FORM NO. SEBG4030

SHOP MANUAL

GUIDANCE FOR REUSABLE PARTS

ENGINE

CRANKSHAFT AND BEARINGS

GUIDANCE FOR REUSABLE PARTS

KOMATSU

INDEX

INTRODUCTION

This publication contains colored photograph of typical failures encountered with crankshaft/main and connecting rod bearings, at the time of engine disassembling and inspection, and is intended to provide guidelines for determining by visual inspection whether the parts are fit to be used or not, prior to reassembly. This guide also contains basic information on the crankshaft and bearings and explanation of the failures and their causes.

Because construction equipment engines are usually operated at high speeds under heavy loads, heat and combustion gas and the condition of the coolant, engine oil and fuel have profound effects on the failures.

This publication should be useful for anybody engaged in the diagnosis and repairs of construction equipment engines.

The writers will be gratified if, "lowering of repair costs" through appropriate reusage of parts as well as, "prevention of reoccurence of failures" through correct diagnosis of their cause, is achieved.

FAILURE SIGNS, THEIR CAUSES AND DIAGNOSIS FOR REUSAGE

When determing whether engine parts can be refused or not, it is important to consider daily maintenance and work conditions, and search to "what cause the very failure", and how to eliminate it. Combined with the distrbutor's acquired experience, the photographs of the typical failures ranked by three should be used as guidelines to determine reusage of each part.

Moreover, the extent of the failure is an important factor in determing whether that part is reusable or not, however, full consideration should be paid to the risk against damage before in the engine as a result of reusing a failed part.

Inspection Points for Parts Reusage Diagnosis

To inspect the parts, wash and clean them and then inspect by referring to the following inspection points.

Part name	Inspection points
Crankshaft	● Scratches, wear and discolor in journal portion ● Crack in fillet portion ● Grooved wear in contact surface with seal
Bearing	● Wear and scratches on bearing surface ● Corrosion on bearing surface ● Flake off on bearing surface ● Damage and wear in back metal and mating surface

Standards for Failure Determination

Rank	Failure degree
Use again	● The failure does not affect engine performance, and will not cause secondary failures.
Use after reconditioning	● The failure does not immediately effect engine performance but is liable to cause secondary failures.
Do not use again	● Performance of the engine is clearly affected by the failure, and further use of the part will surely cause severe damage.

Note: To determine the amount of crankshaft journal and bearing wear or crankshaft bent, refer to the "Repair limit and Maintenance standards" in the Shop Manual.

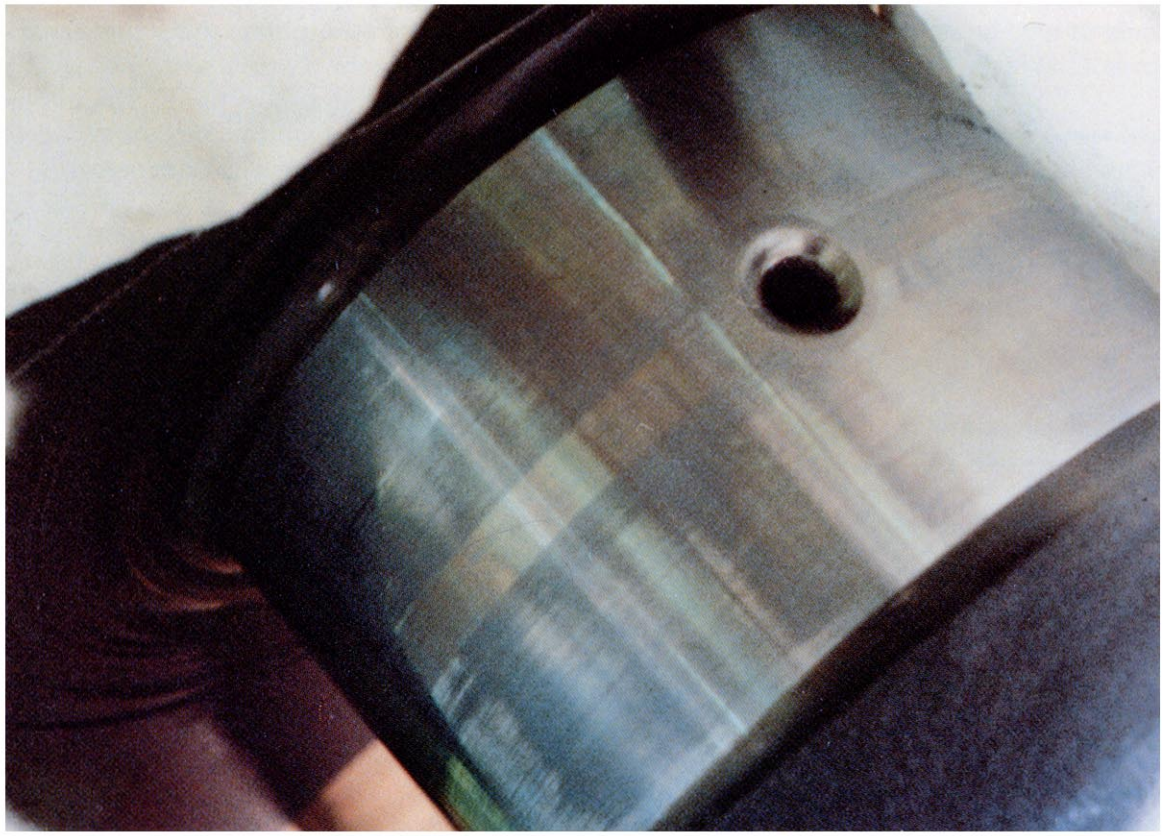
Crankshaft: Determination for Reusage

Failure	Rank	Failure degree
Damage in journal	**Use again**	• Scratches or wear not felt by finger-nail.
	Use after reconditioning	• Discernible scratches felt by finger-nail.
	Do not use again	• Other than above damage (more severe scratches than above rank)
Discolor in journal	**Use again**	• No discolor
	Do not use again	• Discolored
Crank in fillet portion	**Use again**	• No crack
	Do not use again	• Cracked
Grooved wear in contact surface with seal	**Use again**	• Discernible grooved wear, but not felt by finger-nail.
	Use after reconditioning	• Discernible and scratchable grooved wear felt by finger-nail.

Main and Connecting Rod Bearings: Determination for Reusage

Failure	Rank	Failure degree
Wear in overlay	**Use again**	• Remaining more than 80% of overlay
	Do not use again	• Remaining less than 80% of overlay
Damage in bearing surface	**Use again**	• Circumferential scratches not felt by finger-nail.
	Do not use again	• More severe scratches than above rank
Corrosion	**Use again**	• No corrosion
	Do not use again	• Corrosion is discernible.
Flaking	**Use again.**	• No flaking
	Do not use again.	• Flaking is discernible.

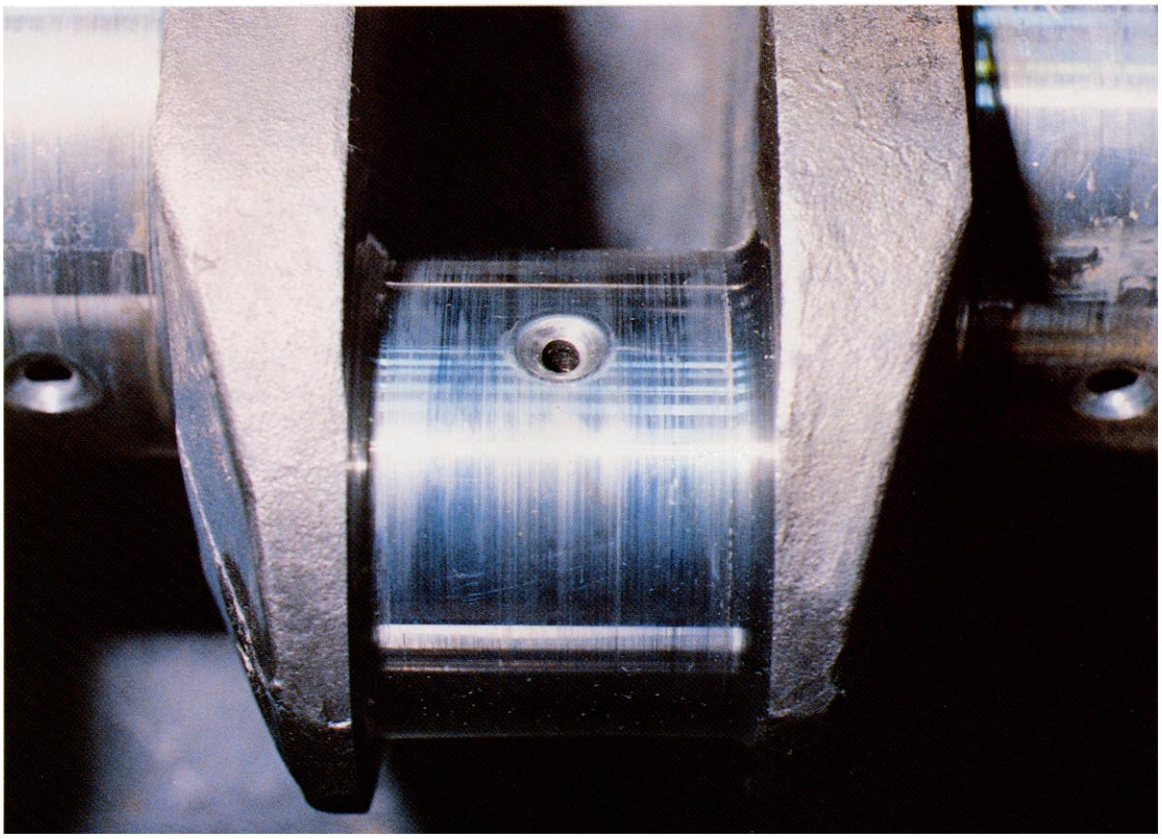
Crankshaft



USE AGAIN

Failure Signs

- Fine scratches are descernible, but not felt by finger-nail.



USE AFTER RECONDITIONING

Failure Signs

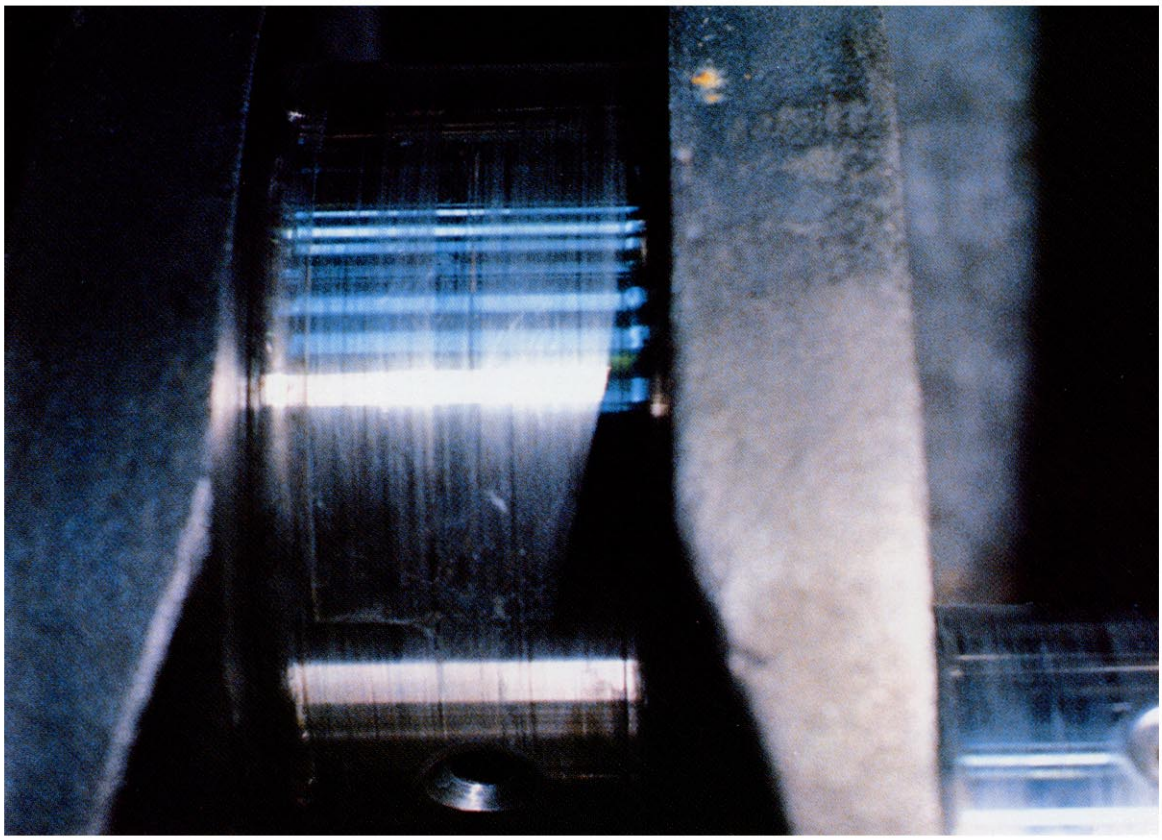
- Hairy scratches felt by finger-nail.

Causes

- Dust and foreign matter entering.
- Incorrect oil maintenance.

Reconditioning Method

- Regrind



USE AFTER RECONDITIONING

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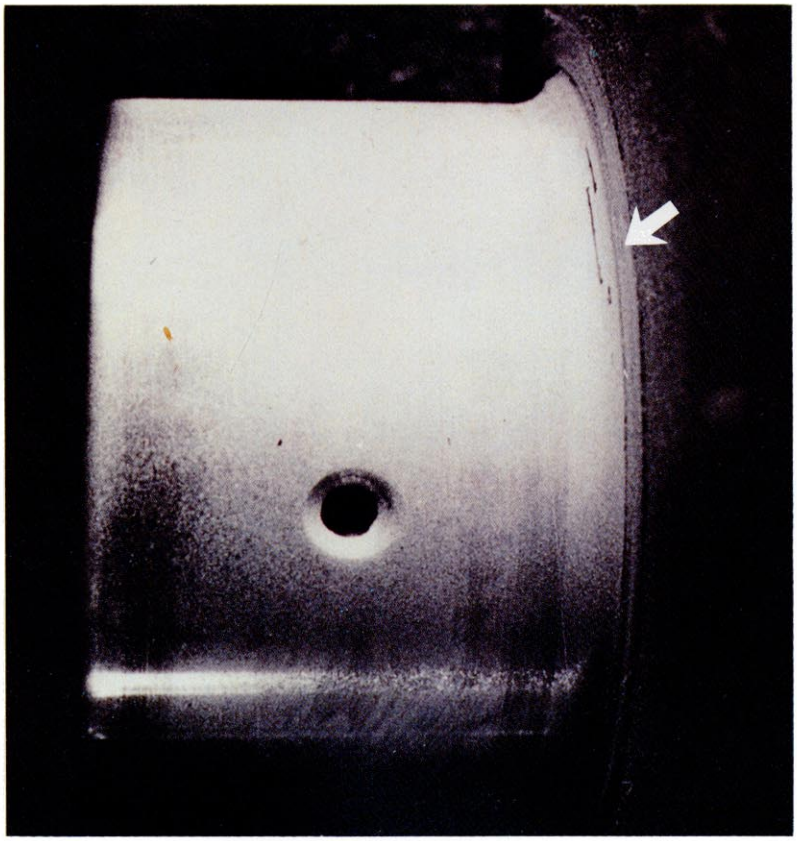
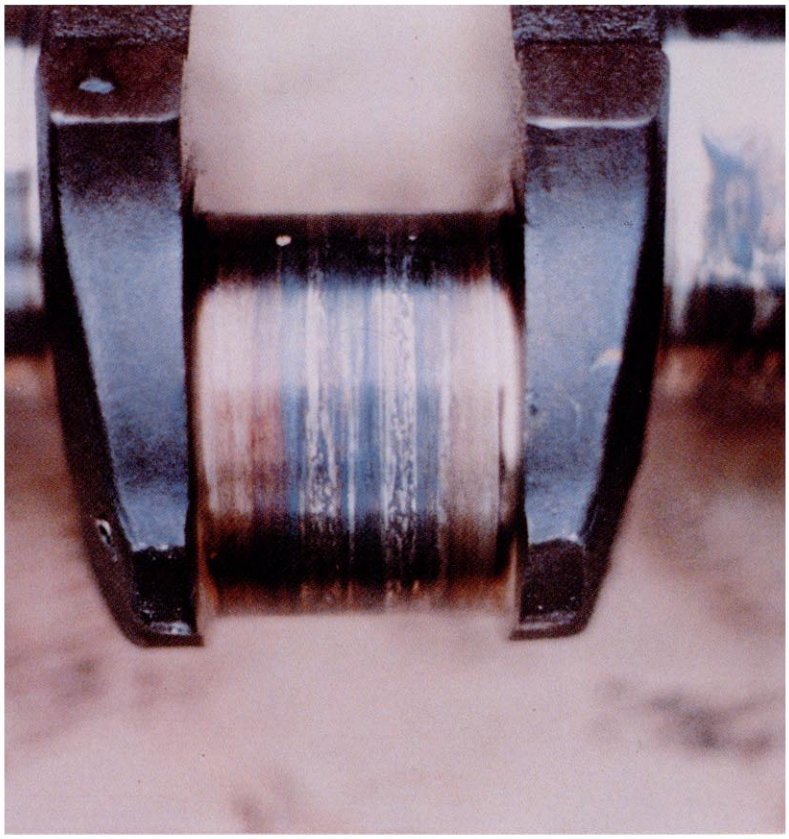


DO NOT USE AGAIN

Failure Signs

- Circumferential crack in fillet portion.



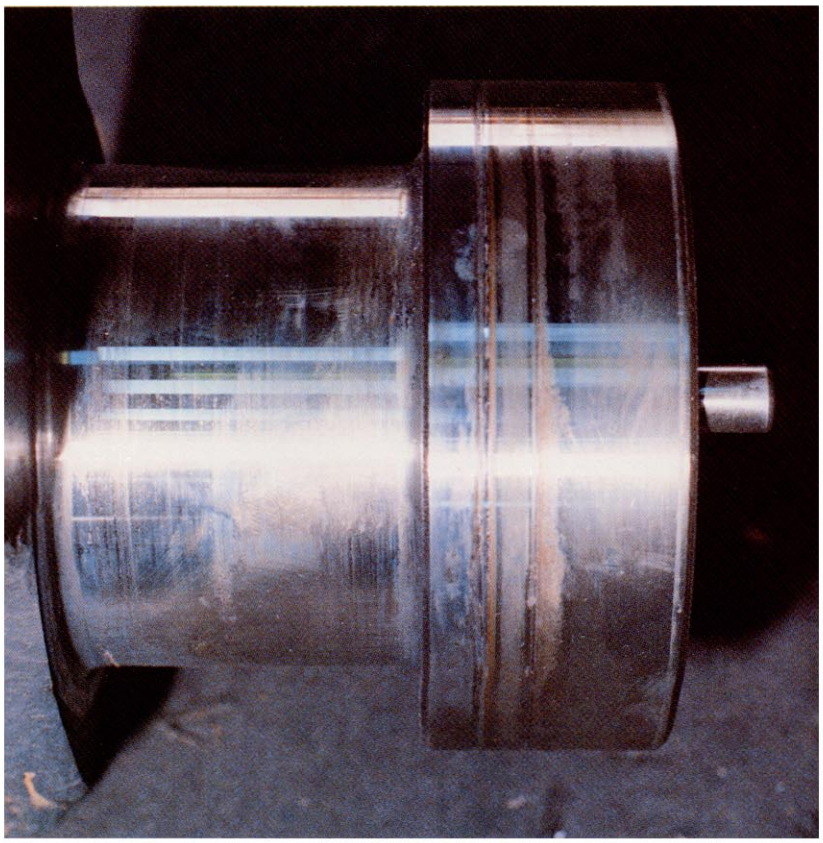
DO NOT USE AGAIN

Failure Signs

- Discernible temper color and damage through melting.

Causes

- Overload running.
- Deteriorated oil.



USE AFTER RECONDITIONING

Failure Signs

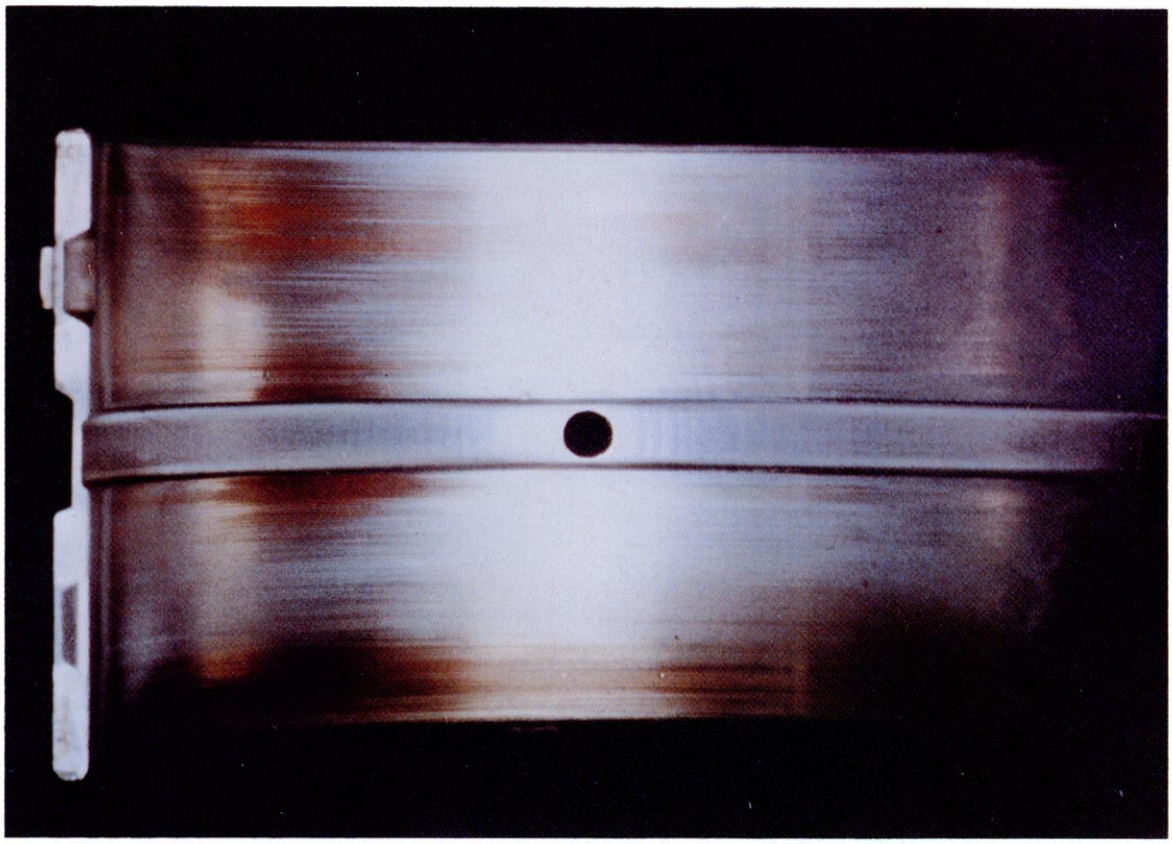
- Grooved wear in contact surface with seal can be felt by finger-nail.

Reconditioning Methods*

- Shift contacting portion between crankshaft and seal lip by driving the seal.
- Insert sleeve.
- Weld and regrind.

* Reconditioning methods vary in the engine models due to variation in their constructions.

Main and Connecting Rod Bearings



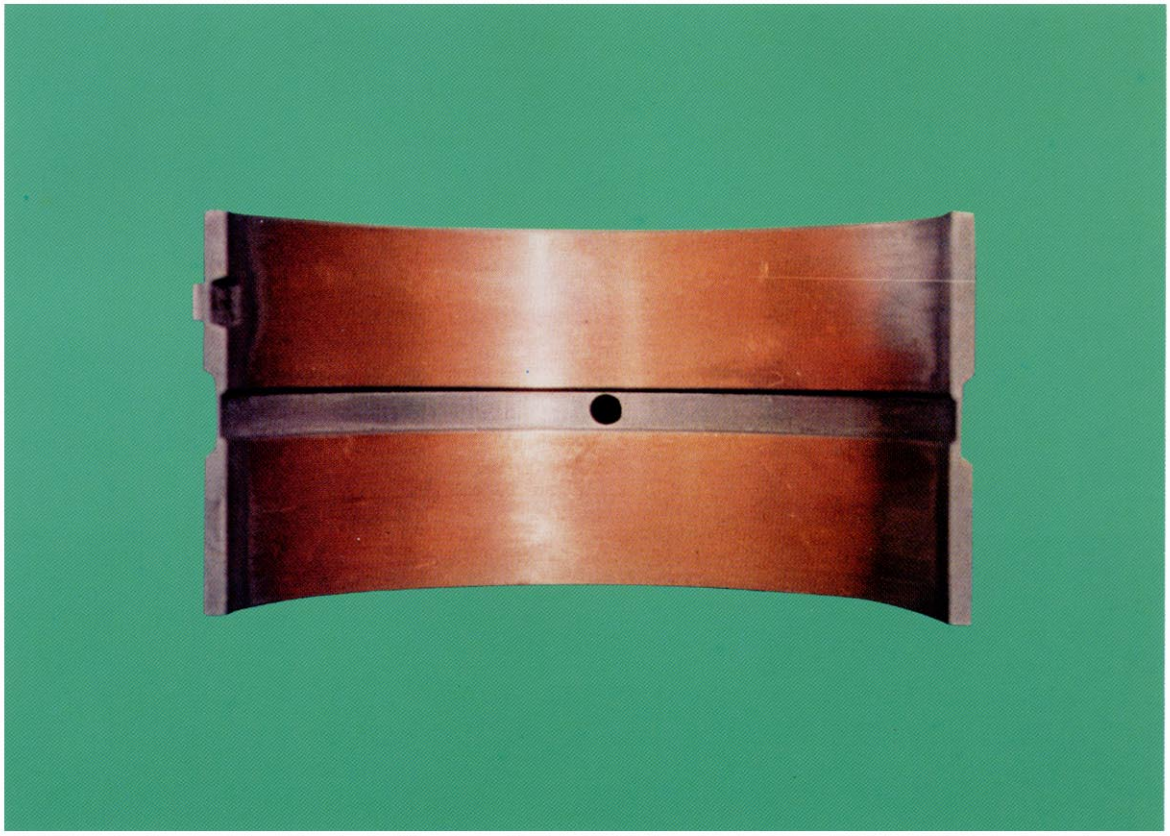
USE AGAIN

Failure Signs

- Overlay is partially worn and exposed with alloy metal layer.

Causes

- Normal wear.



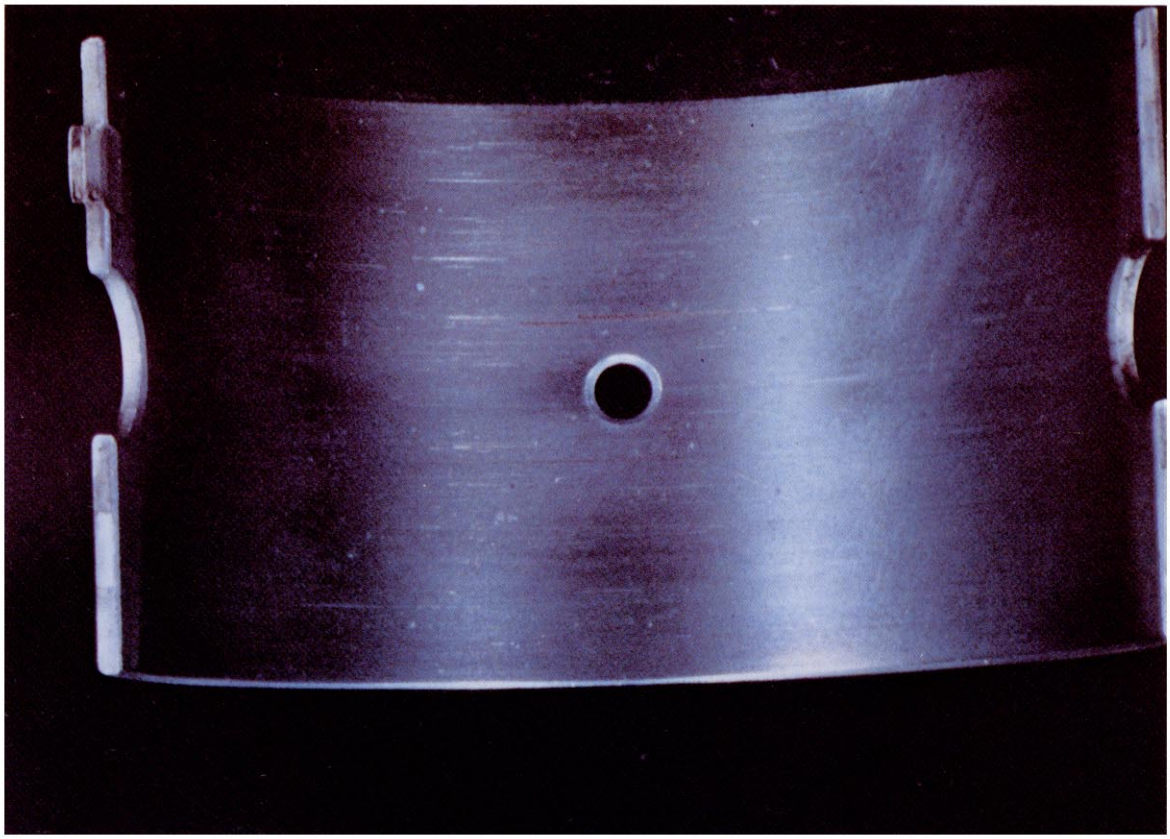
DO NOT USE AGAIN

Failure Signs

- Whole area of overlay is worn out and exposed with kelment layer.

Causes

- Worn by normal running for long duration.



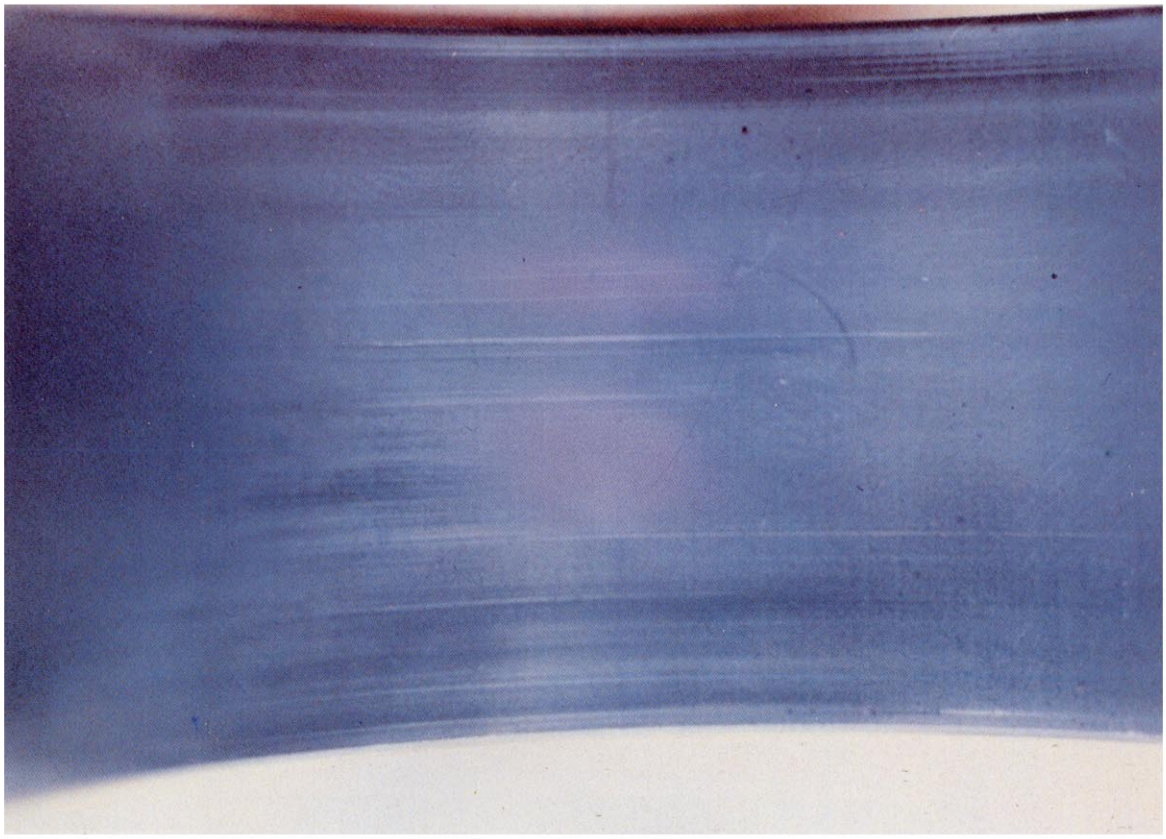
USE AGAIN

Failure Signs

- Circumferential hairy scratches but not felt by finger-nail.

Causes

- Presence of excessive fine dirt.



USE AGAIN

Failure Signs

- Circumferential hairy scratches, but not felt by finger-nail.

Causes

- Presence of excessive fine dirt.

DO NOT USE AGAIN

Failure Signs

- Corrosion

Causes

- Deteriorated oil result of poor oil maintenance.
- Applying poor quality of oil.

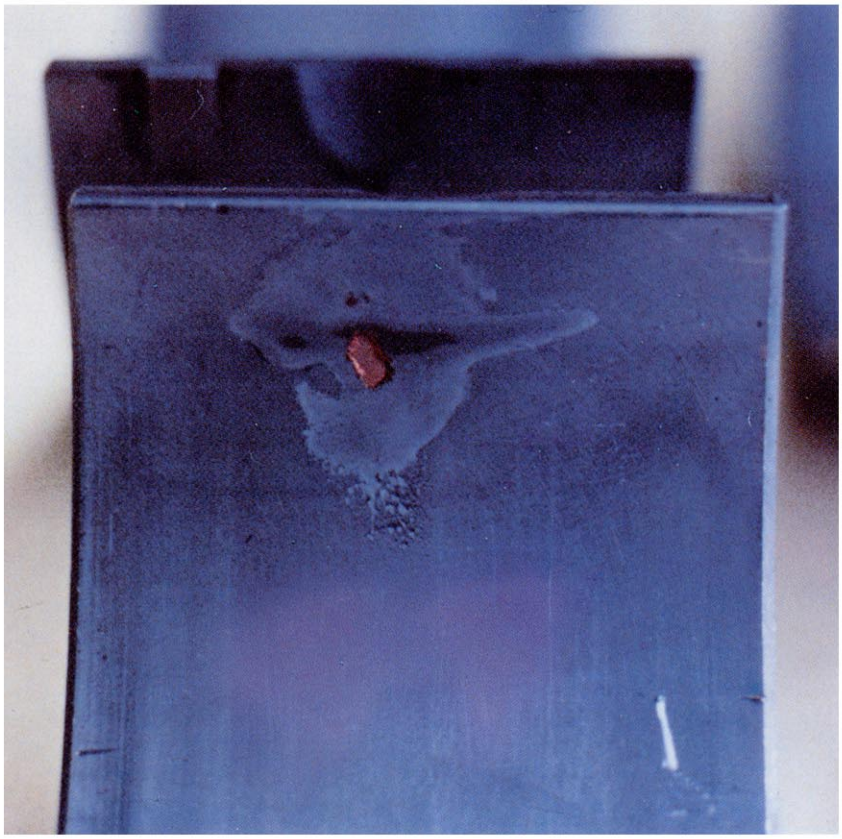
DO NOT USE AGAIN

Failure Signs

- Corrosion

Causes

- Deteriorated oil result of poor oil maintenance.
- Applying poor quality of oil.



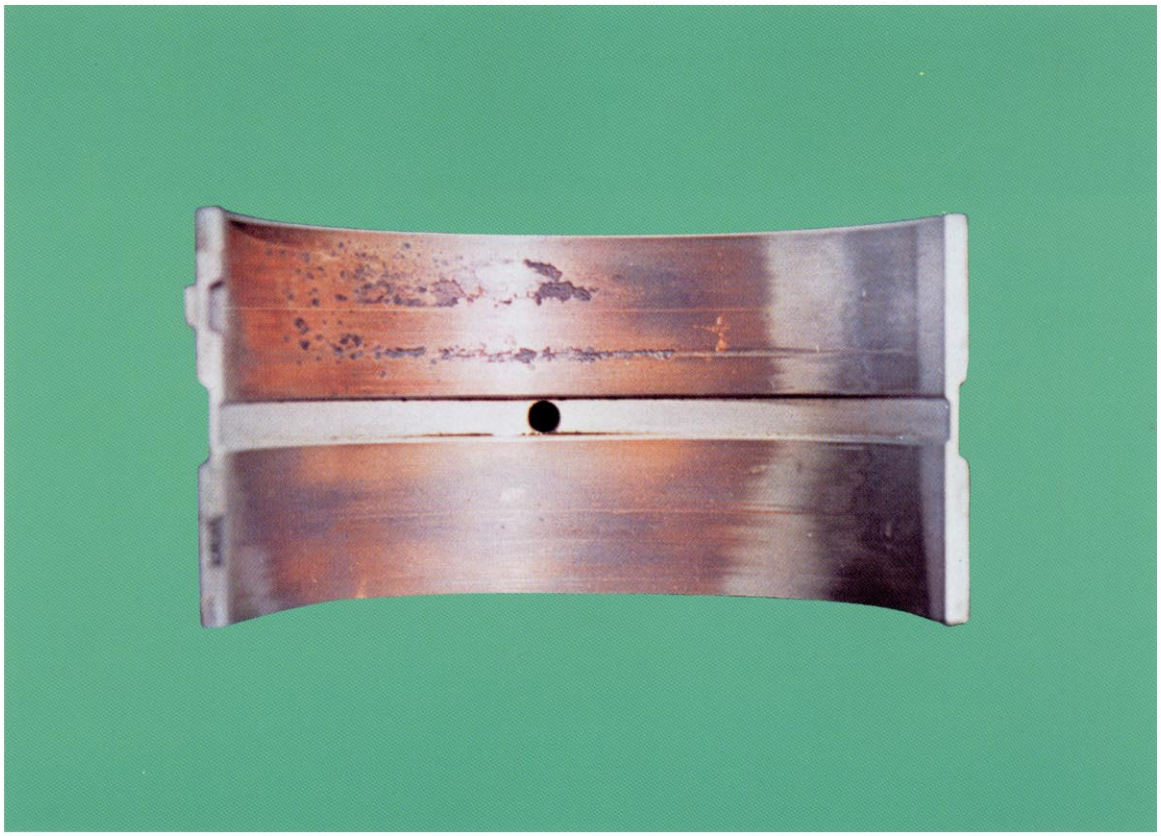
DO NOT USE AGAIN

Failure Signs

- Overlay is flaking.

Causes

- Cavitation in the oil film.



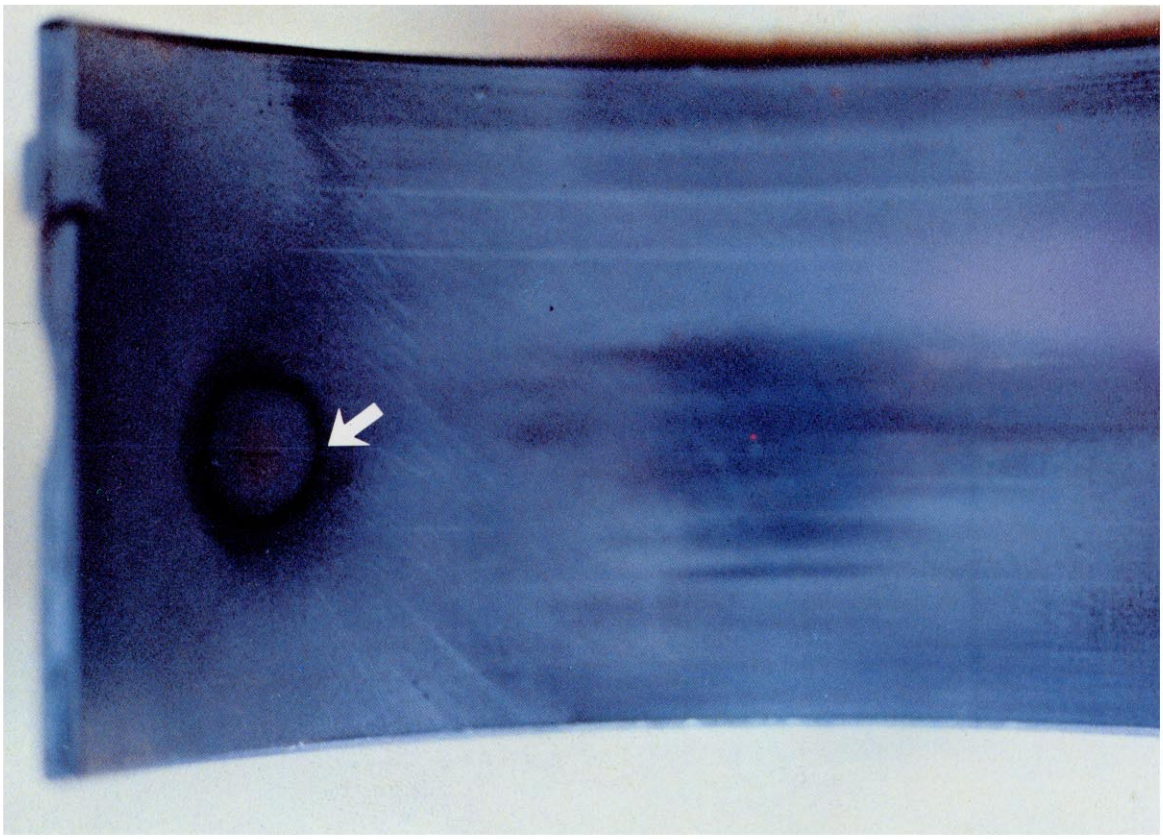
DO NOT USE AGAIN

Failure Signs

- Flaking in alloyed metal

Causes

- Alloyed metal layer is deformed from scratches caused by foreign particles and flaked through fatigue due to partial overload.



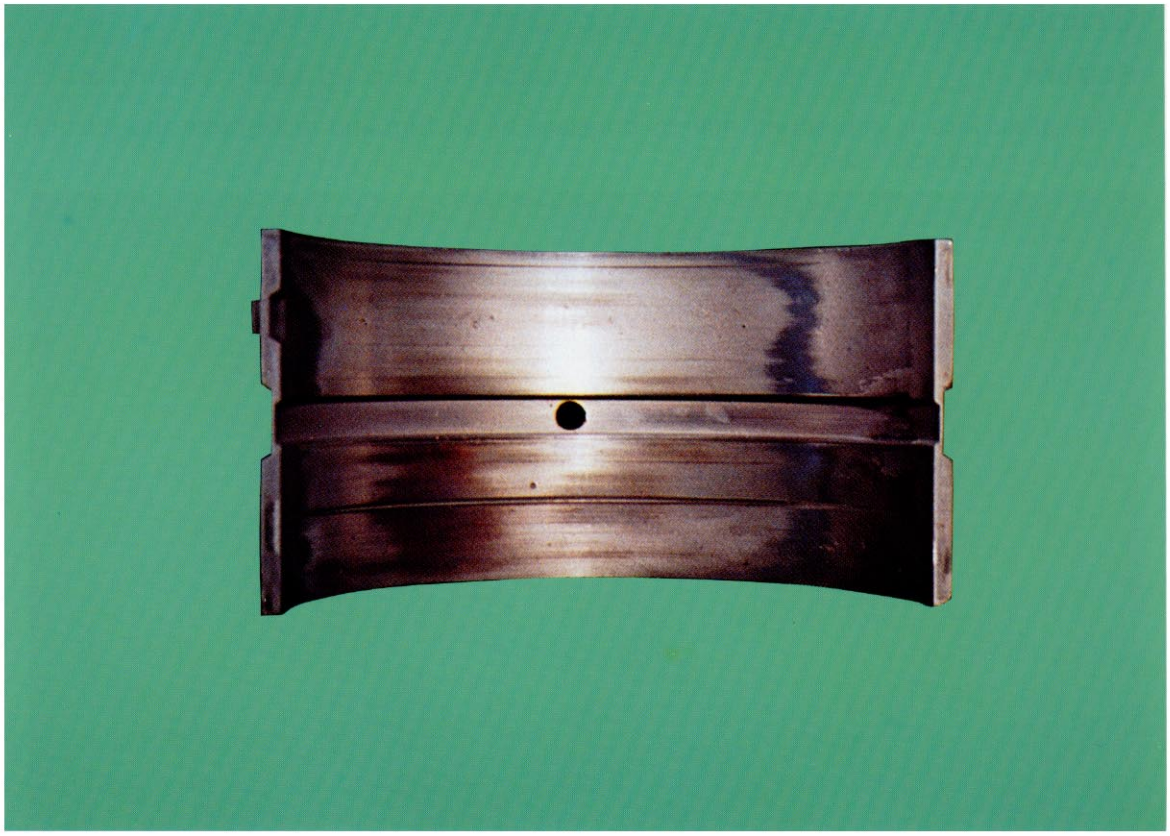
DO NOT USE AGAIN

Failure Signs

- Discernible circular partial contact surface at upper part of metal.

Causes

- Foreign particles left between bearing back and the bore during assembly.



USE AGAIN

Failure Signs

- Discernible blue black pattern.

Causes

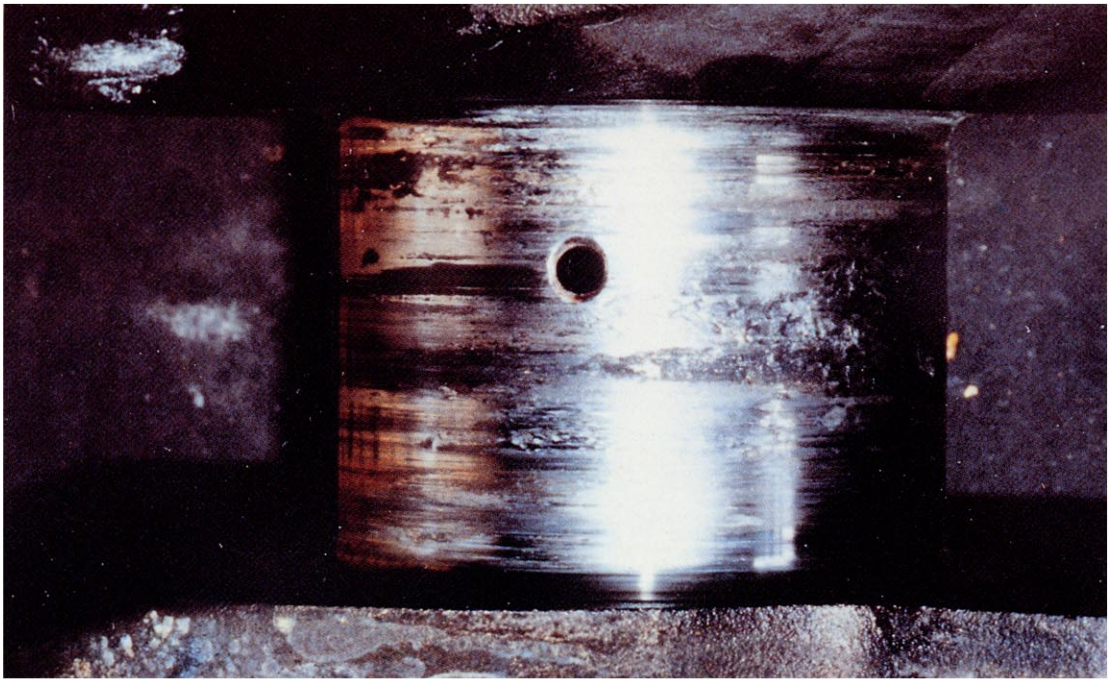
- Presence of water and/or anti-freeze in the lubricant.

TYPICAL EXAMPLES OF FAILURES

Crankshaft

Seizure

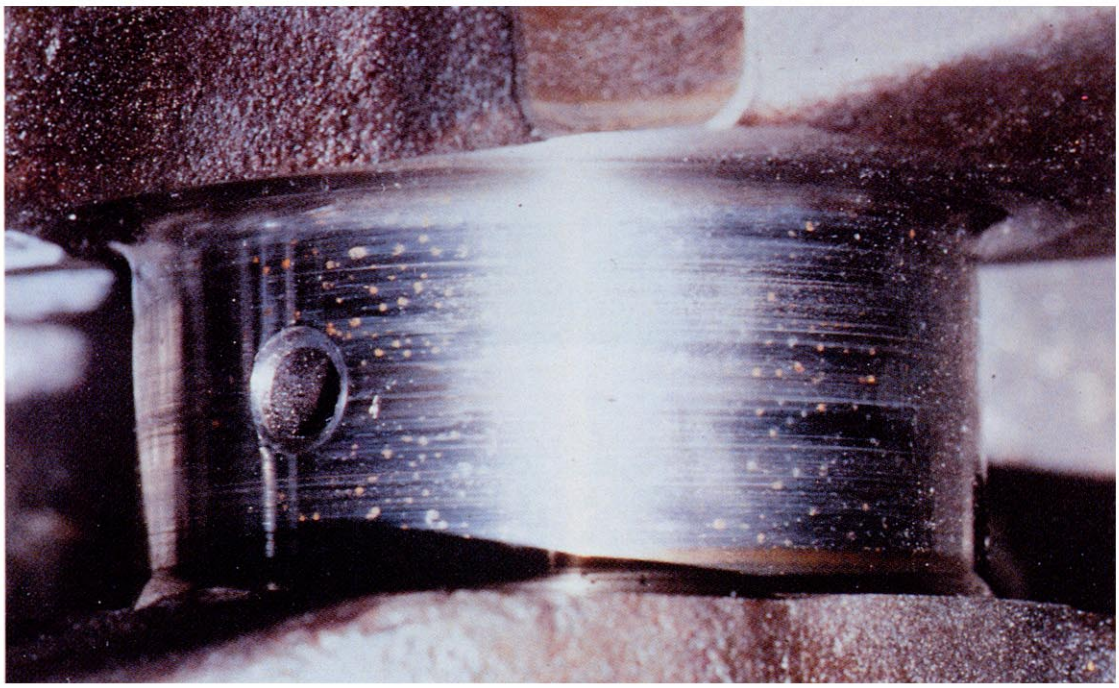
Metal surface is contacting due to breakage of oil film and discernible the seizure caused by excessive heating.



Causes

- Lack of lubricating oil.
- Decrease of viscosity in lubricating oil.
- Breakage of oil film due to dirt particles.
- Deterioration of lubricating oil.
- Usage of improper oil.

Scratches caused by dirt particles



(Dots shown by photograph indicate a rust caused by long aeration)

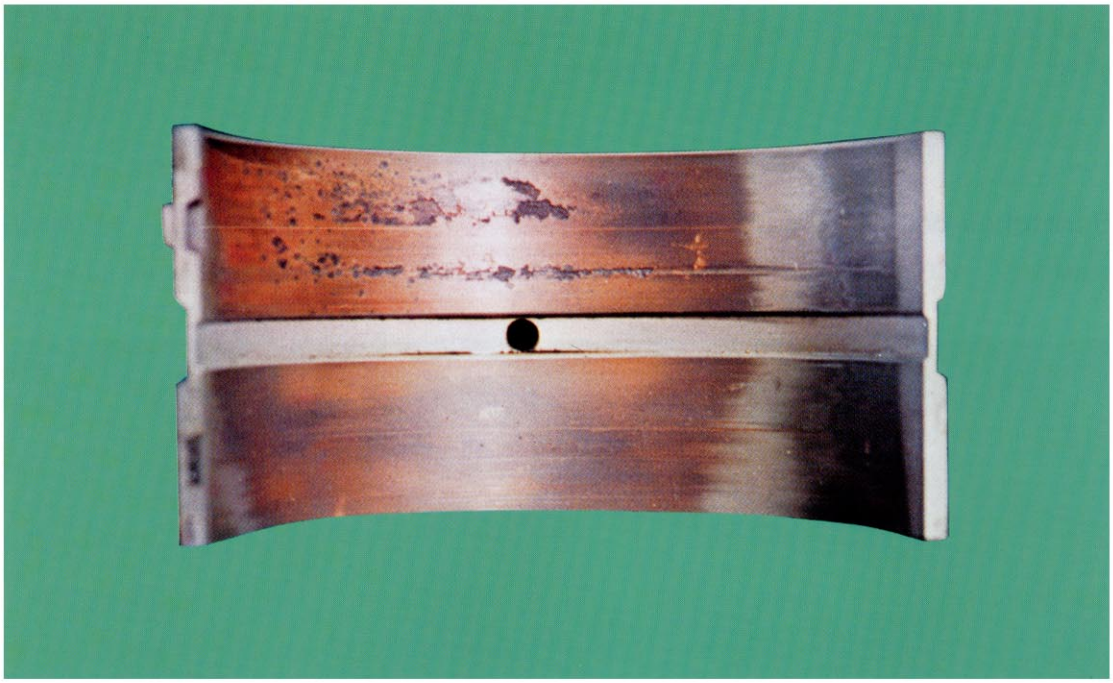
Causes

- Admixtured in case of oil exchange.
- Incorrect maintenance of oil filter.
- Insufficient cleaning when reassembling.

Main and Conecting Rod Bearings

Flaking in Bearing Surface

Fatigue crack is caused by partial overload due to eccentric load and scattering flaked portions are discernible on bearing surface.

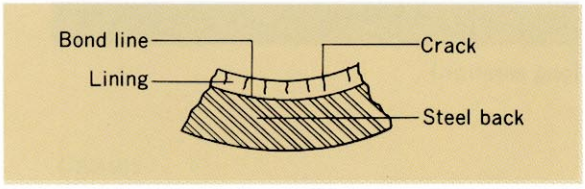


Failure Mechanism

For fatigue

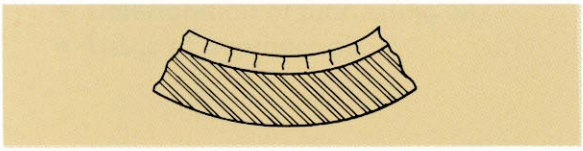
Step 1

Appearing fine cracks on the surface of the bearing metal.



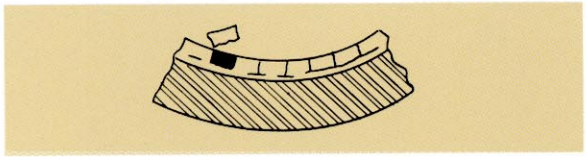
Step 2

The cracks move toward the bond line.



Step 3

When crack moves on toward the bond line, change the direction of crack parallel with the bond line. When the cracks eventually join, pieces of metal flake away.

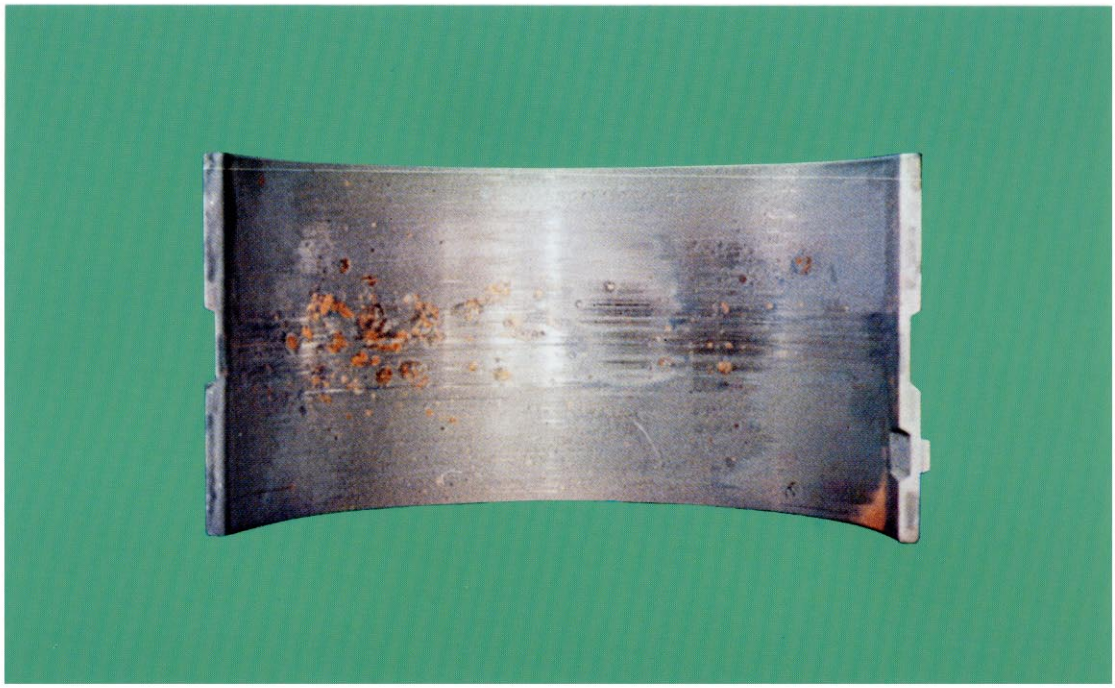


Causes

- Partial overload through eccentric load (due to bend in crankshaft or connecting rod, incorrect alignment of crank case.)
- Partial overload through scratches due to foreign particles.
- Overload caused by abnormal combustion in engine.

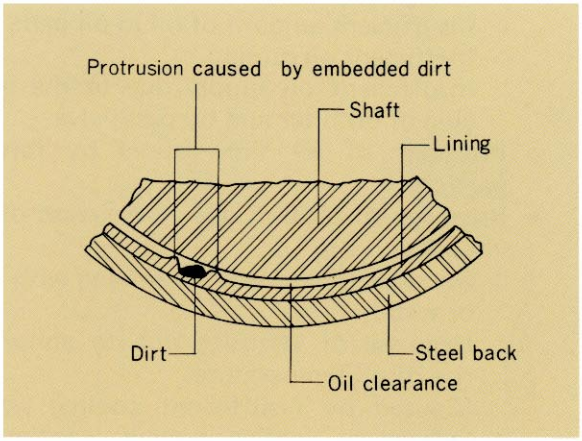
Embedding foreign particles

Damage of scratches and embedded mark caused by dust or foreign particles are discernible.



Failure Mechanism

Embedding of foreign particles



When lubricating oil contains foreign particles which are embedded in soft bearing surface and protrusion are built around them. If such protrusion is so big that destruction will be happened due to severe contact with shaft.

Also protruded foreign object will scratch the shaft.

As similar phenomenon, there are impressed portion by peeled bearing alloy taken up from other bearing surface, if light seizing is occurred.

Causes

- Insufficient cleaning in engine.
- Metal chips caused by abnormal wear in engine parts (piston, cylinder liner, valve and other moving parts).
- Usage of deteriorated lubricating oil, products created by corrosion and abnormal combustion.
- Dust entering from outside together with in taken air, which is allowed by poor filtration.
- Dust entering directly from outside or together with lubricating oil, which are arose from carelessness during storage or exchange of lubricating oil.

Breakage of Oil Film (Seizuring)

Considerable progressed seizuring is discernible, which is caused by breakage of oil film because of insufficient viscosity of oil and/or lack of lubricating oil, thus both surface in bearing and shaft are melted.

Phenomenon: Both surface in bearing and shaft are melted and catastrophic aspect is discernible. This photograph indicates the damage example resulted from decrease of viscosity in oil.

Failure Mechanism

Step 1

- Lack of lubricating oil between bearing and shaft.
- Oil film of lubricant is broken.
- Oil clearance is insufficient.

Step 2

- Metal-to-metal contact area getting larger (Direct contact with shaft and bearing material)

Step 3

- Metal-to-metal contact area generating an abnormal heat

Step 4

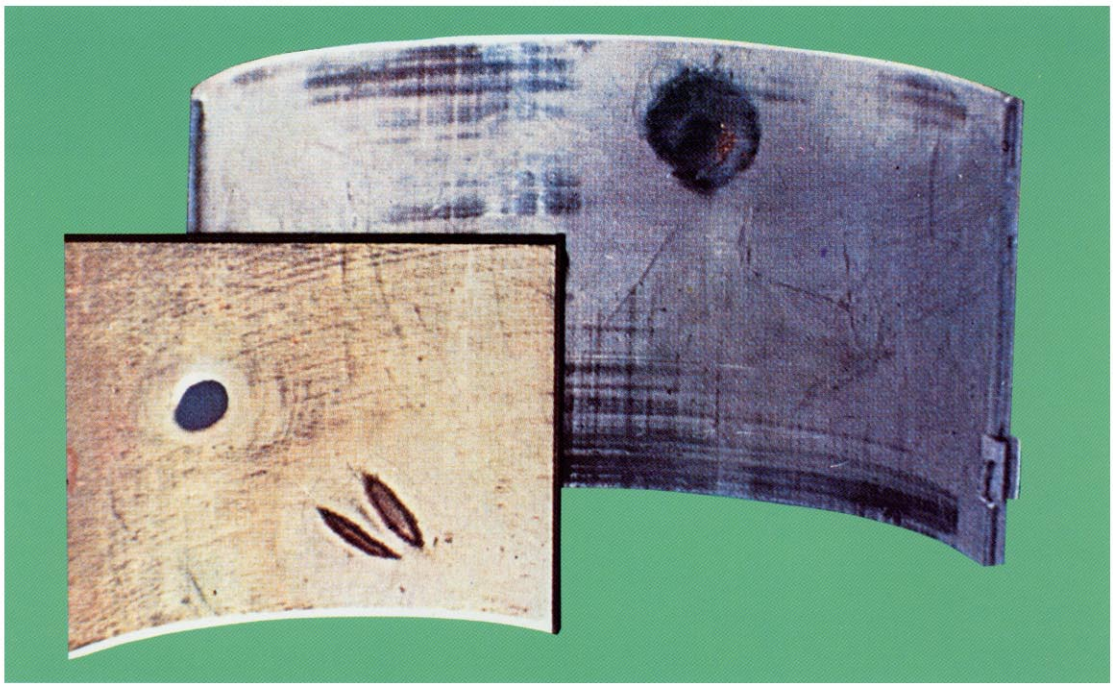
Progressing abnormal heat results in seizuring (Material in shaft and bearing are melted together.)

Causes

- Insufficient oil supply
  - Oil hole is clogged by misassembly or foreign objects.
  - Insufficient amount of oil in oil pan.
  - Inefficient oil pump.
  - Insufficient oil supply due to the clogging of oil filter and by-pass valve.
- Breakage of oil film caused by foreign particles.
- Breakage of oil film due to decrease of oil viscosity.
  - Decrease of viscosity by mixing with fuel or water.
  - Decrease of viscosity due to abnormal rise of oil temperature.
    (Caused by insufficient cooling water, leakage in cooling system, continuous running with overload, failure in cooling fan etc.)
- Improper usage of lubricating oil
  (Low viscosity oil is used in summer season, etc.).
- Insufficient oil clearance
  - Insufficient clearance is caused by mis alignment
  - Insufficient clearance caused by bent in shaft.
  - Insufficient clearance caused by bearing deformation due to excessive crush.
- Insufficient warming up operation.

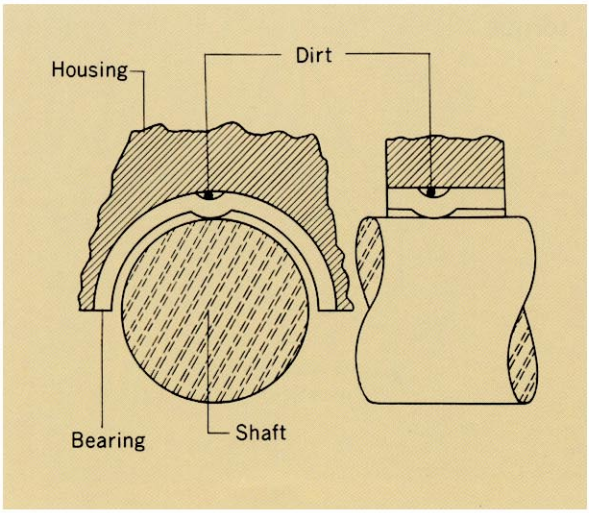
Sticking of Foreign Objects at Behind Back Metal

Partial wear is discernible at bearing surface due to immobile dirt particle left between the bearing back and the bore. Pattern of the particles generally appears on the steel back.



Failure Mechanism

- Immobile dirt particle left between the bearing back and the bore.



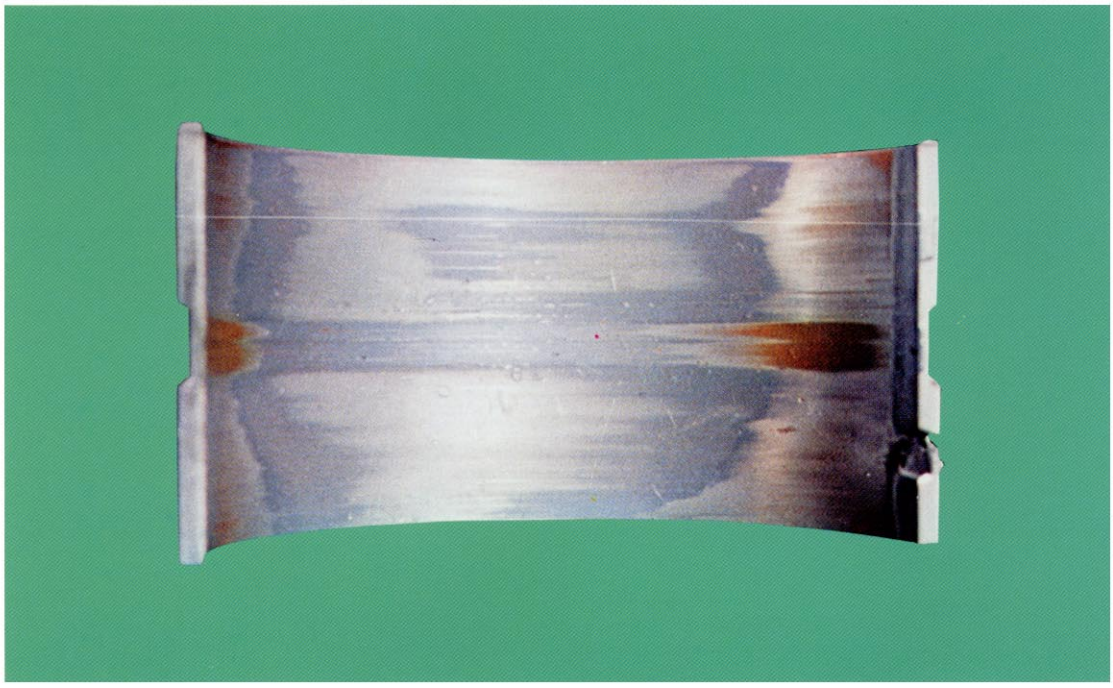
Large dirt particles left between the bearing back and the bore will not allow the bearing to seat.

Pattern of the particle generally appears on the steel back, and excessive wear begins over the particle, thus results in poor and unequal heat transfer, so that bearing life getting shorter due to partial overheat.

Causes

- Dirt particles left between the bearing back and the bore during assembly.

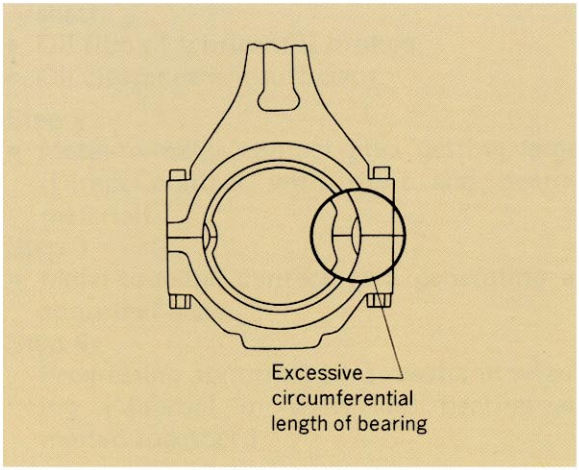
Excessive Crush



Phenomenon: Extreme wear is caused neighbouring split surface of bearing on one side or both side.

Failure Mechanism

Excessive crush

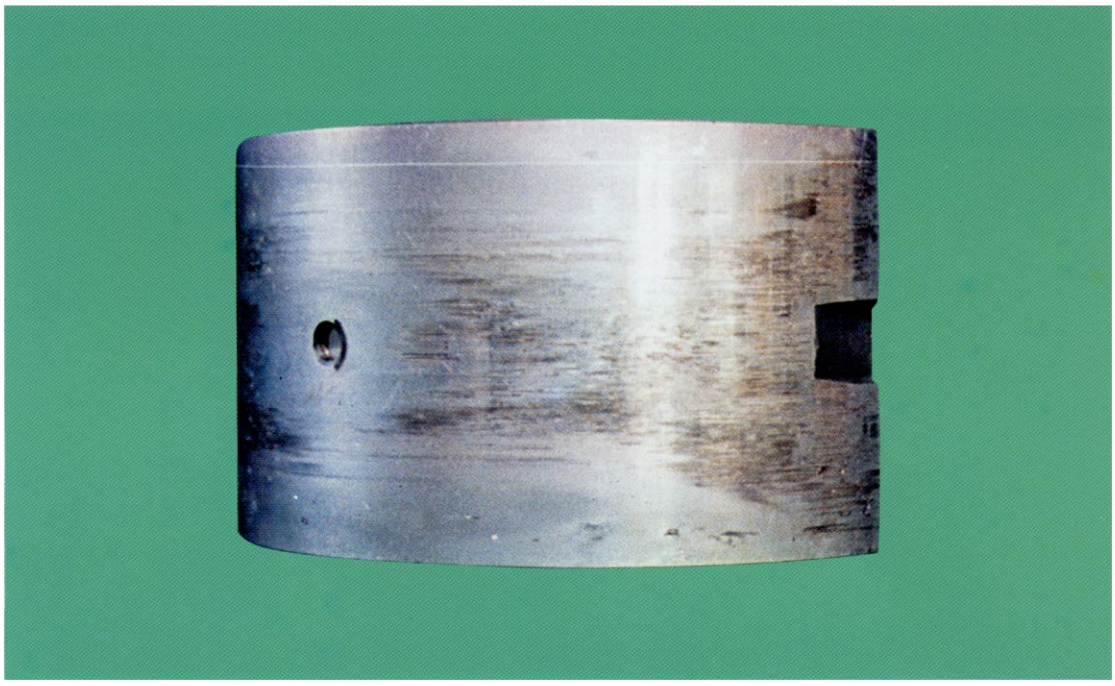


Crush is so big that bearing is contact completely with the bore and excess crush will deform neighboring split furface of bearing inwardly, which leads to wear.

Causes

- File the mating faces of bearing cap and housing so as to decrease the oil clearance.
- Bearing cap is tightened up with excessive torque.

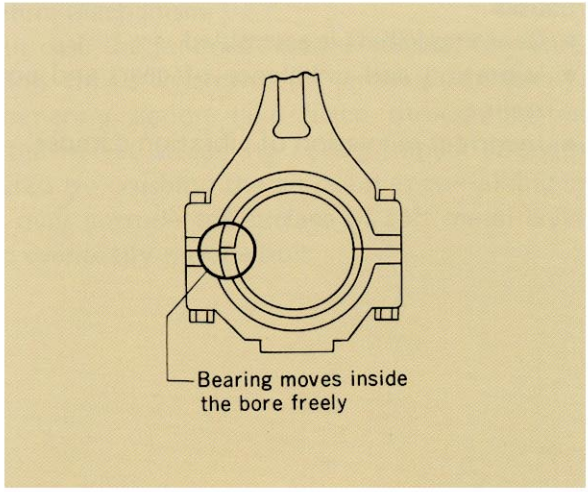
Insufficient Crush



Phenomenon: Well ground portion is discernible at bearing back or mating faces of the bearing. Photograph indicates an example of damage resulted from insufficient cap tightening torque when assembling.

Failure Mechanism

Insufficient crush

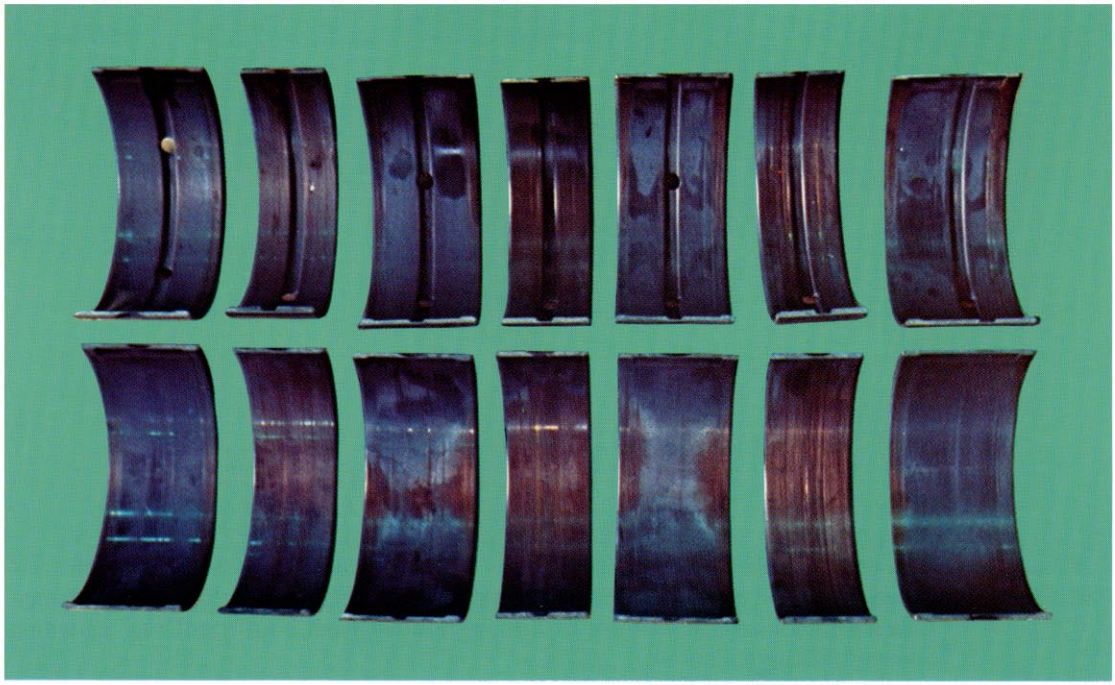


Heat created in bearing is transfered partially through lubricating oil, however, most of them is transfered through bearing bore. If insufficient contact is occurred between bearing and bore heat is not transfered, which results in damage due to overheat.

Causes

- When assembling the bearing mating faces of bearing is filed.
- Lodged in the bearing cap contact surface, a hard particle will destroy crush and leave the bearing shell loose.
- Insufficient cap tightening torque when assembling.
- Bearing bore is expanded.

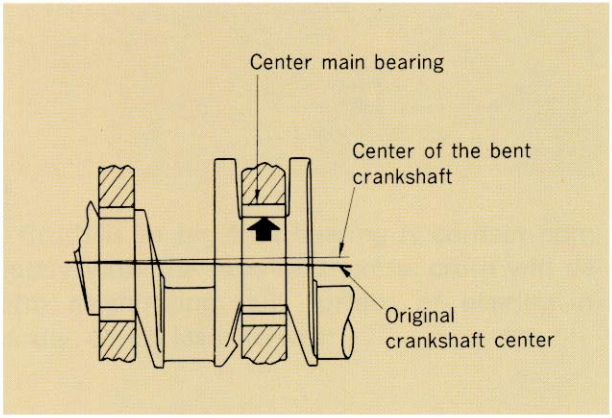
Bent of Crankshaft



Phenomenon: Wear is discernible especially on a couple of the center bearing.

Failure Mechanism

If bent of crankshaft is existing, bearing becomes to support the load partially, thus the part is kept under overload condition in which oil clealance is insufficient, so that metal-to-metal contact is took place. Especially extreme wear tend to occur on center bearing.

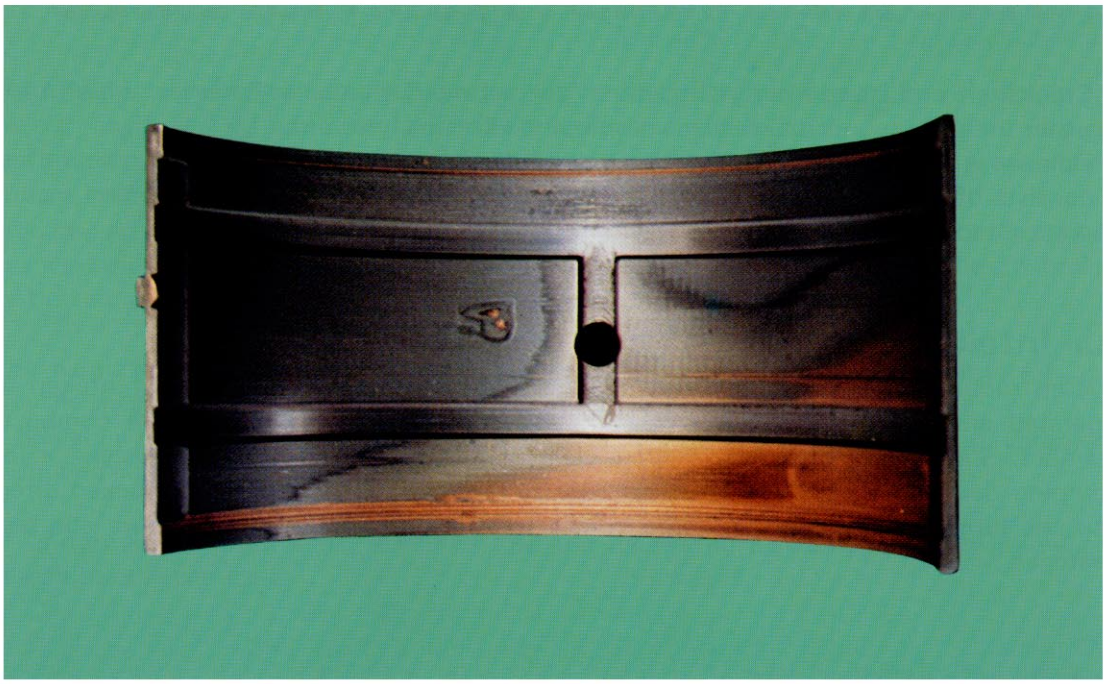


Causes

- Bent crankshaft is assembled.
- Vibration and unbalance of gears and power train.
- Incorrect regulation of vibration damper.

Cavitation

Localized spalling or erosion, apparent on only the unloaded half of the bearing (the upper main and lower connecting rod bearing), is due to cavitation in the oil film.



Failure Mechanism

In case the sectional area of passage for lubricating oil is changed to large area sharply, hammering action take place through partial turbulant jet streaming or big impact strength caused by crushing the air bubbles containing in oil may corrode the surface of soft metal layer and eventually make a hole.

Causes

- Abrupt fluctuation of thickness in oil film due to bend of rotating shaft.
  (pressure fluctuation)
- Mixing in the air bubbles which is caused by malfunctioning oil pump.

FAILURES AND THEIR CAUSES

Crankshaft and its bearing getting wear (normal wear) gradually, however, the problem is whether the wear (abnormal wear) is developing excessively or not.

Damage is caused by accumulating every kinds of factors, especially the important factor is consists of foreign matter from intake air, maintenance of lubricating oil and incorrect operation technique.

Air Intake (Dust)

Construction equipments are operated generally in the dusty place, so that intaken air is separated and filtered in the air cleaner, and clean air is sucked into the combustion chamber. Should any breakage in filter element and gaskets in manifold system or loose clamping device are existing, which cause dirt and foreign particles to be sucked directly into the lubricating oil, thus oil film comes to break and resulting in seizure and severe scratches.

Lubricating Oil

Lubricating oil is deteriorated or oxidized gradually through high temperature and blow-by gases etc. Even if it is operated normally, furthermore the quality of lubrication decrease remarkably if water, fuel or dust is mixing. And the selection of proper lubricating oil matched with ambient temperature is important, the usage improper oil in viscosity or lack of lubricating oil result in seizing and scractching of the parts caused by breakage of oil film.

Operation Technique

When the machine is operated, efficient warming up operation is indispensable, caution shall be paid always to pressure and temperature for oil and high speed overload drive, abrupt acceleration or emergency stop shall be avoided as much as possible.

Abrupt acceleration or high speed overload driving through insufficient warming up operation shall result in seizing or scratching because each sliding parts are subjectd to overload under poor lubrication and insufficient clearance between each part.

PREVENTIVE MAINTENANCE

Constant grasp of engine condition especially for the phenomena on color of exhaust gas, blow-by, overheat, oil pressure, and abnormal noise are necessary to pay a cautious attention in order to prevent a damage of engine in advance and to demonstrate these functions at 100% of their ability.

Accurately following the maintenance procedures outlines in the "operation & maintenance manual" will prevent most of the usually encountered failures, however, the customer's attention to the following items should be insisted upon in particular.

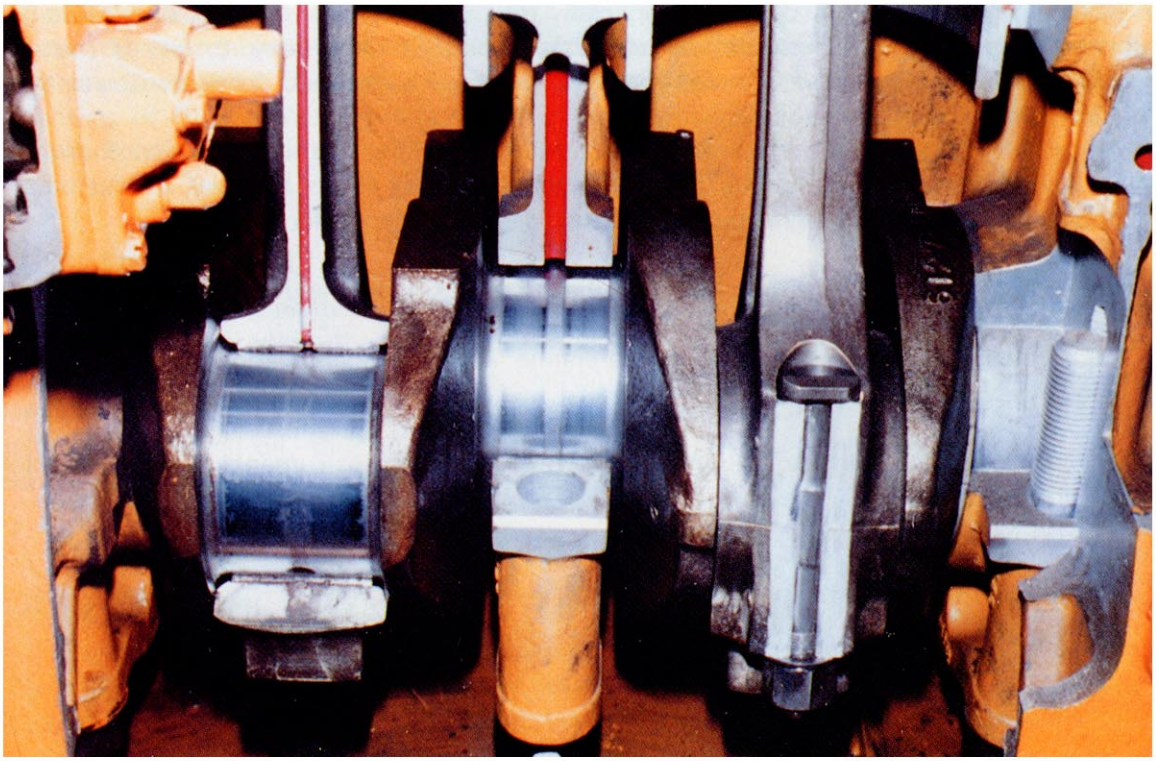
- Use Komatsu's specified lubricating oil, change engine oil at the designated intervals, and use the specified oil type matched to ambient temperature.
- Take your time in warm up running the engine. Avoid, sudden overloads, rapid acceleration, and sudden engine-stopping.

* If abnormal conditions are observed, use the measuring instruments listed below and search for the causes.

Measuring Instrument	Part Number	Measuring Items
Blow-by Checker	799-201-1502	Blow-by pressure
Hydraulic Tester	790-301-1103	Engine oil pressure
Thermister Kit	790-500-1300	Cooling water & oil temperature
Engine Oil Checker	799-201-6000	Water and/or fuel mixing in the oil
Water Tester	799-202-7001	Quality of cooling water
Smoke Tester	Locally available	Color of exhaust gas

Refer to the section on "Testing and adjusting", in the shop manual.

CONSTRUCTION AND FUNCTION



Crankshaft is working to change the energy of reciprocating motion acquired from combustion pressure created within engine cylinder to rotating motion via connecting rod.

In order to guard the sliding part of the crankshaft bearing is built up at main journal and pin journal respectively.

Flywheel being fixed to crankshaft is accumulating the ill-balanced inertia force which is acquired only when combustion stroke is actuated and transmitting the motive power to the following power train as uniform rotating power.

Generally the driving force for cooling fan, alternator and water pump etc. are taken out via V-belt driven by crank pulley which is fixed to the front ent of crankshaft.

And in accordance with a type of engine some are equipped with vibration damper is attached to the front end of crankshaft and this is absorbing the torsional vibration being caused by eccentric load resulted from combustion pressure and eliminating the torsional stress which is likely to grown up to resonance vibration.

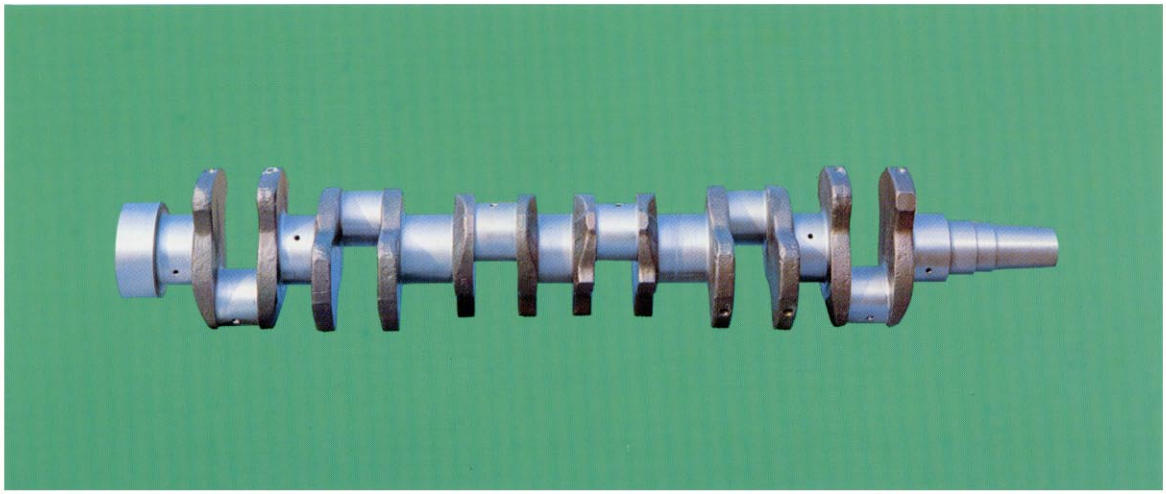
Furthermore, the crankshaft is provided with thrust bearing at its rear end or center of the crankshaft so as to take out engine power from one side and to bear the thrust load which is caused by clutch operation.

Crankshaft

Crankshaft Construction

Construction of crankshaft is equipped with crank pin being placed eccentric against the center of shaft in order to transmit the engine power alternating from reciprocating motion to rotary motion and counter weight is indispensable so as to cansel the ill balanced eccentric load thus the shape of crankshaft becomes to very intricated.

Therefore prudent caution is necessary not only for crankshaft itself but also the strength and wear resistance at each journal and their R-parts (fillet radius).



Function and Material of Crankshaft

Crankshaft is converting the energy of reciprocating motion to rotating motion while always ill-balanced high load is applied by combustion pressure.

And main journal and connecting rod journal are placed in a severe condition in which as a bearing subjected with highest load under sharp fluctuation in addition to torary movement with high sliding speed.

Under these circumstances, the crankshaft must have the following characteristics:

- Strength (in bending stress, torsional stress, impact load, fatigue resistance) shall be excellent.
- Durability (in resistance for repeated load) shall be superior.
- Wear resistance (in bearing parts) shall have good advantages.

The following table indicates the material and necessary characteristics of crankshaft.

Material and Treatment	Requirements
High carbon steel	• Strength, fatigue strength • Durability
Die forging	
Induction hardening on journal surface	• Wear resistance

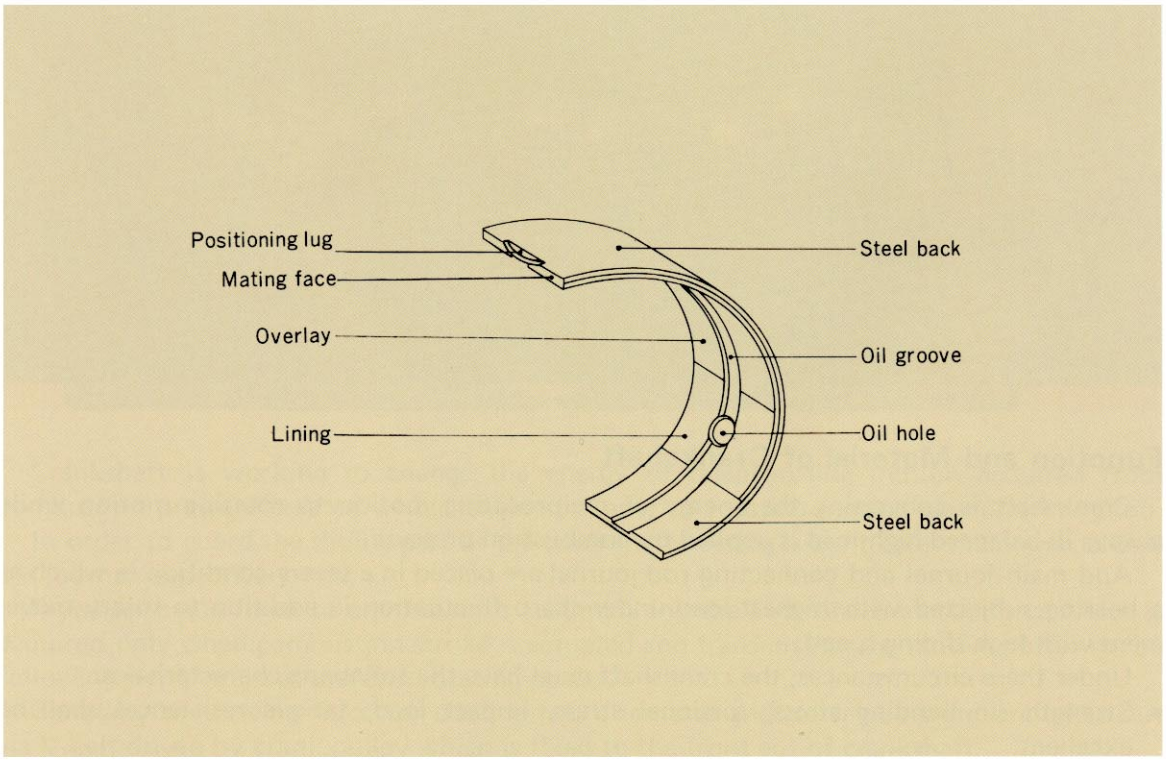
Main and Connecting Rod Bearings

Bearing Construction

Regarding the bearing in crankshaft journal, there are main journal built in cylinder block and main cap and connecting rod bearing (in connecting rod) which is assembled in connecting rod cap.

Each of them are assembled as upper and lower half of round split and arranged with oil grooves and holes to lead an oil.

And the bearing is difficult to provide many required characteristics within only one material, so that the material is consists of two or three layers so as to make the best use of the characteristic for these material.

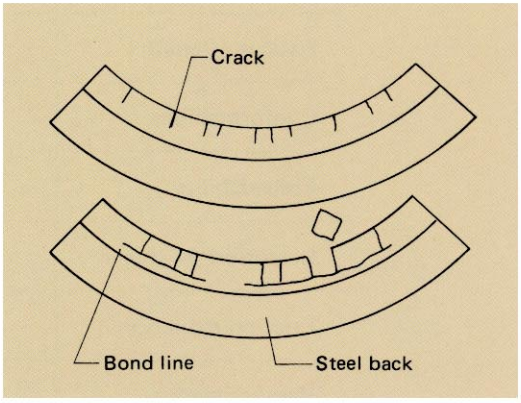


Bearing Metal Properties

No one metal can provide all the properties demanded of a bearing. Therefore bearings are a compromise combination of metals. Below is a list of six bearing metal properties in their order of importance. The chart illustrates these qualities relative to construction material.

Fatigue Strength:

Bearing fatigue is the gradual deterioration of the bearing metal caused by loading. The first signs of fatigue are fine cracks on the surface of the bearing metal. The cracks move toward the bond line and turn, running parallel to the bond line. When the cracks eventually join, pieces of metal flake away. This is sometimes mistaken for a bad bond, but very rigid controls during bearing construction make a bad bond highly improbable. The steel back provides optimum fatigue strength.



Conformability:

No crankshaft journal or crankpin is perfectly round or straight, nor are the bearing bores. To overcome these slight imperfections the bearing must be able to mold itself to conform with these imperfections. The softer metals of lining and overlay are necessary for conformability.

Embedability:

No matter how careful you are and how excellent a filtering system is provided, some dirt is going to be present. Particles of dirt can score the shaft or bearing. If the bearing surface can absorb the particles, further damage can be prevented. Softer lining metals permit conformability and embedability.

Corrosion Resistance:

The by-products of combustion which include water and other chemicals, combine to form harmful acids and compounds which attack the bearing metals. Any resistance possible against this attack must be included in bearing metals.

Friction Reduction:

Since it is impossible to prevent all contact between a bearing and shaft, it is desirable to have two metals which can run in contact. A material which can resist seizure under such conditions is desirable to help prevent failures when lubrication is marginal.

Heat Transfer:

Heat is created by the friction which exists in movement. While some of the heat is removed by the oil film, much of it must be conducted away through the bore and cap. A good conductive metals is desired along with good contact with the bearing bore.

Properties

	Back 100% Steel	**Lining** 75% Copper 25% Lead	**Overlay** 90% Lead 10% Tin
Fatigue strength	High	Med	Low
Conformability	Low	Med	High
Embedability	Low	Med	High
Corrosion resistance	High	Med	High
Friction reduction	Low	Med	High
Heat resistance	High	Med	Low

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