POLYMER BASED ENGINE BEARING OVERLAYS

Modern design of internal combustion engines has a tendency to reduce the weight and dimensions of the engines and to increase their power and rotation speed.
In addition to this the engine designers are required to diminish the fuel consumption as a response to more strict regulations of air pollution, expensive crude oil and climate change (greenhouse effect).

One of the measures to save fuel is a reduction of the friction between the engine crankshaft and the bearings.
Most of time engine bearings work in the regime of hydrodynamic lubrication, in which the friction is determined by the viscosity of the oil. Therefore reduction of the engine power loss is achieved by using oils with low viscosity.
High loads applied to the bearings and low viscosity of the lubricant result in a reduction of the minimum oil film thickness, which may cause a metal-to-metal contact between the bearing and the shaft (boundary lubrication regime) characterized by high coefficient of friction (power loss), increased wear, possibility ofseizure between the bearing and shaft materials , non-uniform distribution of the bearing load (localized pressure peaks).
The situation is further aggravated by the distortions of the lightweight crankshaft (due to the loads applied to it) and of the lightweight connecting rod, big end of which changes the shape of its bore and the bearing mounted in it from circular to elliptical (due to the inertia forces at high rotation speed).

In the initial period the bearings of the engine working at such conditions conform themselves to the crankshaft. During this period anti-friction properties of theoverlay material (compatibility, conformability, embedability, wear resistance)) are very important.

Polymer based bearing overlays (coatings) partially fill the bearing clearance, and this must be taken into account.
Coatings can help to eliminate or reduce metal-to-metal contact between the bearing and the journal surfaces during start-up and the initial period of bearing operation.
Coating promotes conforming of the bearing surface resulting in lower wear of the bearing material.
Components of coating have excellent anti-friction properties (very high seizure resistance, low coefficient of friction, embedability, conformability).

However coatings are a sacrificial layer, they can wear fast under high load in mixed lubrication regime (metal-to-metal contact).
When the coating is removed by friction, the bearing clearance is increased by the value of the coating

thickness. Therefore coatings should not be too thick (not more than 0.0004"/0.01mm). Coatings have no effect on bearing load capacity.

Currently polymer coatings are applied primarily to the soft lead-based overlays of tri-metal bearings. Since a lead-based overlay itself has very good anti-friction properties, the effectiveness of coating in such applications is somewhat limited. Bearing coatings may be more effective when applied onto high strength bearings to improve their surface properties.

Composition of polymer based engine bearing overlays

Polymer based overlay materials are Polymer Matrix Composites composed of particles of Solid lubricants and hard abrasives (dispersed phases distributed within a polymer binder (matrix phase).

The components of polymer based overlays:

- **Polymer matrix (binder)**. Thermosetting resins and Thermoplastics are used as the matrix material:
  - Polyamide-imide
  - Epoxy
  - Phenolics
- **Solid lubricant** in the amount of 50-80 vol.%:
  - Molybdenum disulfide (MoS_2)
  - Graphite
  - Tungsten disulfide (WS_2)
  - Boron nitride (BN)
  - Polytetrafluoroethylene (PTFE)
- **Hard abrasive particles** for improvement of wear resistance in the amount of 2-5 vol.% (some polymer based overlays do not contain hard particles).
  - Alumina (Al_2O_3)
  - Silica (SiO_2)
  - Silicon carbide (SiC)
  - Silicon nitride (Si_3N_4)

Polymer based materials containing solid lubricants and abrasive particles and thinned with appropriate Solvents are applied on the bearing surface by spraying technique and then cured (cross-linked) at 300-480ºF (~150-250ºC).

Source : http://www.substech.com/dokuwiki/doku.php?id=polymer_based_engine_bearing_overlays