

## Description and function of crankshaft

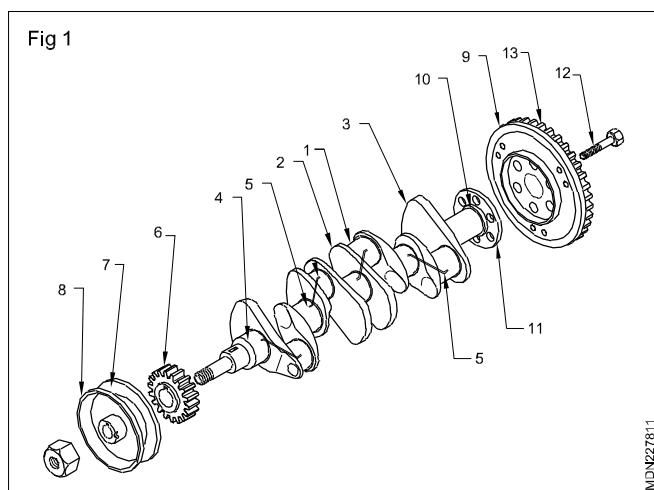
**Objectives:** At the end of this lesson you shall be able to

- state the function of the crankshaft
- state the constructional features of crankshafts
- state the material of crankshaft
- state the necessity for heat treatment, and the balancing of the crankshaft
- state the constructional features of bearing shells
- list out material of the bearing shells.

### Functions of a crankshaft

The crankshaft converts the reciprocating motion of the piston into rotary motion, and transmits the torque to the flywheel.

### Construction



A crankshaft consists of a crank pin (1) (Fig 1), webs or crank arm (2) and balancing weights (3) which are provided on the opposite side of the crank arms for balancing the main journals (4). Crankshafts have drilled oil passages (5) through which oil flows from the main bearings to the connecting rod bearings.

The front end of the crankshaft carries the gear or sprocket (6) to drive the cam shaft. A vibration damper (7) and a fan belt pulley (8) are fitted in front. The pulley (8) drives the water pump, engine fan and generator/alternator, through a fan belt.

At the rear end of the crankshaft, a flywheel (9) is fitted. The inertia of the flywheel (9) tends to keep the crankshaft to rotate at a constant speed. Next to the rear end main journal an oil seal (10) is fitted. In some engines, oil return threads are provided which return the lubricating oil to the sump.

### Materials

A crankshaft has to withstand the centrifugal force, the impact force by the piston and the connecting rod. It should be light in weight. It is made of the following material.

- Nickel steel
- Chrome, vanadium steel
- Nickel chrome steel
- Nickel chrome molybdenum steel

### Heat treatment of the crankshaft

A crankshaft is made of forged and heat-treated alloy steel. It is machined and ground to provide suitable journals for the connecting rods and main bearings. The following methods are used to harden the crankshaft journals.

- Nitriding
- Carburising
- Chrome plating

In the above process the case of the crankshaft journal is hardened. These process give very little depth of hardness. Some manufacturers recommend hardening of the crankshaft journals after regrinding.

### Induction hardening

Induction hardening gives more depth of hardness, and, therefore, the crankshaft need not be hardened again and again.

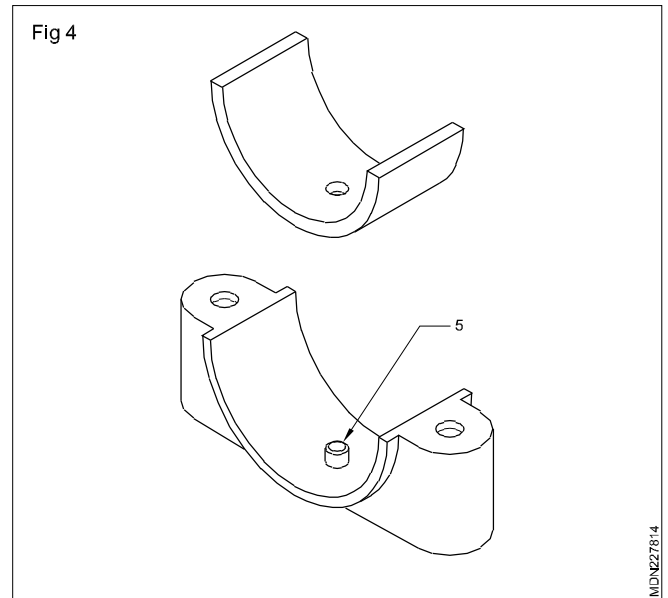
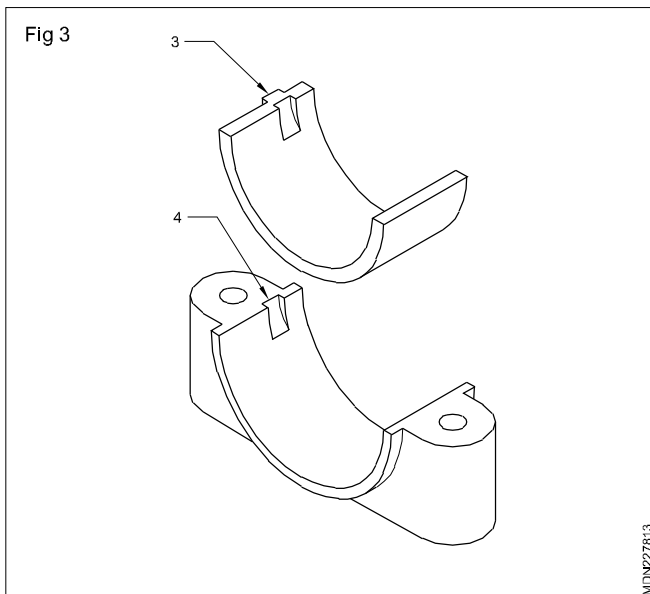
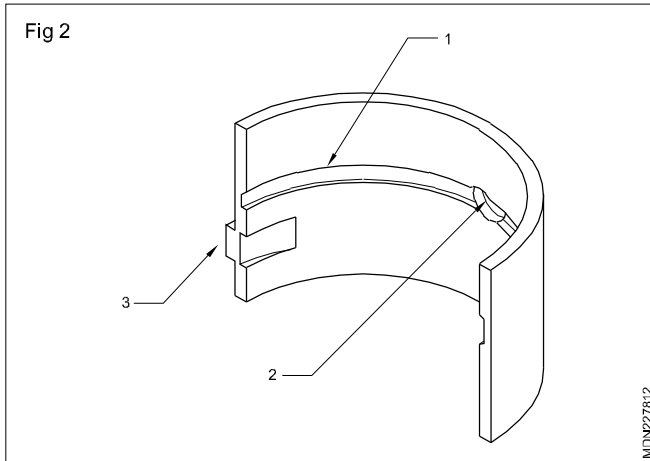
### Crankshaft bearings

These bearings are made into two halves. These bearings operate at critical loads and high rotational speeds. These bearings run quieter and are easy to replace.

These bearings are also called thin wall bearings. These are made of a thin steel shell base with a thin lining on it.

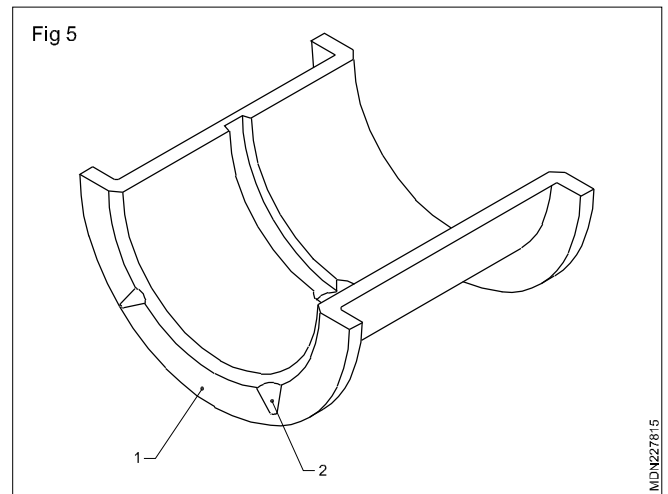
The lining materials are copper-lead or lead-bronze or tin-lead or soft aluminium alloy. Cadmium alloy with copper or cadmium alloy with silver withstands high pressure. Iridium with copper and lead has excellent wear and corrosion resistance. The lining is plated to a thickness of about five thousandth of an inch.

Half shells are provided with an oil groove (1) (Fig 2, 3 & 4) and oil feed holes (2). The bearing shell also has a locking lip (3) on it to fix it on the lip slot (4) of the bore and cap. In some cases dowel pins (5) are provided in the parent bore which aligns with the hole on the bearing shell and avoids rotation of the shell.



### Thrust bearings

This type of bearing (Fig 5) takes care of thrust loads. The bearing shells on the crankshaft, which has thrust faces (1) on it, takes the end thrust of the crankshaft when it is in operation. The thrust faces have oil notches (2) to hold lubricating oil. In some cases separate thrust washers made up of bearing material are also used to take the end thrust.



# Bearings

**Objectives:** At the end of this lesson you shall be able to

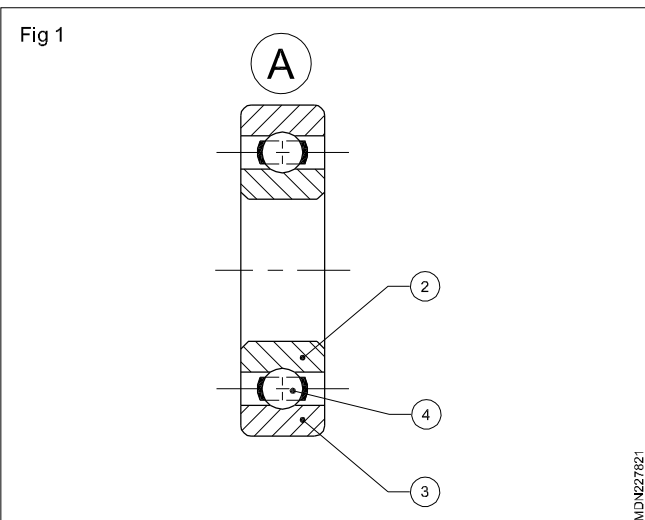
- understand the need of bearings
- list out the different types of bearings used in vehicle
- list out the uses of the different types of bearings
- explain the function and application of different types of bearings.

Bearings are used to support rotating components and to reduce friction between the static and rolling components.

The following types of bearings are used in automobiles.

- Shell bearing
- Bush bearing
- Ball bearing
- Roller bearing
- Needle roller bearing
- Taper roller bearing

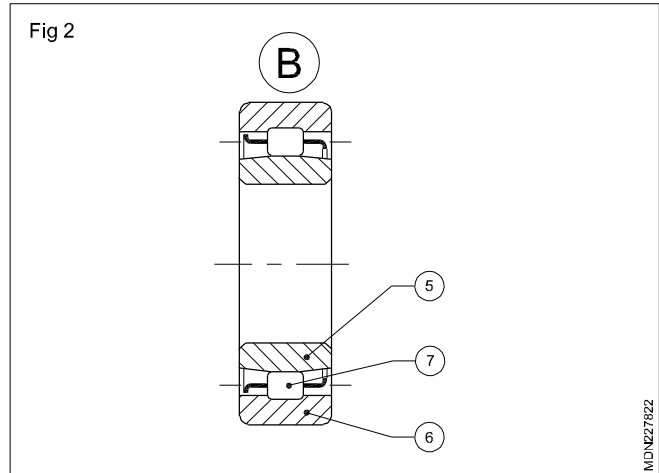
Bush bearings are made of copper-lead, tin-aluminium, tin-copper and used in the small end of the connecting rod, camshaft, oil pump drive shaft etc.



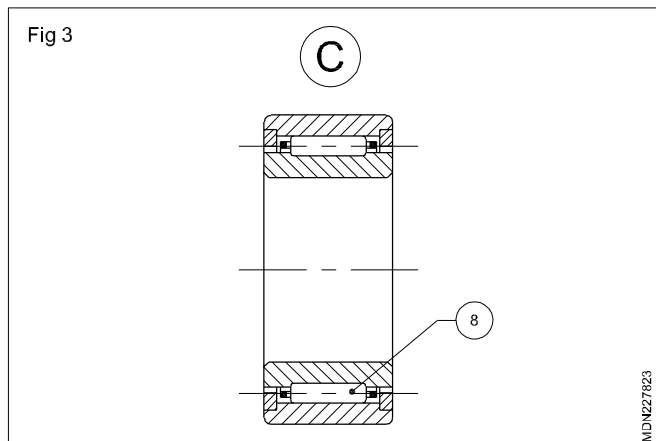
Ball bearings (A) (Fig 1) reduce friction between rotating parts to a minimum, and can take radial as well as axial load.

Ball bearings consist of an inner race (2), outer race (3) and balls (4). These bearings are used in the gearbox.

Roller bearings (B) also consist of an inner race (5), outer race (6) and rollers (7). (Fig 2) These bearings can take heavy radial load but no axial load and are used in the final drive, flywheel, water pump etc.



Needle roller bearings (C) (Fig 3) are similar to roller bearings except that the ratio between the length of the needle roller (8) and the diameter of the roller is much more than that of a roller bearing.

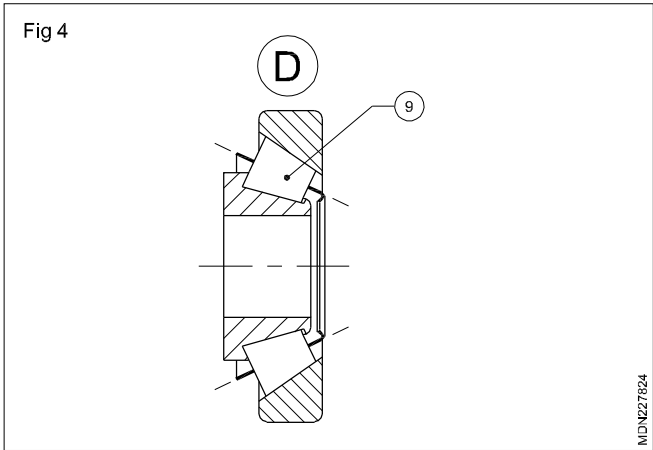


Taper roller bearings (D) (Fig 4) have taper rollers (9) instead of plain rollers. In automobiles, these bearings are generally used in pairs and these can take axial and radial loads. These bearings are used in the differential assembly, wheel hubs etc.

## Details of engine bearings

### Engine bearings

These are also called "Shell bearings or sliding function bearings or precision insert bearings. These are largely used for free rotation of crankshaft, connecting rods and camshaft. They provide low frictional areas for these shafts to rotate smoothly under different speeds and loads.



## Shell bearings

These have been dealt in I Year Trade Theory. In this lesson, some more useful points are discussed on the shell bearings. They are stated as below:

- Qualities of engine bearings
- Bearing materials
- Bearing spread and crush
- Bearing failures and remedies
- Connecting rod and camshaft bearings
- Load on precision insert bearings
- Advantages of using insert bearings.

## Qualities of engine bearings

The bearing should have

- Excellent fatigue strength
- Good conformability
- Fine embeddability
- Superior surface action
- High temperature strength
- Adequate corrosion resistance
- Quick thermal conductivity

## Fatigue strength

The capacity of the bearing to withstand high loading and impact loads, without being crushed for a reasonable period of life is known as fatigue strength.

## Conformability

The capacity of the bearing to adjust to the conditions of crankcase distortion and crankshaft warpage and conform to the journal at all times is termed as conformability.

## Embeddability

The bearing should be able to absorb dirt and metal particles and keep them below their working surface to avoid abrasive wear on the journals. This aspect is called embeddability.

## Surface action

The bearing should have enough self lubricating properties to withstand metal to metal contact between journals and bearings. This property is termed as surface action.

## Temperature strength

Bearings are subjected to higher temperature condition during operation and as the temperature raises, they become softer. The bearing should not become too soft and lose its load carrying strength, at operating temperature.

## Thermal conductivity

The bearing should quickly conduct the heat through the shell and parent bore to the block and keep its temperature low. Bearing materials are selected in such a way to suit each engine design requirements in these areas.

## Bearing materials used

Different varieties of materials now in use are :

- Tin base babbitt
- Lead base babbitt
- Cadmium nickel or silver alloy
- Copper lead alloy (with tin overlay)
- Aluminium alloy
- Silver lead

## Tin base babbitt

Low fatigue strength but has good conformability, embeddability, surface action and corrosive resistance. This is popularly used on heat engines. (Petrol engines)

## Lead base babbitt

Improved fatigue strength compare to tin base babbitt and similar to them in other respect. This is popularly used in petrol engines.

## Cadmium nickel or silver alloy

Fatigue strength is further improved but not very good in conformability, embeddability and surface action popularly used in high speed high pressure engines.

## Copper lead alloy

Superior fatigue strength even at higher temperature. These are improved by overlay tin coating or tin base micro babbitt surface and popularly used in high speed diesel engines.

## Aluminium alloy

Aluminium alloy excels with respect to fatigue strength, load carrying capacity, corrosion resistance and freedom from scoring tendencies. In case of seizures, only bearing get affected and journals are saved from scoring when aluminium bearings are used. The sticking bearings material can be easily removed from the journals. Due to poor embeddability, improved hardening of the journals is necessary.

## Silver lead bearings

These alloys have the greatest load carrying capacity, but, prohibitively expensive. Limited to aeronautical purposes where this factor is of great importance. Embeddability is poor with these alloys.

## Bearing spread and crush

### Bearing spread

The bearing should have full contact with its parent bore and for this purpose bearing spread and crush are provided. Both main bearing and con-rod inserts have the outer dia. at parting forces slightly larger than the housing bore dia. This will be about .005" to .020" in the case of main bearings and .020" for con-rod bearings in excess of the bore dia. This is known as bearing spread and this helps to hold the inserts in place during assembly.

### Bearing crush

The parting faces when assembled stand proud of the parent bore half. When bearing caps are tightened, a radial pressure is exerted at the parting faces and forces the inserts tightly into the housing bore to ensure complete

## Application bearing, failure of its causes and care of maintenance

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**Objectives:** At the end of this lesson you shall be able to

- state the application of bearing
  - state the causes for bearing failure
  - state the care and maintenance of the bearing.
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The device for supporting the rotating shaft is called bearing, bearings are used in all types of machineries, engines and mechanism for supporting and controlling the motion of rotating, soldering or reciprocating parts, shafts, spindles, axles, rods & pins.

The contact surface of bearing may wear out due to friction and rubbing by rotating or moulding parts. To moulding parts. To minimise the frictional resistance, bearing are lubricated and adjusted that they serve their purpose with a minimum of friction power loss and generation of heat.

contact. This is about .004" to .008" for main and big end bearings. This is checked by torquing the both ends to recommendations, then loosening one end and inserting feeler gauge between cap face and crankcase face.

## Camshaft bushings

Precision bearings are used for camshaft in many engines. But they are not split but pressed into the block as a full bush and held thereby means of a press fit. These bushings are designed for radial loads only. But, end thrust is being taken by a special thrust plate bolted to block.

## Small end of connecting rod

The small end of connecting rod is fitted with a phosphor bronze bush and the small end is joined to the piston by a means of a piston pin passing through this bush.

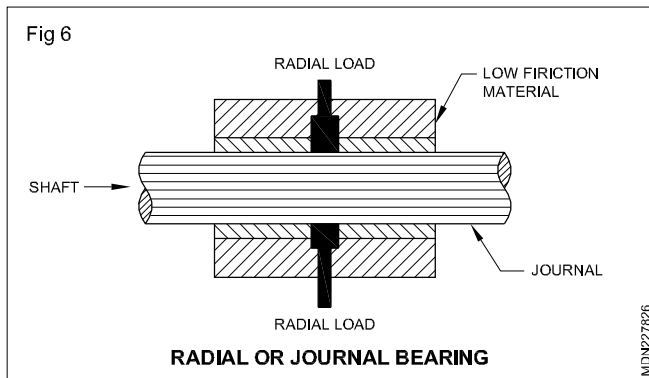
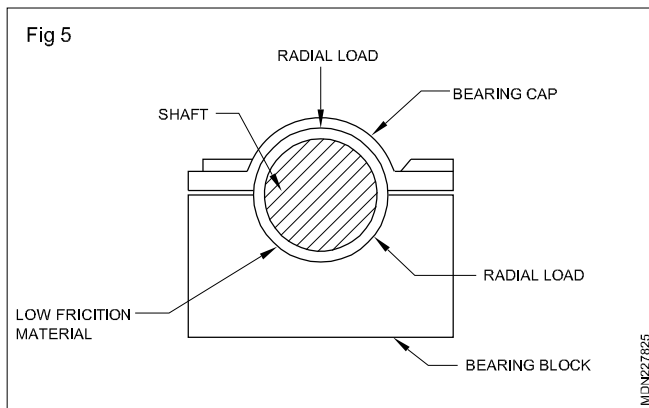
Load on the precision insert bearings

- The precision insert bearing used as a main bearing in an engine take up radial and the thrust loads applied to the crankshaft.
- The connecting rod bearings are normally constructed for radial loads only. The thrust will be taken up by the crank cheeks which are machined surfaces to match the machined side faces of big end of the connecting rod.

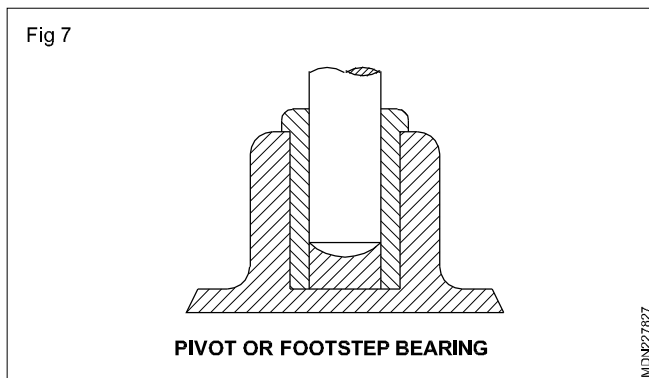
## Advantages of using precision insert bearings

- Variety of bearing materials may be used.
- Desired structure can be obtained
- Controlled babbitt thickness is possible
- Easier and quicker replacements can be done.
- Improved load carrying characteristics is possible.

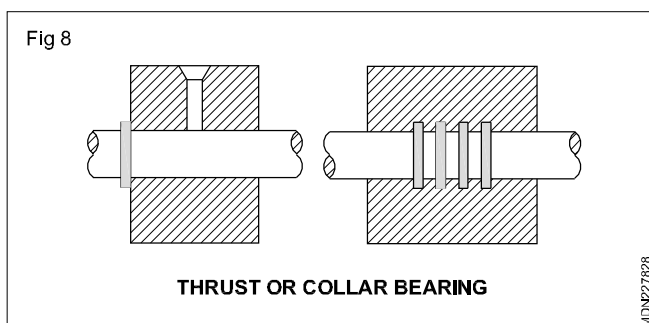
Radial bearing supports the rotating shaft in a fixed position against the load acting perpendicular to the axis of the shaft.



A pivot or foot step bearing supports the vertical shaft as its end.



Thrust bearing supports the rotating shaft against the side thrust of the shaft side collars are provided on the shaft to resist the side thrust.



## Bearing failures

### Fatigue failure

This is identified by small sections of bearing material detaching from the steel back and this spreads to the entire bearing. Excessive loading, detonation, inadequate lubrication, high temperature build up are the major causes for this problem.

### Foreign matter on bearing surface

Dirt, dust, metal particles left before assembly, due to improper cleaning, dirty oil, due to inadequate maintenance result in suspended hard particles staying the lub. system. These find a way into the bearings under pressure with lub. oil and when they are too big to pass through the bearing clearances, they get embedded into the bearings, displacing the bearing material. continued condition of such nature, lead to the bearing surface getting full of such particles which work on the journals as an abrasive and score them. This will accelerate bearing and journal wear. Hygienic conditions in the system and also during assembly is therefore very important.

### Improperly seated bearing

This is possible due to existence of foreign matter or dirt between bearing back and seating at parent bore, filed parting faces or bearing caps or shims below the bearing shells or between parting faces when not needed. This will affect full contact with parent bore, oil clearance and load distribution, thermal conductivity etc. and the problems following them. Localised wear or peeling of bearing material or seizure may be the result.

Dirt between bearing and the seat is due to improper cleaning before assembly, Bearing crush may be lost by filing parting faces and even the bearings may start working loose in the parent bore. This may lead to bearing rotation and complete seizure very quickly.

Filed bearing caps result in out of round parent bores. This is ignorantly attempted to reduce oil clearance. This may lead to excessive crush and insufficient oil clearance and landing up in a total bearing failure.

### Con.rod mis-alignment

Bend and twisted con.rods wear the bearing unevenly. This affects bearing clearances also.

### Shifted bearing caps

This can be caused by

- Improper doweling or by damaged dowel holes or dowels.
- Using too bigger socket spanner for the cap screws.

## P.T.F.E. bearings

Polytetrafluoro ethylent (PTFE) is extremely inert plastic material with an unusually low dry coefficient of friction its use is limited by its thermal properties. This bearing particularly suitable for applications where corrosive liquids would attack conventional bearing materials.

### Care and maintenance of bearing

- Identify correct size of bearing for selected application.
- Clean the dirt, dust, rust and metal particles on the bearing before use.
- Setting proper bearing clearance and proper seating in its place
- Specified lubricant use for bearing lubrication.
- Periodically change the lubricant for increase the bearings life.
- Replace the damaged worn bearings.
- Use the quality of bearings as specified in service manual.

### Types of bearings damages

- Abrasive damage
- Erosion damage
- Fatigue damage
- Corrosion damage
- wiping damage
- Cracks, scoring, overheating

## Types of bearing damages and causes

- |   |                                |
|---|--------------------------------|
| - Edge wear                             | - Less clearance               |
| - Score of scratches (situational wear) | - Bad workmanship              |
| - Overheating & surface                 | - Insufficient lubrication     |
| - Cavitation of erosion                 | - Interior quality of material |
| - Corrosion                             | - water mix with lubricant     |
| - Cracks in galvanne layer              | - Overheat and overload        |
| - Pitting of fretting                   | - Metal particles in lubricant |

### Factors affecting bearing clearance

- Desired operating temperature extremely critical
- Engine speed
- Oil flow rate
- Oil film thickness
- Working viscosity of lubricant
- Load carrying capacity
- Operating temperature of engine

### Bearing defect symptoms

- Low oil pressure
- Reduce load capacitor
- High impact load on crankshaft
- Noise

## Crankshaft balancing, firing order of the engine

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**Objectives:** At the end of this lesson you shall be able to

- state the types of crankshaft balancing
  - state the importance of the crankshaft balancing
  - state the function of firing order.
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### Balancing of crankshaft

Internal combustion engines have reciprocating parts and they create vibrations, when the engine is running. Every two revolutions of the crankshaft one power impulse in four stroke engine. Balancing of the engine is necessarily required for smooth running of the engine.

The crankshaft is subjected to torsional vibration and engine vibration. Engine vibration is due to the uneven weight distribution on the crankshaft and the unbalanced reciprocating forces of pistons and connecting rods. Balancing is achieved by removing materials (by drilling) in the crank web or by adding weight to the shaft between centres in a special balancing machine.

### Types of balancing

There are two types engine balance, (i) power balance (ii) mechanical balance

**Power balance:** When the engine power impulses occur at regular intervals with relation to the revolution of the crankshaft and each power of the engine impulse exerts the same force.

**Mechanical balance:** Engine mounting parts crankshaft connecting rod and pistons are rotating in reciprocating motion, so that crankshaft counter balance in operation mechanically minimize the vibration of the engine. The rotating parts of an engine can be balance by bringing them into static and dynamic balance. The main rotation parts

are balanced mechanically by crankshaft counter weight and flywheel piston of connecting rods shocks on crankshaft are called primary inertia forces. The angularity of the connecting rods produce secondary lubrication, it is called secondary inertia forces. The perfect static and dynamic balance of crankshaft and flywheel reduce the vibration.

Firing order: The sequence of power impulses occur rider engine is called firing order. The firing order in which cylinder deliver their power strokes is selected as a part of the engine design to obtain the best engine performance. The firing order is shown by the sequence of the number of cylinder in which the cylinder deliver their power strokes. Which is the nearest cylinder to radiator is designated as number one cylinder in and in line engine

Three cylinder 1 -3 -2

Four cylinder 1 -3-4-2

Five cylinder 1-3-5-4-2

Six cylinder 1-5-3-6-2-4

Eight cylinder inline engine 1-8-7-3-6-5-4-2

Eight cylinder v8 engine 1-3-2-5-8-6-7-4