

Engine bearing failures and how to avoid them

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Most engine bearing failures are caused by one of two factors:

- Mixed lubrication with direct metal-to-metal contact between the bearing and crankshaft surfaces;
- Fatigue of the bearing material.

1. Bearing failures due to metal-to-metal contact

Mixed lubrication is one of the main causes of engine bearing failures.

Metal-to-metal contact may appear in the following forms of bearing wear:

- **Accelerated wear:** is when the bearing is not overheated and only a shiny appearance of the bearing surface is observed.
- **Wiping or heavy wear:** this appears in the form of overheating and partial melting of the overlay (the left part of the Fig.1).
- **Severe wear or Hot Short:** it results in torn surfaces, severe overheating, melted overlay and lining material (right part of the Fig.1).



Fig.1 Metal-to-metal contact

Causes of mixed lubrication and the methods of solving the problem are presented in the table below:

Bearing failures due to metal-to-metal contact	
Cause	Solution
Insufficient oil supply (oil starvation)	Check oil supply system (e.g. clean clogged oil passages ,insufficient clearance, etc)
Breaking the oil film (due to oil contamination or bearing material fatigue)	Change bearing material (tri-metal instead of bi-metal) or solve overloading problem
Misalignment (e.g. out-of-shape grinding, distorted connecting rod)	Correct deficient machining, fix/replace distorted parts
Poor journal surface finish	Verify proper grinding/polishing procedures
Foreign particles embedded in the bearing surface	Determine origin of particles, improve cleaning procedures prior to assembly. Clean parts with hot soapy water. Do not clean with solvents
Low viscosity oil (diluted with fuel or coolant)	Identify/address source of oil dilution, use higher viscosity oil
Grinding chatter marks (waviness) and lobing	Check crank grinder table + wheel bearings for excessive play, replace/re-grind crankshaft

2. Engine bearing failures due to fatigue

Bearing material fatigue is the second cause of bearing failure.

Fatigue of an aluminum lining. The fatigue cracks form on the surface and propagate inside the lining reaching the steel back.

The cracks then progress along the bond line between the lining and the steel.

Pieces of the lining flake out from the steel back resulting in oil contamination and eventual bearing failure.

Fatigue of aluminum alloys may also cause extrusion of the lining material past the length of the bearing edges.



Fig.2 Fatigue of aluminum lining of bi-metal bearings

- **Fatigue of a tri-metal overlay.** Spider web-like cracks are seen on the surface (Fig.4). Fatigue limit of an overlay is determined by the strength of the material and the thickness of the overlay. The thinner the overlay, the higher its fatigue strength.

Overlay fatigue itself does not cause the bearing to fail.

However, running the bearing with fatigued overlay may cause partial flaking of the overlay, lowering the oil film thickness and eventual seizure of the exposed intermediate layer.



Fig.3 Fatigue of the overlay of tri-metal bearings

- **Fatigue of a copper based intermediate layer.** Fatigue of a copper based lining (Fig.4) starts from a fatigue of the overlay. The overlay flakes out from the copper lining resulting in an interruption of the oil film, breaking the hydrodynamic lubrication regime. The load localizes at the contact area causing formation of small cracks on the lining surface. The cracks then propagate throughout the lining thickness, meeting the steel back surface and continuing to advance along the steel-copper boundary. As a result, parts of the intermediate layer detach from the steel surface.

Fig.4 Fatigue of the copper based intermediate layer of tri-metal bearings



The table below shows factors that cause fatigue and methods of preventing bearing failures due to fatigue.

Engine bearing failures due to fatigue	
Cause	Solution
Wrong selection of engine bearing material	Change to a bearing material with higher load capacity (e.g. tri-metal instead of bi-metal)
Fuel detonation / advanced ignition	Retard ignition or use a fuel with higher octane number
Running engine at high torque and low RPM for a long time (climbing)	Change to bearing material with higher load capacity (e.g. tri-metal instead of bi-metal)
Poor conforming of the bearing back with the housing surface	<ol style="list-style-type: none"> 1. Check the bearing crush height 2. Properly re-size the housing
Oil starvation causing localization of load at particular bearing areas	Check oil supply system for clogged oil passages, check clearances, component geometry, oil pressure + volume
Geometry misalignments causing localization of bearing loading	Fix/replace distorted parts or use more conformable material (bi-metal instead of tri-metal)
Corrosive action of contaminated oil enhancing fatigue	Eliminate/diminish oil dilution or use oil with corrosion inhibiting additives

3. Geometric irregularities

Fig. 5 and 6 show examples of the effect of geometric irregularities.

Both problems are seen in the picture: local wear with shiny appearance and the overlay fatigue in form of spider web like cracks on the areas of metal-to-metal contact.

- **Distorted (bent or twisted connecting rod)** is one of the causes of localized loading of engine bearings (Fig.5).
Overloading of an internal combustion engine due to detonation or running under high torque at low rotation speed may cause distortion of the connecting rods. The distortion results in non-parallel orientation of the bearing and journal surfaces.
The non-parallelism causes localized excessive wear of the bearing surface due to metal-to-metal contact (boundary or mixed lubrication) occurring near the bearing edge.
Localized metal-to-metal contact may also cause fatigue cracking of the bearing material in the locations of the contact.

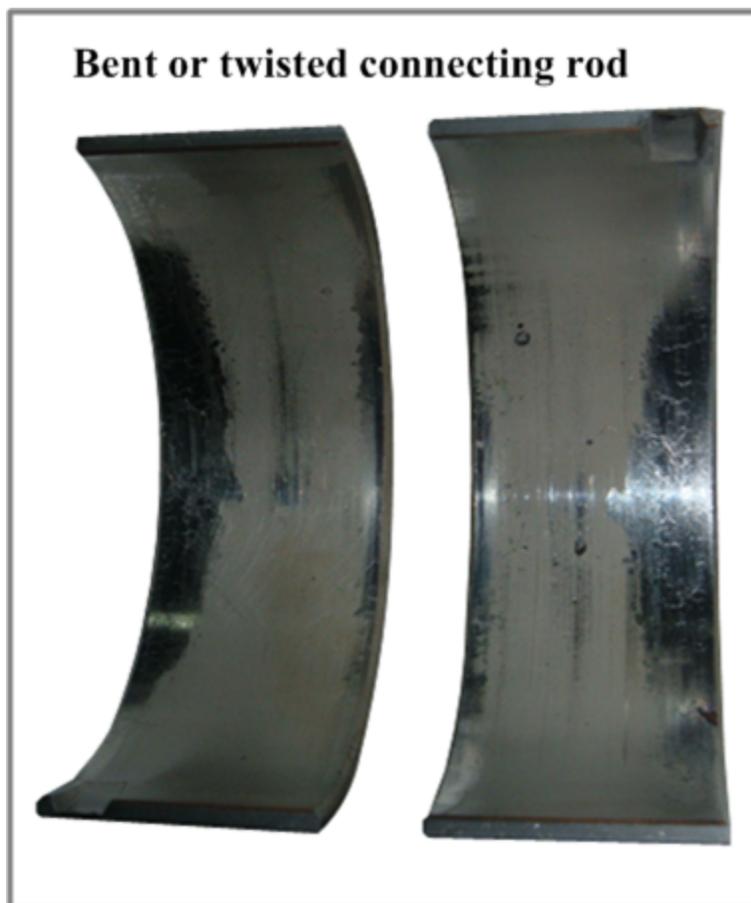


Fig. 5 Bent or twisted connecting rod

- **Imperfect journal geometry** is another cause of localized loading of engine bearings (Fig. 6).
Use of a worn stone in grinding a crankshaft results in obtaining an imperfect (out-of-shape) journal surface: taper shape, hour glass shape or barrel shape. The parts of the journal surface having higher diameter (central part of the barrel shape journal, edge parts of hour glass shape journal) come to metal-to-metal contact (boundary lubrication) with the bearing surface. The metal-to-metal contact causes excessive wear. Fatigue cracking of the bearing materials may occur in the contact areas.



Fig. 6 Imperfect journal geometry

4. Cavitation erosion of the overlay

Cavitation erosion is another type of engine bearing failure differing from both fatigue and metal-to-metal contact.

Cavitation is a phenomenon related to hydrodynamics.

Cavitation occurs when the load applied to the bearing fluctuates at high frequency (high RPM). The oil pressure instantly falls causing formation of bubbles (cavities) due to fast evaporation. When the pressure rises the cavitation bubbles collapse at high velocity. Such collapse results in impact pressure, which can erode the bearing material (Fig.7).

Soft lead based overlays of tri-metal bearings are prone to the cavitation erosion. Therefore replacement of tri-metal bearings with babbitt overlay with bi-metal material or with high strength tri-metal bearings (e.g. GP) will prevent the failures due to cavitation.



Fig.7 Cavitation erosion of soft lead based overlay