sn2	Ni	$PbSn10TiO_2$	electroplated
	steel	CuPb10Sn10 CuPb15Sn7	Ni	PbSn18Cu2	electroplated
	steel	CuPb22Sn2 CuPb20Sn4	Ni	lgSn85CuNi	cast
	steel	CuPb22Sn2	Ni	$PbSn10TiO_2$	electroplated rillenlager
	steel	CuPb22Sn2	Ni	AlSn220Cu	sputtered
	steel	CuPb22Sn2	Ni	PbSn18Cu2	electroplated bearing rillenlager
	steel	CuPb10Sn10	Ni	CuPb30	electroplated
	steel	CuPb22Sn2	Ni	CuPb40	electroplated
Aluminum	steel	AlSn6CuNi	Ni	PbSn18Cu2	electroplated
	steel	AlZn4SiPb	Ni	PbSn18Cu2	electroplated
	steel	AlZn4.5SiPb	Ni	$PbSn10TiO_2$	electroplated
	steel	AlSn6CuNi	Ni	PbSn18Cu2	electroplated rillenlager
	steel	AlZn4SiPb	Ni	PbSn18Cu2	electroplated rillenlager
	steel	AlZn4SiPb		AlSn20Cu	sputtered

a)

b)

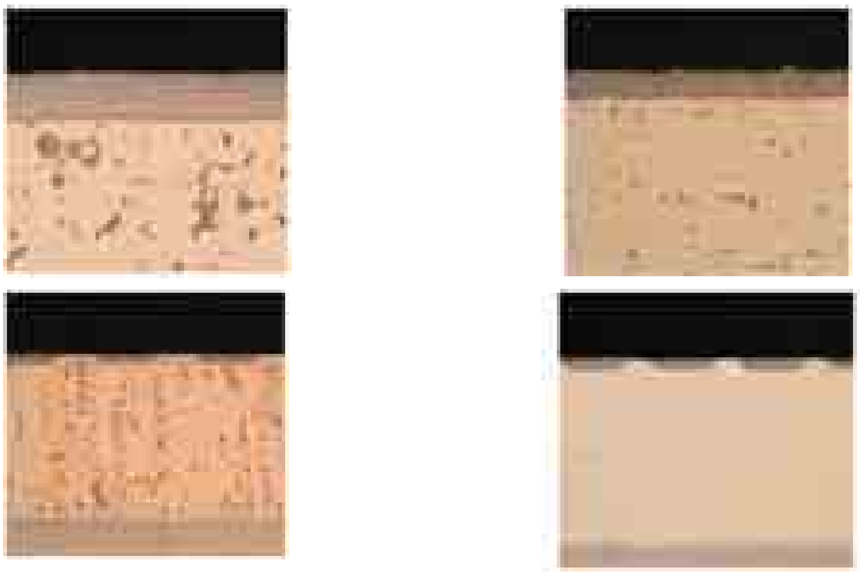

Fig. 3. *Bearing cross-sections [11]:*

a) trimetal one: left hand side - steel + lead bronze alloy (CuPb22Sn2) + Ni + PbSn18Cu2, right hand side - steel + aluminum alloy (AlSn6CuNi) + Ni + PbSn18Cu2,

b) Rillenlager: left hand side - steel + lead bronze alloy (CuPb22Sn2) + Ni + PbSn18Cu2, right hand side - steel + aluminum alloy (AlZn4SiPb) + Ni + PbSn18Cu2

Fatigue strength is one of the most important properties of bearing material. The fatigue failures result from dynamic loads of the crank mechanism especially dangerous at elevated temperatures. Application of the third layer, as it is practiced in trimetal shells [1], can improve the fatigue strength. The study [9] presents a probability of bimetal bearing failure caused by scuffing or fatigue of the overlay, respectively. The example of typical trimetal bearing and the Rillenlager failure probability has been presented in Fig. 4. A definitely longer life of the Rillenlager with a worn sliding surface in comparison to the trimetal bearing can be seen in the diagram.

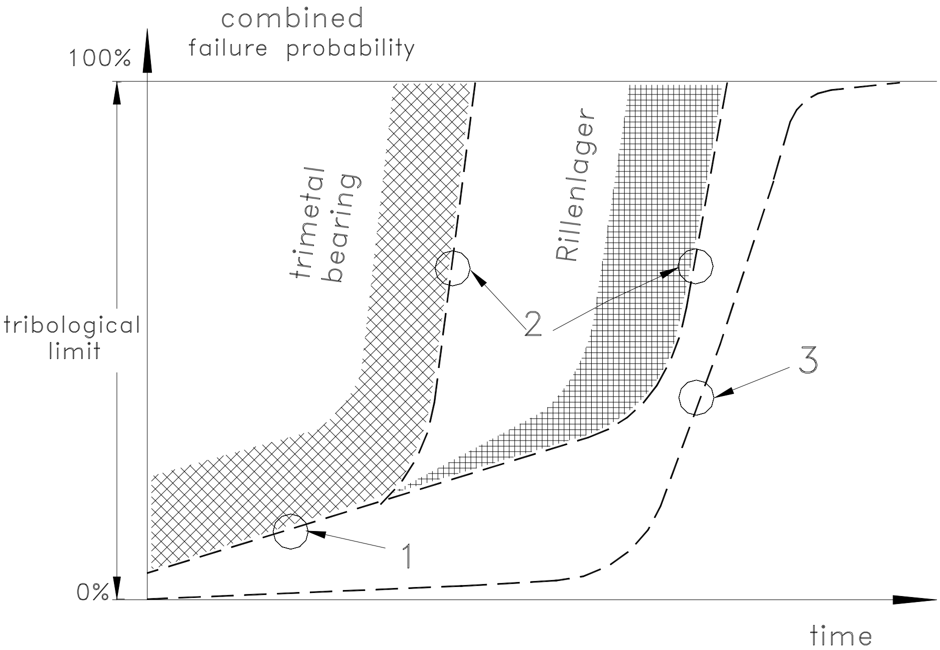

Fig. 4. *Failure probability of a trimetal bearing: 1 – tribological limit for bearing with overlay, 2 – tribological limit for bearing with worn overlay, 3 – lining fatigue strength corresponding to the load level [1]*

4. Conclusions

A number of new materials for individual layers spread over the steel support have been introduced in recent years. The efforts concentrate on an improvement of overlay fatigue strength, because fatigue failures are the serious problem for operation of an engine crank mechanism. Another way to expand the bearing life is an application of inhomogenous bearing material (Rillenlager) or sliding surface sputtered with AlSn, which is much more expensive and applied only to the bearings of highly loaded engines.

Bearing materials used for production of trimetal bearing shells presented in this paper are the examples of variety of possible compounds covering the steel support and applied as bearing sliding surface. Unfortunately, this review of materials is very limited as the information concerning both materials and technologies are strictly confidential and unavailable to the common user.

5. References

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TRÓJWARSTWOWE ŁOŻYSKA ŚLIZGOWE STOSOWANE W MECHANIZMIE KORBOWYM TRAKCYJNYCH SILNIKÓW SPALINOWYCH

Streszczenie. W celu ograniczenia zużycia łożysk mechanizmu korbowego i zapewnienia im niezawodnej pracy prowadzi się ciągłe prace nad nowymi konstrukcjami, materiałami i technologiami produkcji łożysk ślizgowych. W artykule przedstawione zostaną obecne tendencje odnośnie produkcji łożysk trójwarstwowych przy wykorzystaniu ich na łożyska główne i korbowe trakcyjnych silników spalinowych.