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Following on the six Autocare booklets issued as a supplement to Autocar, *we are now publishing a weekly Autocare feature on car maintenance and the fitting of accessories*

Why do main bearings fail?

Main and big-end bearings seldom fail nowadays. When they do, there is always a good reason. The following notes will help you find it.

THE well-being of a plain bearing is very much dependent on efficient lubrication. To understand what this implies, it is necessary to examine the principles involved.

Fig 1 (A) shows a shaft or journal at rest. Although ample lubricant may be present in the bearing as a whole, very little separates the actual load-carrying surfaces. In fact, metal-to-metal contact may well exist in extreme cases. These are known as *boundary lubrication* conditions.

When rotation begins, friction causes the journal to climb to the position depicted in Fig 1 (B). As the shaft continues to turn, oil is carried into the "contact" area between the journal and the bearing. The wedge of oil so formed generates considerable hydraulic pressure and the shaft ultimately adopts a position such as that shown in Fig 1 (C). The majority of lubrication points within an engine rely on this phenomenon, which is termed *hydrodynamic lubrication* (sometimes called *fluid-film lubrication).*

Fig 2 shows the distribution of hydrodynamic pressure within a typical journal bearing. Note how it reaches a peak just before the point of minimum clearance. Also bear in mind its magnitude is independent of pump pressure, being largely a function of oil viscosity and linear speed.

Bearing Clearance

Continuous shearing of the oil film within a highly stressed bearing generates a considerable amount of heat. To help dissipate this, oil is allowed to leak from the open edges of the bearing and the loss made good by pumping cool oil into the low-pressure side (low hydrodynamic pressure, that is).

Leakage is largely governed by bearing clearance and pump pressure. Too little clearance will cause over-heating and introduce the risk of metal-to-metal contact. On the other hand, excessive clearance will delay the build-up of the hydrodynamic film, with consequent knocking and wear when starting. There is also a risk of the pump and galleries failing to keep pace with the high leakage rate, leading to breakdown of the hydrodynamic film.

Oil Pressure

Increasing pump pressure—a dodge often used by tuning specialists—offers a way of improving the flow rate (and thus heat dissipation) without resorting to abnormal bearing clearances. Bear in mind, however, that the resultant increase on the pressure drop across the filter element can cause the by-pass valve to open. This, in turn, allows unfiltered oil to reach the main- and big-end bearings. As explained later, this can lead to abnormally rapid wear. In the same way, of course, failure to renew the filter element at proper intervals can ultimately prove expensive.

When sump temperatures frequently exceed 90 deg. C., an oil cooler may well improve bearing life. Consistently low temperatures (below 55 deg. C.), on the other hand, encourage the formation of sludge and corrosive acids. The ideal solution is a cooler incorporating a thermostatic valve.

Viscosity Index

Mention has already been made of the shearing action to which oil is subjected within main- and big-end bearings. This, of course, takes place throughout the engine. It has the effect of ultimately breaking up the long-chain polymers used as viscosity-index improvers in modern oils. Without delving too deeply into technicalities, this means that the oil is less able to cope with elevated temperatures. The moral is obvious: it must be changed at proper intervals, no matter how effective the filter.

The lubrication requirements of main- and big-end bearings can thus be summarized as follows:

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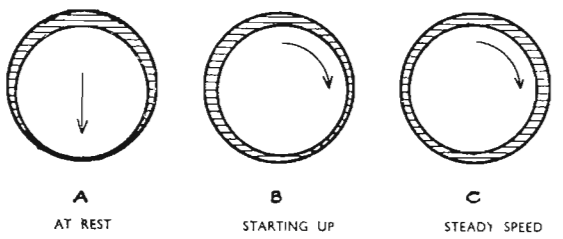


Fig 1 (above): Sequence of events leading to the formation of a hydrodynamic film within a plain bearing

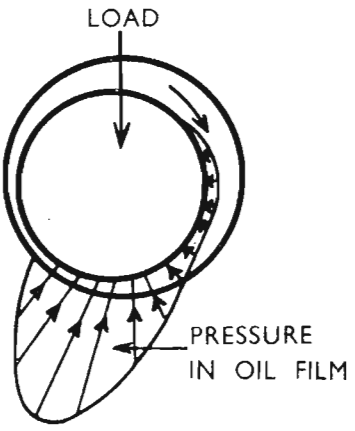


Fig 2 (right): Sketch showing distribution of hydrodynamic oil pressure. Its value is largely independent of oil-pump pressure

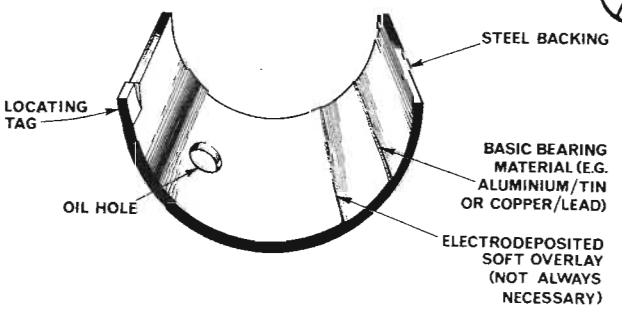


Fig 3 (left): Construction of a typical bearing shell

Fig 6 (below): Embedded particles can cause sufficient distortion for metal-to-metal contact to occur

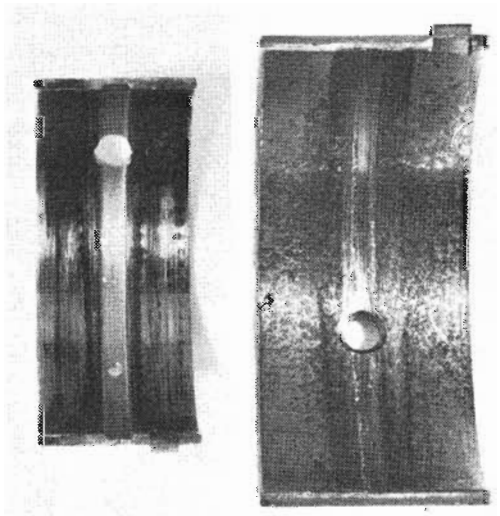
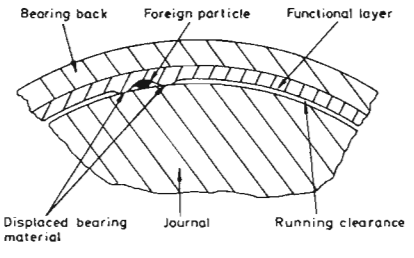


Fig 4 (above, left): A shiny bearing surface is indicative of oil starvation
Fig 5 (above, right): Dirt between the journal and bearing often causes tracking or scoring



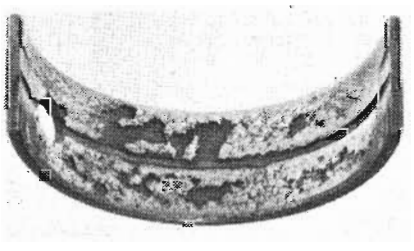


Fig 7: This is a particularly bad example of corrosive wear. Compare with fatigue failure shown in Fig 9

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1) The oil must have sufficient lubricity to cope with boundary lubrication conditions.

2) Its viscosity index must conform with the engine manufacturer's recommendations.

3) No unfiltered oil should be allowed to reach the bearings.

4) The oil must be changed at the recommended intervals. More frequent renewal may be necessary when operating conditions are severe; e.g., frequent short journeys in cold weather.

5) Sump temperatures should be high enough to disperse the acidic products of combustion blow-up. Too high a temperature, on the other hand, can lead to breakdown of the oil film within the bearings and promotes excessive oxidation of the sump oil.

6) Bearing clearances must be correct.

7) Last, but by no means least, there must be no interruption of the oil supply while the engine is running.

Bearing Materials

A typical main or big-end bearing shell is depicted in Fig 3. Most of its strength can be attributed to the steel backing, to which is bonded the basic bearing material. The alloys used for this purpose are as follows:

a) *Babbit or whitemetal.* This tin-based alloy was widely used for many years. It has excellent surface properties, but lacks mechanical strength at high temperatures. As a consequence it is rarely used on modern high-output engines.

b) *Copper-lead.* Although much stronger and more resistant to fatigue, this lacks whitemetal's excellent surface properties. As a consequence, a thin, soft overlay is used. Usually a lead-tin alloy, this overlay is electrodeposited on the bearing surface. When copper-lead bearings are employed, good filtration is of vital importance.

c) *Aluminium-tin.* Widely used nowadays, these alloys have excellent mechanical properties. Furthermore, those with a comparatively high tin content (usually 20 per cent) can be used without an overlay.

d) *Aluminium-cadmium.* These are commonly found in engines of American origin. They have good mechanical strength, but poor surface properties. As a consequence a lead-tin-copper overlay is necessary.

e) *Aluminium-zinc.* Chief users of this alloy are Volkswagen. No steel backing is provided in this instance. Surface properties are dependent on zinc content. Where this is low, an overlay is required.

Causes of Bearing Failure

We have already dealt with the failures likely to result from improper lubrication. The following notes and illustrations will assist in the diagnosis of such faults.

Inadequate lubrication

This includes all failures resulting from metal-to-metal contact. As already discussed, causes include unsuitable oil, insufficient oil, inadequate clearance, etc. Unless seizure has occurred, the bearing surface will have an abnormally shiny appearance (Fig 4).

Dirt Ingress

The presence of dirt in the bearing surface indicates one of two things, dirty assembly or inefficient filtration. The softer the bearing alloy, the more tolerant it is in this respect. Babbit is particularly good, whereas copper-lead is badly affected. Aluminium-tin falls somewhere between these two.

Bearings which fail for this reason often display scraping or tracking marks (Fig 5). It is also possible for embedded particles to cause

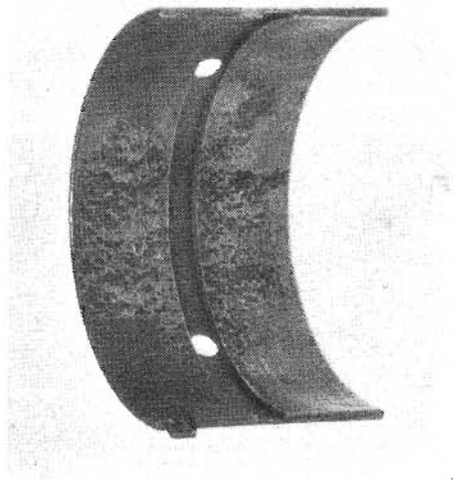


Fig 8 (below, left): A more typical example of corrosive damage to a bearing surface

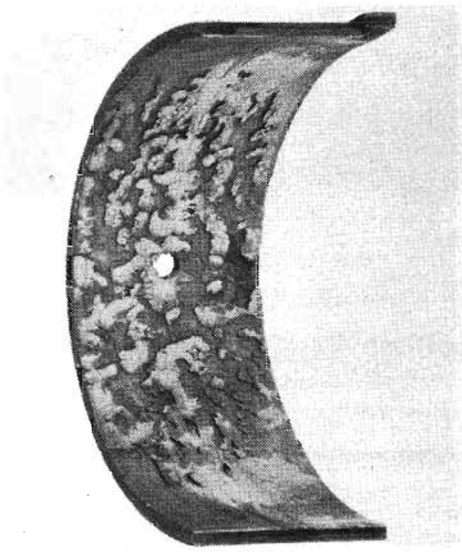


Fig 9 (above): This is what severe fatigue failure looks like. Evidence of surface cracking still remains

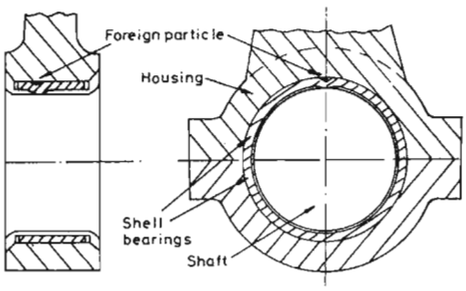


Fig 10 (left): Dirt trapped between a shell and its housing causes localized high-spots

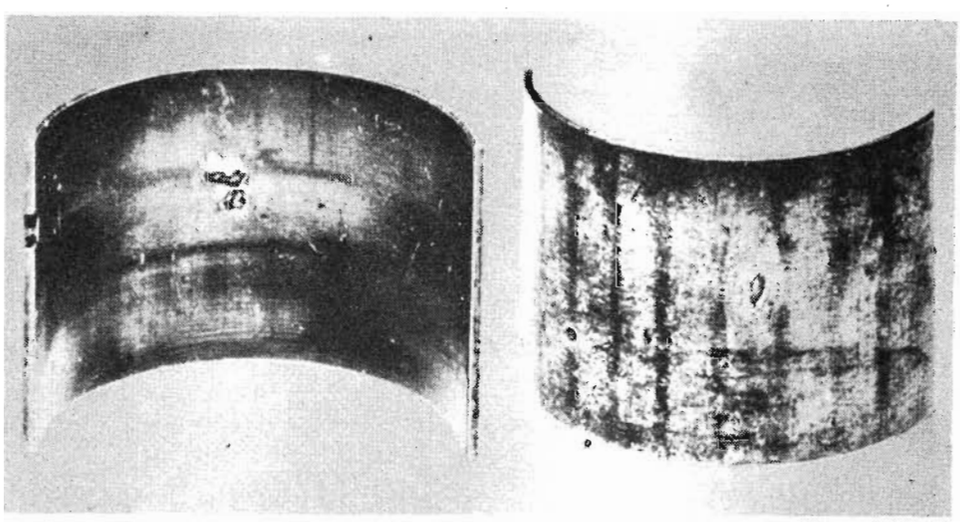


Fig 11: This is the kind of damage caused by dirt between shell and housing

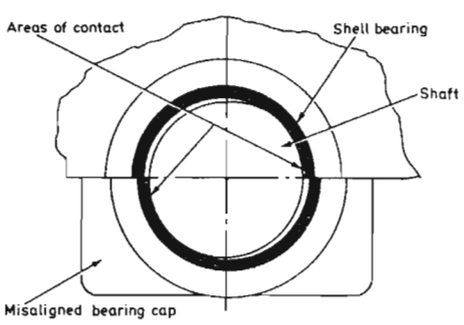


Fig 12: If bearing caps are reversed or interchanged, effective clearance is reduced and metal-to-metal contact may occur

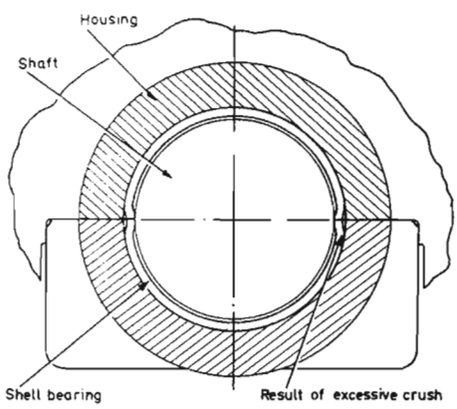


Fig 13: Excessive crush causes ends of shells to bulge inwards

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sufficient distortion for metal-to-metal contact to take place (Fig 6).

Corrosion

Acidity of the lubricating oil can result in the type of failure shown in Fig 7. Copper-lead bearings are the most likely to suffer in this way, the acid attacking the lead content of the alloy. This weakens the structure, causing it to collapse under load.

Bear in mind, however, that high temperatures can result in a similar decomposition of the lead.

Surface Fatigue

As specific power outputs rise, so do crankshaft speeds and inertia loads. This imposes severe stresses on main and big end bearings (the latter especially). Where the bearing material is not equal to the task, it will flex and crack. As these cracks develop, large areas of the bearing surface tend to break away (Figs 8 and 9).

Many bearing failures occur as a result of faulty machining or careless assembly. Among the more common faults are the following.

Dirt between bearing and housing

This is an assembly fault. If dirt is trapped in this way, the bearing cannot seat properly. This impairs heat dissipation and may adversely affect bearing life. Furthermore, the bearing is likely to be deformed, leading to localized areas of abnormal wear (Figs 10 and 11).

Misaligned Bearing Cap

Reversing or interchanging bearing caps may result in the situation depicted in Fig 12, causing excessive wear at one end of the cap and the opposite end of the housing

Excessive nip or crush

To ensure that the bearing shells are held firmly in place, it is usual for the ends to protrude slightly beyond the parting faces. When the cap is assembled, the ends butt to provide the desired degree of interference. This is known as "nip" or "crush".

If crush is excessive, the ends of the shells bulge inwards, (Fig 13).

Insufficient Crush

When clearance exists between the ends of the two shells (Fig 14), they are free to move within the housing. Lack of radial pressure impairs heat dissipation, thus shortening bearing life. This condition can be identified by the highly polished appearance of the shell backs.

Fig 15 shows a method of checking crush. One bolt (or nut) is torqued to a figure of 10 lb. ft. and the gap between the cap and housing checked at the opposite end. It should be possible to insert a 0.0015in. feeler here. Where this is not so, it is important to verify that the ends of the shells are in firm contact.

Misaligned connecting rod

Although a connecting rod is unlikely to bend in service, handling damage is by no means unknown. This can result in a situation such as that shown in Fig 16. Localized wear will take place on opposite sides of upper and lower shells (Fig 17). There will also be evidence of piston misalignment.

Distorted crankcase

If the cylinder head bolts are not tightened in correct sequence and to the specified torque, considerable block distortion can take place. This may well result in misalignment of the main bearings, with a consequent reduction in oil-film thickness. In extreme cases, this can lead to metal-to-metal contact. A bent crankshaft will have the same effect (Fig 18).

Mis-shapen journal

Normal wear usually results in ovality, together with a little taper. If a connecting rod is bent, the crankpin may be worn into a barrel form. An hourglass effect, on the other hand, is usually caused by incorrect grinding. Whatever the fault, it will be reflected in the wear pattern

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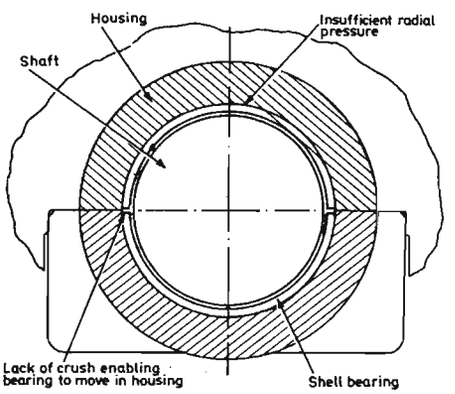


Fig 14: Too little crush allows shells to move slightly. Heat dissipation is also impaired

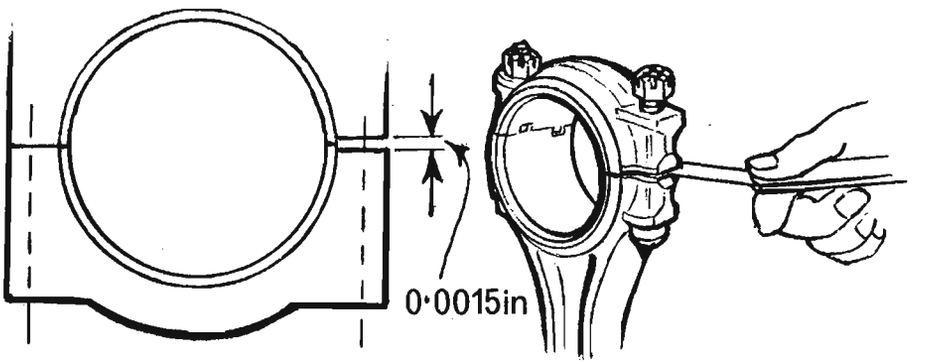
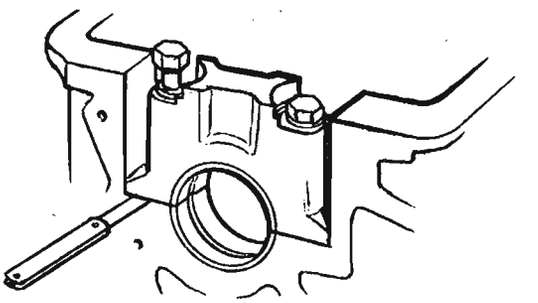


Fig 15: A simple way of checking crush. Around 0.0015in. is an average figure



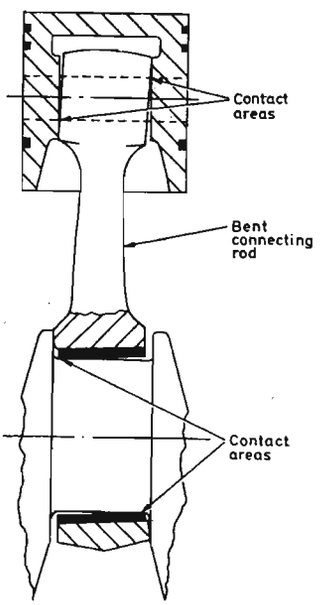


Fig 16 (left): A bent connecting rod causes opposite edges of cap and rod to contact the journal

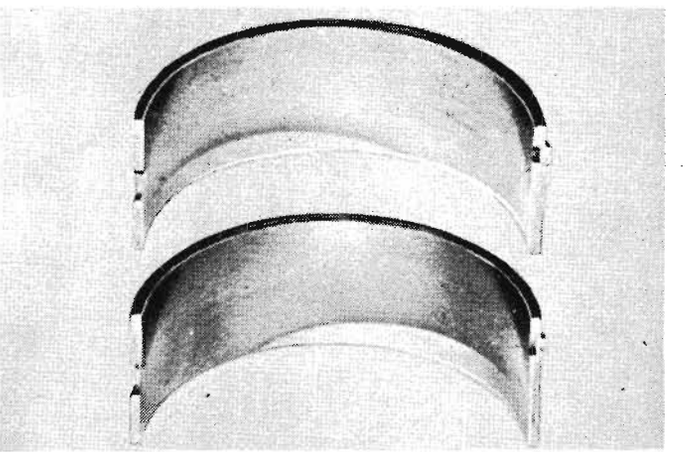


Fig 17 (right): This is the wear pattern which results from a bent connecting rod

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found on the bearing shells. Examples are shown in Figs 19 and 20.

We are indebted to the editor of TRIBOLOGY for many of the illustrations used in this article. Published by IPC Science and Technology Ltd, this quarterly journal deals with all aspects of lubrication, friction and wear.

Fig 18 (right): A bent crankshaft or misalignment of main bearings can cause metal-to-metal contact

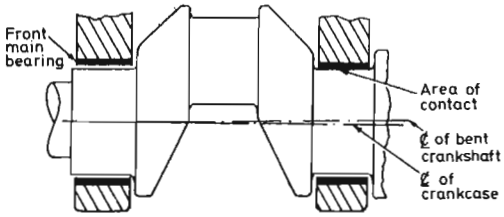


Fig 19 (below, left): A concentration of wear in the centre of a bearing indicates a barrel-shaped journal

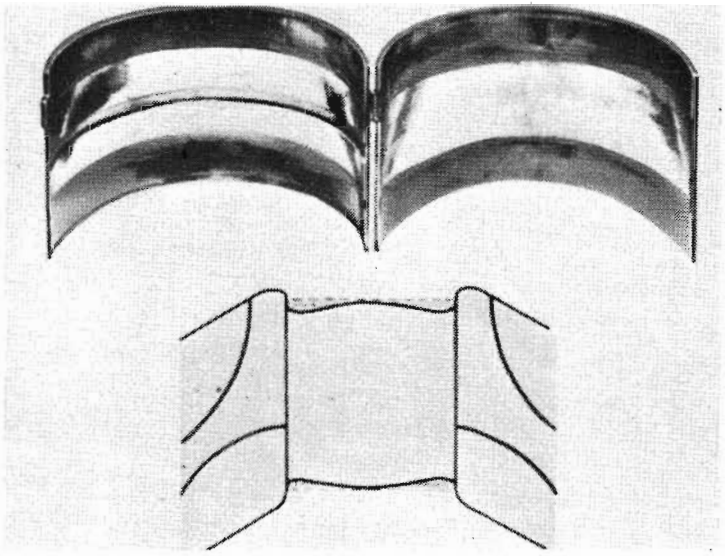


Fig 20 (below, right): Wear at the edges indicates an hourgalss shape, probably caused by incorrect grinding

