MODERN TRENDS IN MATERIALS FOR HIGH PERFORMANCE ENGINE BEARINGS

Introduction

The design of internal combustion engines has been continuously modified. Engine output and efficiency have dramatically increased due to the great efforts of engineers and the latest technological achievements in materials engineering, electronics and computer control.

Engine evolution is well illustrated by the history of the Chevrolet small-block V8.
The first generation (1955) had a displacement of 265 cu. in. and an output of 180 hp. This means that each cubic inch of displacement produced 0.68 hp. 50 years later GM offered its LS9 supercharged small block engine having a displacement of 376 cu (6.2 L) and a maximum of 638 hp. This is equivalent to 1.7 hp/cu. in. – an increase of 150%.

Of course the conditions under which the engine bearings operate have also changed. Greater output, higher combustion pressures and engine downsizing result in higher specific loads being applied to the bearings. In parallel, there is a trend towards lower oil viscosity and reduced ZDDP content in motor oils. Thus, bearingsin modern engines work in a regime of lower minimal oil film thickness. As a result, there is a greater probability of fatigue, abnormally fast wear and seizure.

Traditional Tri-metal Bearings

One of the most popular engine bearing constructions is the tri-metal bearing. It is composed of a steel back, copper-lead intermediate layer, nickel diffusion layer and a soft overlay forming the bearing top surface made from a lead-tin-copper alloy.
Tri-metal bearings were invented in 1947 and have not basically changed since then. However, in order to meet the demands of increased loads, the overlay thickness has been reduced. Thinner overlay thickness produces better Fatigue strength (load capacity)). Originally, overlay thickness was 0.001-0.002”. Now it is as low as 0.0005-0.0007”.
Unfortunately, the reduced thickness of these soft overlays decreases bearing life. Traditional thin overlays wear off more quickly, increasing the threat of seizurebetween the crankshaft journal and the exposed bronze of the intermediate layer.
Overlay thickness is always the result of a compromise between the required load capacity and the bearing’s anti-friction properties. However, in many modern engines the required compromise is unachievable. The traditional tri-metal engine bearing, which has been used for decades, becomes unsuitable for these applications.

pMax Black™ Bearings

The solution for this problem lies in developing bearing materials that perform as stronger overlays with greater fatigue strength and better Wear resistance. King Engine Bearings has developed an effective method of producing such a material by means of a surface hardening process that strengthens lead

based alloys. This innovative technique enables the formation of an ultra-thin hardened shield on the overlay surface.
This shield, of nano-scale thickness, is sufficient to effectively suppress the formation of fatigue cracks on the surface.
It measures 18.1 Hardness Vickers compared to 14 H.V.or less found in competitors' performance bearings. This results in a minimum 29% stronger overlay surface that withstands greater loads and delays or prevents the formation of fatigue cracks and distress.
At the same time, the properties of excellent seizure resistance, conformability and embedability – which are characteristics of soft overlays – are preserved. This new overlay, called pMax Black™, has proven its effectiveness in increasing the fatigue strength of high performance tri-metal bearings. All King XP series high performance bearings are manufactured with this hardened pMax Black™ overlay. These bearings are easily recognizable by their distinctive dark color.

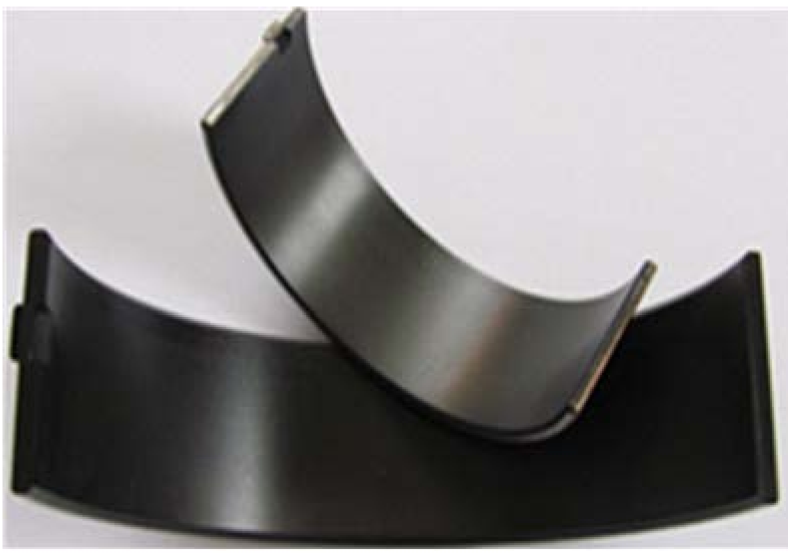
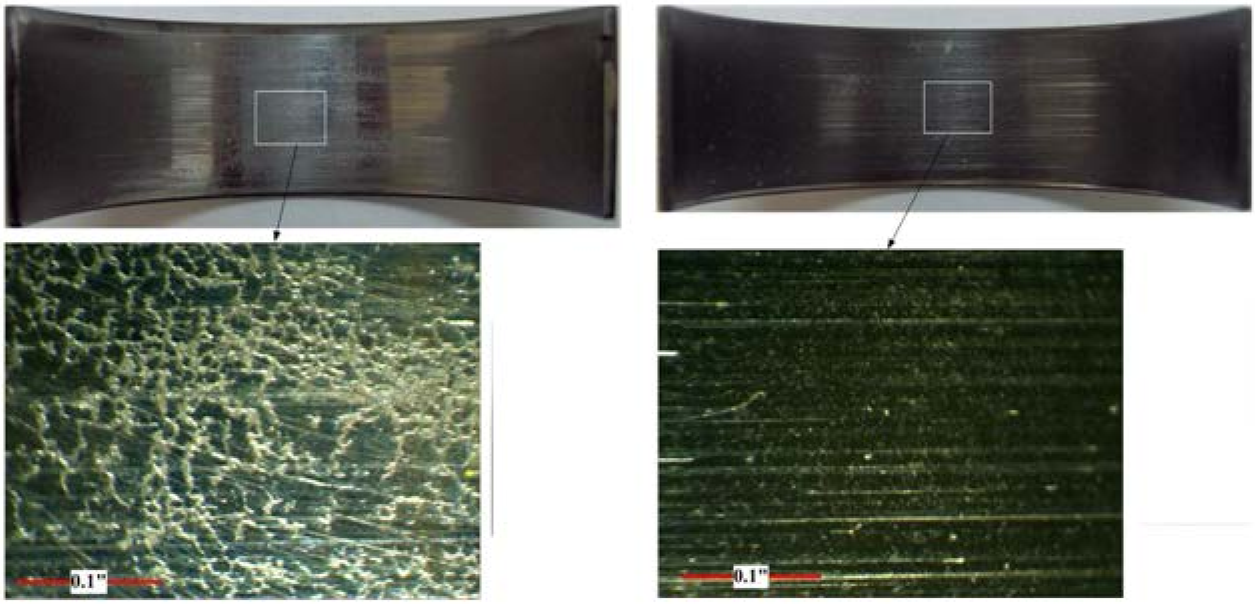


Fig. 4 King pMax Black™ structure in King XP series

The new material has been tested in comparison with traditional tri-metal bearings. The results of the comparative tests conducted in King's Test Rig are presented in figure below. The tests were performed under a bearing load of 10,200 psi for 4,300,000 cycles. Both conventional and pMax Black™ bearings had the same dimensions.

Rig Tested bearings



Traditional tri-metal bearing **King pMax Black™ bearing**

The test results are as follows:

- The conventional high performance bearing has a large area (about 30% of the surface area) with overlay fatigue cracks.
- King pMax Black™ has no fatigue cracks.

“Next Generation” Materials For Extreme Load

The load applied to the bearings in some boosted high performance engines may exceed 10,200 psi. The bearings, particularly the upper rod shells, should be made from materials that are much stronger than even pMax Black™.

For such applications, King has developed bearings made of a strong intermediate layer copper alloy and high strength metallic overlay. The fatigue resistance of these bearings is 17,400 psi.

The overlay pairs extremely high fatigue strength and Wear resistance with high seizure resistance. This is due to the combined properties of its base metal and special solid lubricant additives.

Bi-metal Bearings

Bi-metal bearings with a lining made of aluminum alloy have some advantages over tri-metal bearings. The most important advantage is the absence of thin overlays, which allows for greater wear with minimum risk of seizure.

Bi-metal bearings have been traditionally used in low and medium loaded engines. However, developments in engine design require bearings with greater load capacity. Traditional aluminum-tin bearings cannot be used in such engines.

Newer aluminum alloys contain strengthening additives and are processed with special thermo-mechanical treatments. They have an enhanced fatigue strength that exceeds the load capacity of conventional bi-metal bearings by 25-30%.

Polymer Coatings

Polymer coatings are composed of a polymer and additives in the form of small particles of Solid lubricants (molybdenum disulfide, graphite, PTFE). Polymer coatings applied onto the overlays of conventional high performance tri-metal bearings are quite popular.

The main purpose of coatings in existing applications is to provide some protection from wear to the overlay during mixed lubrication regimes (metal-to-metal contact with the journal due to an absence of oil film). For example, coatings prevent cold start wiping. Coatings prolong bearing life when operating with very thin or negligible oil film.

Today, coatings are considered by some to be nothing more than a sacrificial layer…helpful but not necessary. We believe that the true potential and benefits of coatings are quite underestimated. They can play a much more important role in preventing seizure of highly loaded bearings. Extensive research and testing is being conducted, with particular emphasis on improving wear resistance and extending the service life of coatings. Much more is yet to be developed and introduced in this regard.

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