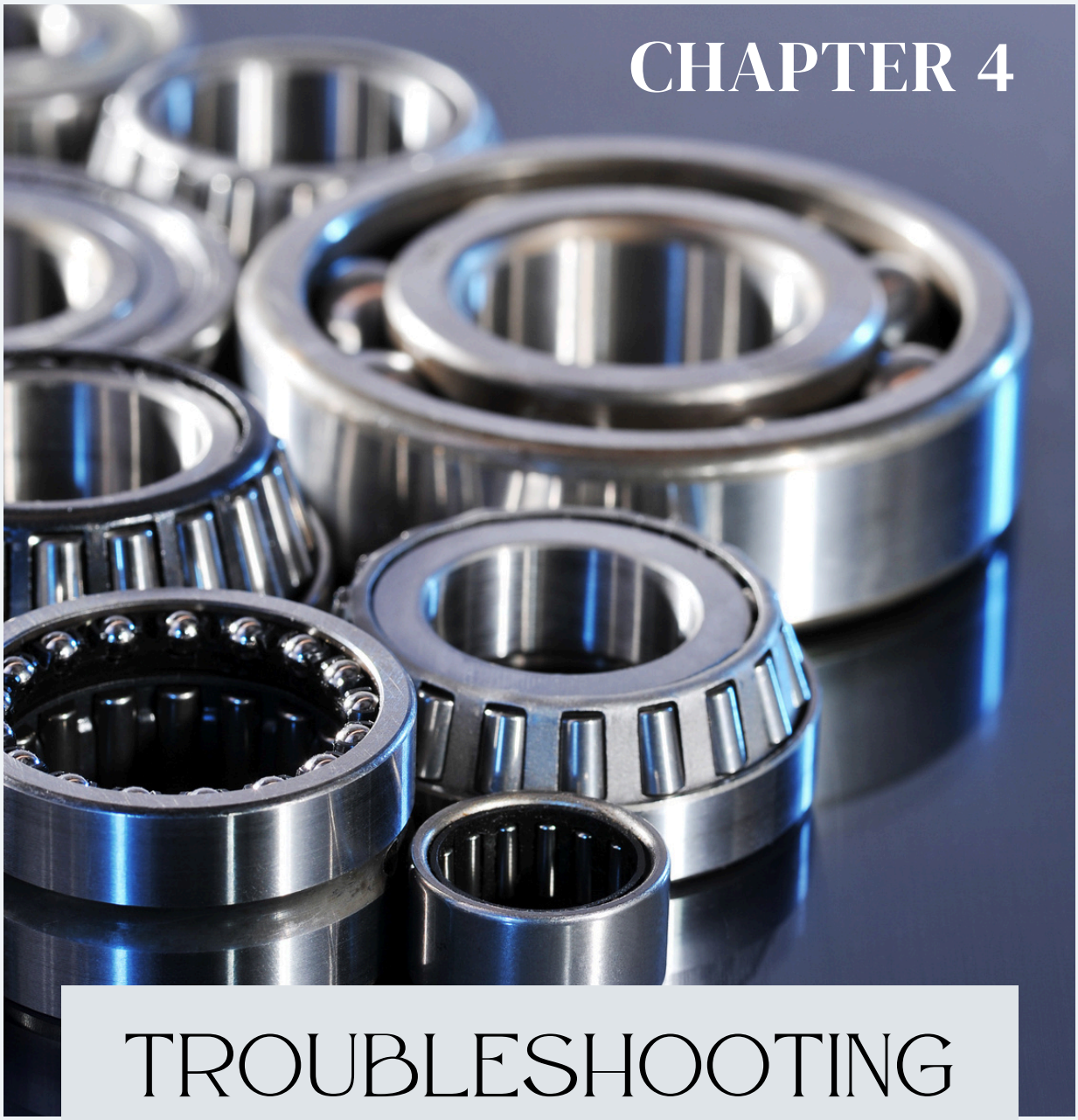

CHAPTER 4

TROUBLESHOOTING AND MAINTENANCE FOR MECHANICAL COMPONENTS

Amizan Yahaya bin Jamil
Leanna binti Mohd Yunos

TROUBLESHOOTING AND MAINTENANCE FOR MECHANICAL COMPONENTS

Chapter 4 : Bearing

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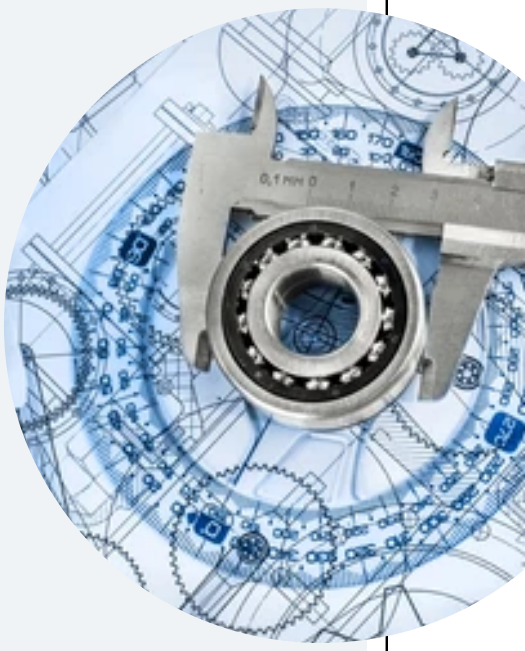

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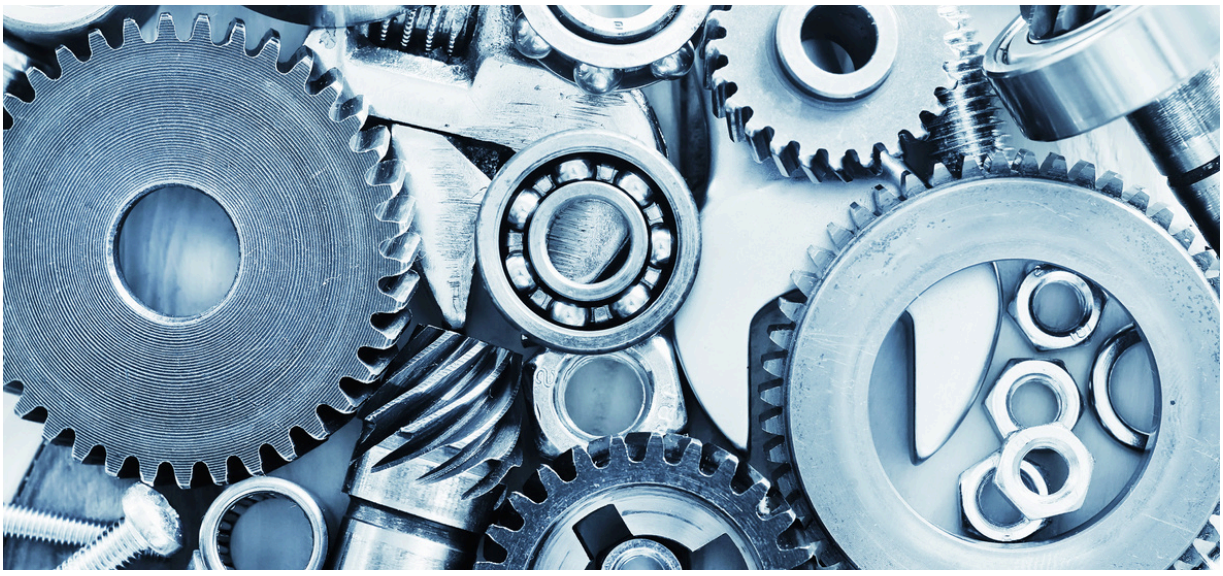
SINOPSIS

TROUBLESHOOTING AND MAINTENANCE FOR MECHANICAL COMPONENTS covers basic mechanical components needs in Industry. The topic includes maintenance & troubleshooting principles and procedures, lubrication, power transmission, bearing and pumps. This course also gives knowledge and skills regarding maintenance & troubleshooting of mechanical components and assemblies.

Editor



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4.4 Perform analysis on bearing damage.

4.4.1 Produce a check list of bearing damage maintenance, failure symptoms.
4.4.2 Record observations for preventive maintenance:
- a. Fatigue, vibration and wear
- b. Corrosion damage.
- c. Scuffing and sliding marks.
- d. Local indentations in the raceway.
- e. Faulty mounting and defective installation methods.
- f. Poor lubrication and fault in design.

4.4.3 Produce bearing maintenance procedures.

05

4.5 Explain the bearing failures, diagnosis and troubleshooting.

4.5.1 Diagnose the bearing failures.
- a. Abnormal bearing temperature.
- b. Noises of rotating bearing.
- c. Vibration of rotating bearing – wear and tear of bearing material.

4.5.2 Diagnose and troubleshoot the bearing failure above.

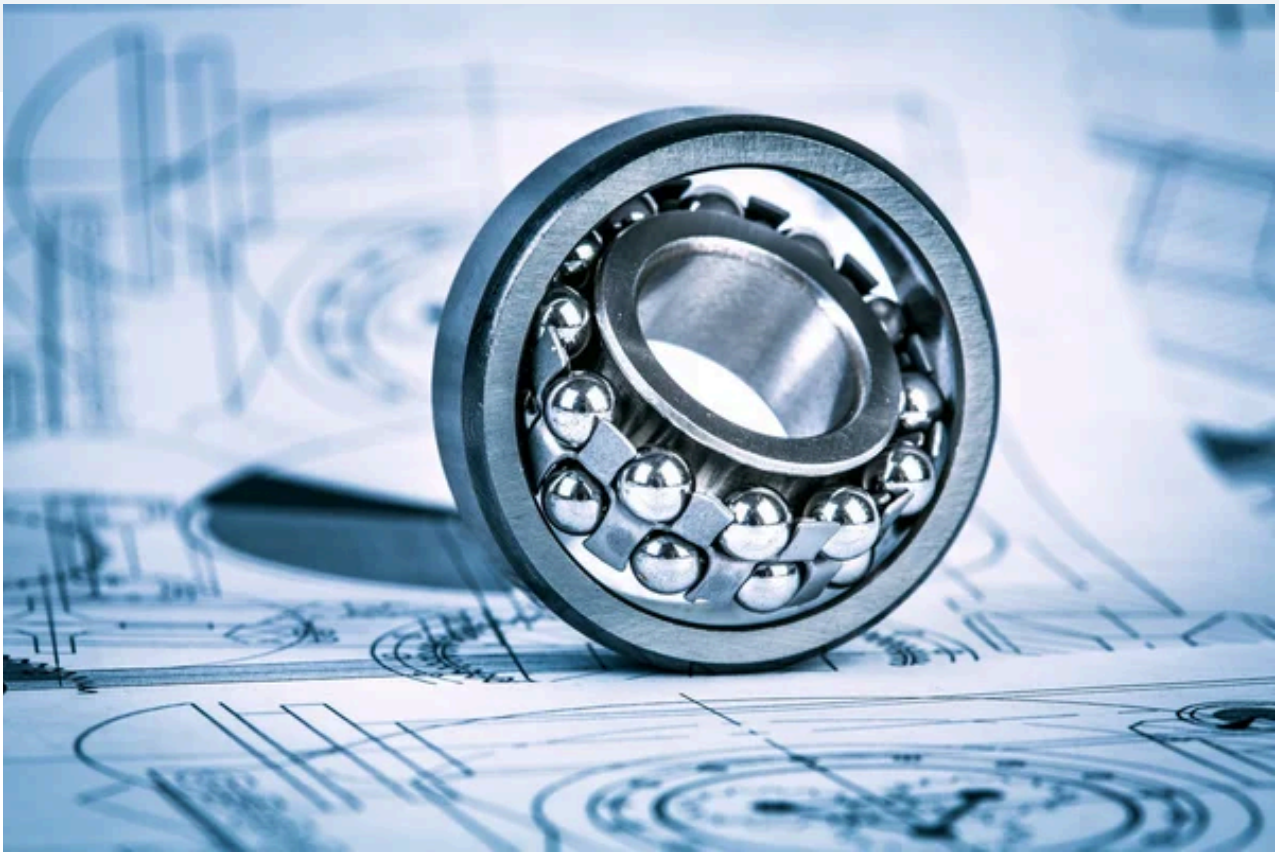
OBJECTIVE

Upon completion of this course, student should be able to :

Apply the concept of mechanical components to solve related problems.

Organized appropriately experiments in groups according to Standart Operating Procedure

Perform the troubleshooting on mechanical components failure and damage



CHAPTER 4 : BEARING

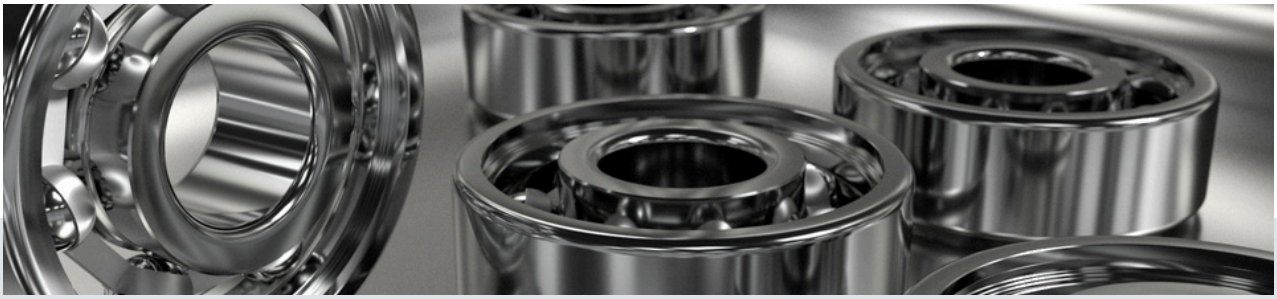
4.1 Analyze bearing concepts.

4.1.1 List the applications of bearing.

The main purpose of bearings is **to prevent direct metal to metal contact between two elements that are in relative motion.** This prevents friction, heat generation and ultimately, the wear and tear of parts. It also reduces energy consumption as sliding motion is replaced with low friction rolling.

- The design of the bearing may provide for free linear movement of the moving part or for free rotation around a fixed axis or, it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts.

- Bearings are classified broadly according to the type of operation, the motions allowed, or to the directions of the loads (forces) applied to the parts.



- Bearing are used to support rotating shaft and are classified according to the direction of the main load. (see figure 4.1.1)

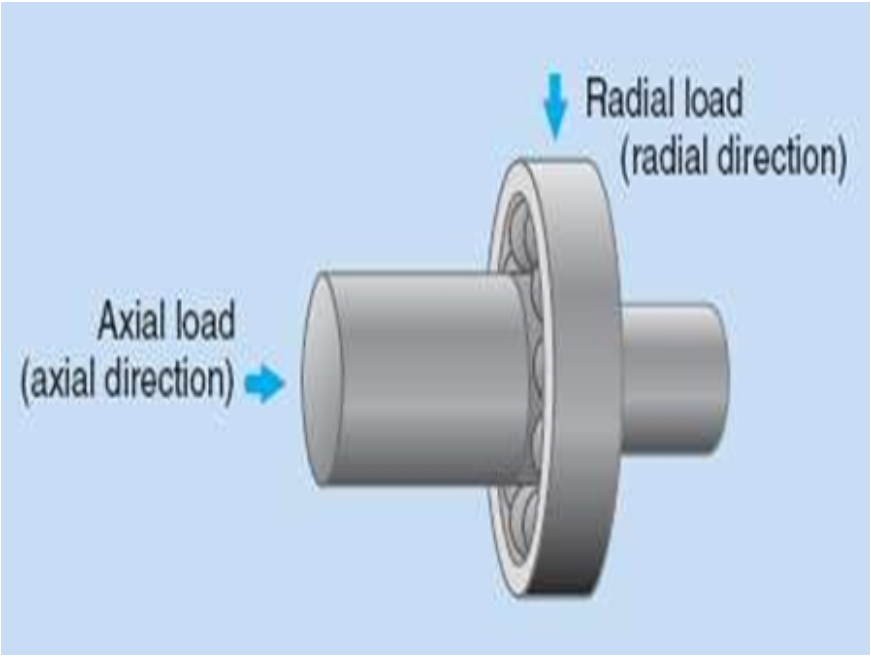


Figure 4.1.1

- axial bearing are design to withstand axial thrust
- Radial bearings are designed to withstand radial load
- Combination of both

4.1.2 Classify types of bearing and their characteristics based on their function.

The bearings are classified broadly into **two (2) categories** based on the type of contact they have between the rotating and the stationary member.

A. ROLLING ELEMENT BEARINGS

- Rolling element bearing also called an antifriction bearing because the created by this bearing is rolling friction rather than sliding friction created by the plain bearings. The rolling element bearing is a cylinder containing a moving inner ring of steel balls or rollers.

- Rolling element bearings have balls or roller for increase efficiency. Rolling friction is always less than sliding friction.The following are the three basic types of rolling element bearings.

    i. Ball Bearings
    ii. Roller Bearings
    iii. Needle Bearings

- Different designs of ball and roller bearings can handle radial, axial and combination loads. Needle bearings are used only for radial or axial loads.

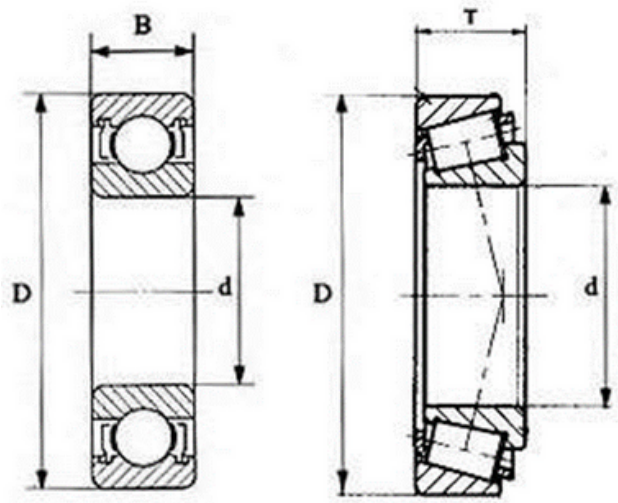
B. SLIDING / JOURNAL / PLAIN BEARINGS

- A plain bearing is any bearing using a sliding action rather than a rolling action. It may or may not be lubricated. Plain bearings are sometimes referred to as journal or sleeve bearings. Plain bearings are typically cylindrical shape bearings designed to carry radial loads.The terms journal and sleeve are often used interchangeably

- Plain bearing can categorized into three classes :
  i. Class I
     - Bearing systems are lubricated from an outside sources
  ii. Class 2
     - Bearing systems have internal lubrication
  iii. Class 3
     - Bearing systems have graphite , PTFE (Teflon) or plastic bearings that require no lubricant

4.1.3 State the code number of rolling bearings.

- When it comes to radial and thrust bearings for radial and axial loads, respectively, there are also some bearing types that are designed to support both radial and axial loads. In general, ball bearings are suggested for light to moderate loads and roller bearings for heavy loads. Nine basic bearings are available. Some of these fundamental types come in a wide variety; for example, cylindrical roller bearings can be found with one, two, or four rows of rollers.



d = Inside diameter
D = Outside diameter
B/T = Width diameter

- Each bearing has an inside diameter, outside diameter and width diameter in that order. Most bearings are metric in size, but can also be imperial. On our site, each bearing shows its principal dimensions.

NMB part number (example1)

R-830X10ZZSD10MTRP5P24LO1

- Bearing series: Thick type
- Outer Diameter: 8mm
- Bore: 3mm
- Internal Design X10 Type
- Shield
- Special Design Spec
- *materials: no code (equivalent to SUJ2)
- Noise Sensitive Application (motor quality)
- Ribbon Retainer
- JIS Grade 5
- Radial Clearance: 5.0μm~10.0μm
- Lubricant: LO1 (Oil)

NMB part number (example 2)

DDL-1680DDMNP5P58LY551

- material: Stainless Steel
- Bearing Series: Thin type
- Outer Diameter: 16mm
- Bore: 8mm
- Contact rubber seal
- *Lubricant Fill Quantity: No Code (25%~35%)
- Plastic Retainer
- JIS Grade 5
- Radial Clearance: 12.5μm~20.0μm
- Lubricant: LY551 (grease)

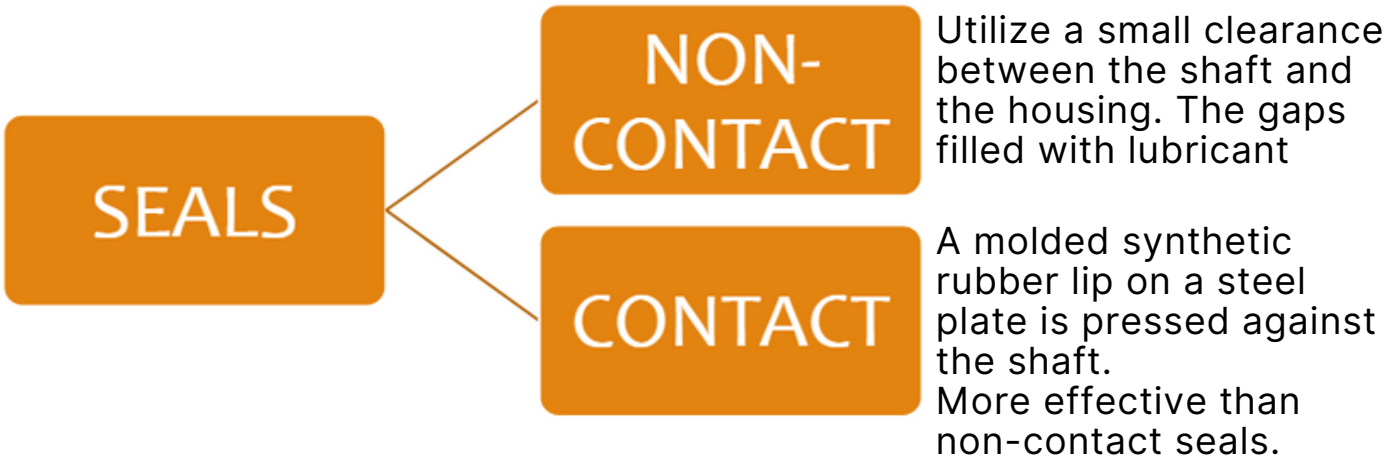
4.1.4 differentiate the suitable application of bearing based on the bearing value and service life value in hour or kilometer.

- Basic life or L10 as defined in ISO and ABMA standards is the life that 90% of a sufficiently large group of apparently identical bearings can be expected to reach or exceed.
- The median or average life, sometimes called Mean Time Between Failure (MTBF), is about 5 times the calculated basic rating life.
- Table below shows the suggested minimum bearing rating lives for various operating and reliability conditions:

Name of the gasket	uses
1. Rubber gasket	It is used at low temperature and pressure water line.
2. Synthetic rubber	It is used at oil and chemical line
3. Polytetrafluorethylene	It is better only for chemical line.
4. Asbestos and asbestos compound gasket	It is used for high and medium temperature and pressure line.
5. Paronite or clinggarite gasket	It is used for high temperature and pressure line.

4.1.5 Apply seals, Gaskets and Packing Concept Into Bearing System

- Seals to prevent leakage of lubricant and entry of dust, water and other harmful material like metallic particles.
- The seals must be free from excessive running friction and the probability of seizure.
- They should also be easy to assemble and disassemble .
- It is necessary to select a suitable seal for each application considering the lubricating method.



Non-Contact Type Seals

- Various sealing devices that do not contact the shaft, such as **oil grooves, flingers, and labyrinths** are available.
- Satisfactory sealing can usually be obtained with such seals because of their close running clearance.
- Centrifugal force may also assist in preventing internal contamination and leakage of the lubricant.

Oil Groove Seals

- The effectiveness of oil groove seals is obtained by means of the small gap between the shaft and housing bore and by multiple grooves on either or both of the housing bore and shaft surface.
- Since the use of oil grooves alone is not completely effective, except at low speeds, a flinger or labyrinth type seal is often combined with an oil groove seal.
- The smaller the gap between the shaft and housing, the greater the sealing effect; however, the shaft and housing must not come in contact while running.
- The recommended groove width is approximately 3 to 5mm, with a depth of about 4 to 5mm. In the case of sealing methods using grooves only, there should be three or more grooves.

Seal Packing

- Seals protect bearings against moisture, impurity and prevent leaking of lubricant. Lack of lubricant is main cause for bearing failure. Proper installed seals can significantly extend bearing life.

4.2 Investigate the friction, temperature and lubrication.

4.2.1 Distinguish the friction in bearing system.

- The friction in a rolling bearing is made up of several component.
- Due to the large number of influencing factors, Such as :
  - dynamic in speed and load,
  - tilting and skewing resulting from installation
  - actual frictional torques
  - frictional power
- Frictional component and influencing factor

Frictional Component	Influencing Factor
Rolling Friction	Magnitude of load
Sliding Friction of rolling elements Sliding Friction of cage	Magnitude and direction of load Speed and lubrication conditions, Running- in condition
Fluid Friction (Flow Resistance)	Type and speed Type, quality and operating viscosity of lubricant
Seal Friction	Type and preload of seal

4.2.2 Analyze the operating temperature with bearing friction

Friction

- Main function required of a bearing is that must have low friction
- Under normal operating conditions rolling bearings have a much smaller friction coefficient than slide bearings.

Temperature Rise

- Almost all friction loss in bearing is transformed into heat cause of temperature of the bearing rise.
- Determined by the equilibrium or balance between the amount of heat generated or the amount of heat conducted away from the bearing.
- In most cases the temperatures rises sharply during initial operation, Then increases slowly until it reaches a stable condition and then remains constant.

- The time it takes to reach this stable state depends on:
  - the amount of heat produced
  - heat capacity / diffusion of the shaft and bearing housing
  - amount of lubricant
  - method of lubricant

- Possible causes of abnormal temperature include:
  - Bearing misalignment (due to moment load or incorrect installation)
  - Insufficient internal clearance
  - Excessive preload
  - Too much or too little lubricant or heat produced from sealed units

4.2.3 Distinguish The Principles of bearing lubrication

- Many bearings require periodic maintenance to prevent premature failure,although some such as fluid or magnetic bearings may require little maintenance.
- Most bearings in high cycle operations need periodic lubrication and cleaning and may require adjustment to minimise the effects of wear.
- Bearing life is often much better when bearing kept clean and well-lubricated.
- Many applications make good maintenance difficult. Example:
- Bearings in the conveyer of a rock crusher are exposed continually to hard abrasive particles.
- Cleaning is of little use because cleaning is expensive yet the bearing is contaminated again as soon as the conveyer resumes operation.
- A good maintenance program might lubricate the bearings frequently but never clean them.
- 4 types of the principles of bearing lubrication:
    - Packing
    - Ring oiler
    - Splash Lubrication
    - Pressure lubrication

Packing

- Some bearings use a thick grease for lubrication which is pushed into the gaps between the bearings surface, also known as packing.
- The grease is held in place by a plastic, leather or rubber gasket (also call a gland) that covers inside and outside edges of the bearing race to keep the grease from escaping.
- Bearings may also be packed with other material :
  - the wheels on railroad cars used sleeve bearings packed with waste or loose scraps cotton or wool fiber soaked in oil then used solid pads of cotton.

Ring Oiler

- Bearing can be lubricated by a metal ring that rides loosely on the central rotating shaft of the bearing.
- The ring hangs down into a chamber containing lubricating oil.
- As the bearing rotates, viscous adhesion draws oil up the ring and onto the shaft, where the oil migrates into the bearing to lubricate it.
- Excess oil is flung off and collects in the pool again.

Splash Lubrication

- Some machines contain a pool of lubricant in the bottom, with gears partially immersed in the liquid, or crank rods that can swing down into the pool as the device operates.
- The Spinning wheels fling oils into the air around them, while the crank rods slap at the surface of the oil, splashing it randomly on the interior surfaces of the engine.
- Some small internal combusion engines specifically cointain special plastic flinger wheels which randomly scatter oil around the interior if the mechanism.

Pressure Lubrication

- For high speed and high power machines, a loss of lubricant can result in rapid bearing heating and damage due to friction.
- Also in dirty environments the oil can become contaminated with dust or debris that increases friction.
- In this applications, a fresh supply of lubricant can be continuously supplied to:
- the bearing and all other contact surfaces.
- the excess can be collected for filtration
- cooling
- possible reuse
- Pressure oiling is commonly used in large and complex internal combustion engines in parts of the engine where directly splashed oil cannot reach, such as up into overhead valve assemblies.
- High speed turbochargers also typically require a pressurized oil system to cool the bearings and keep them from burning up due to the heat from turbine.

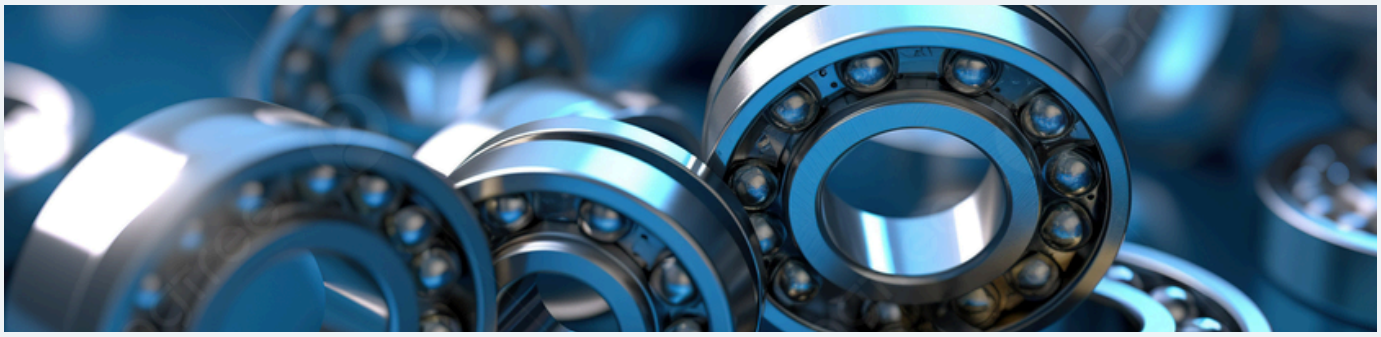
4.3 Perform mounting and dismounting of bearing.

4.3.1 Apply Mounting And Dismounting Equipment And Tools

- Mounting and installation of bearing depends on the type and fitting practice.
- The procedures covered are concerned with the proper methods and tools to accomplish installation of pressed fitted bearing ring.

Cold Mounting Kits

1. Extremely light kit makes it very portable and convenient to handle.
2. Ensures ready availability of components for mounting the bearings when required.



Hook Spanners

1. Locknuts can be easily tightened and loosened on shafts, adapter sleeves and extraction sleeves using socket wrenches
2. Both kits and sets contain suitable torque wrenches

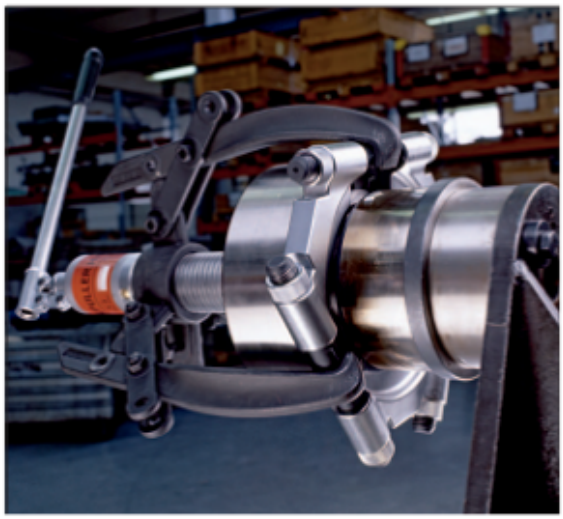
Mechanical puller

1. For extracting complete rolling bearings of all types or tightly fitted inner rings as well as other parts.
2. Good radial and axial accessibility of the bearing location, possibly by means of slots, is required.

1. For tight fit of inner ring or outer ring.
2. For cases in which the inner ring is adjacent to a shaft shoulder without extraction slots.

Back puller

1. For all rolling bearing types. For extracting complete rolling bearings or tightly fitted inner rings.
2. Principally for cases in which the inner ring is adjacent to a shoulder on the shaft without extraction slots. Good radial access to the bearing location is required



Mechanical puller

1. For extraction of complete bearings or tightly fitted inner rings.
2. Principally for cases in which the inner ring is adjacent to a shoulder on the shaft without extraction slots. Good radial access to the bearing location is required.

Mounting

Hot Plate Bearing Heater

Dismounting

Induction Heater

Mounting and Dismounting

Thread Hydraulic Nut

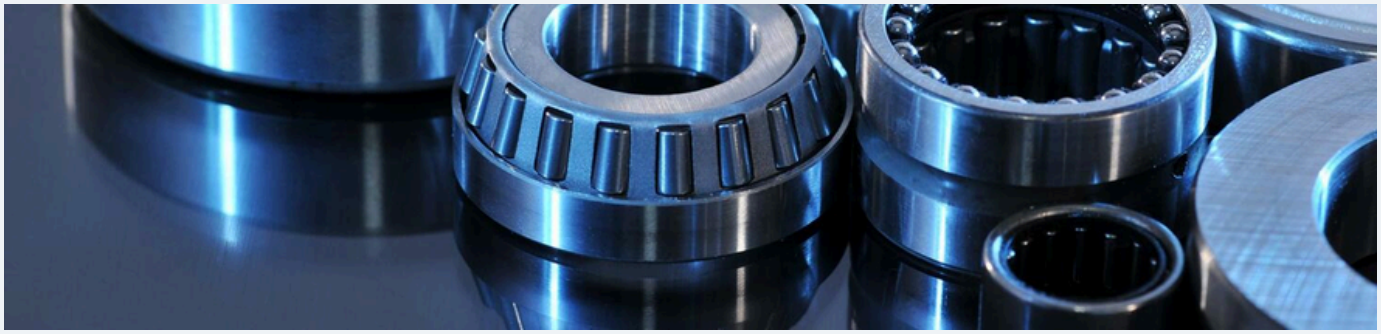
Air-driven hydraulic pumps

4.3.2 Apply Measuring Equipment For Bearing Installation

Waviness, Roundness and Form Analyzer

- Waviness on the bearing components can cause high vibration levels in most applications. As the amplitude of these waves is as small as some nanometers, you can understand the importance of measuring accuracy and resolution.

Waviness and roundness analyzers



- Waviness testers allow analysis of the waviness on the components and thus give the production engineer a powerful tool to improve the production process. Because low noise and vibration of bearings is becoming more important, there is a high demand on the measuring accuracy and resolution.
    1. Rotational measuring system with top concentricity precision, with electronics and mechanics combined to perfection
    2. Air-bearing spindle with run out better than 0,02 µm and velocity-proportional evaluation gives you direct indication of the waviness level of the component
    3. The calibration of this equipment is also very important and is performed to an excellent standard.

Waviness and roundness analyzers

Noise and Vibration Tester

- A noisy application might be caused by wavy bearing components, local defects in the rings and balls or by dirt particles in the bearing. While basic requirements on a bearing like stiffness, load capacity, speed limit and service life play a critical role in applications, low noise and vibration are becoming even more important.
- High tech analysis and measurement such as frequency analysis (FFT) and further advanced analysis pinpoints faults. Spectral masks help to optimize the bearing performance in the particular application.

Noise and Vibration Tester

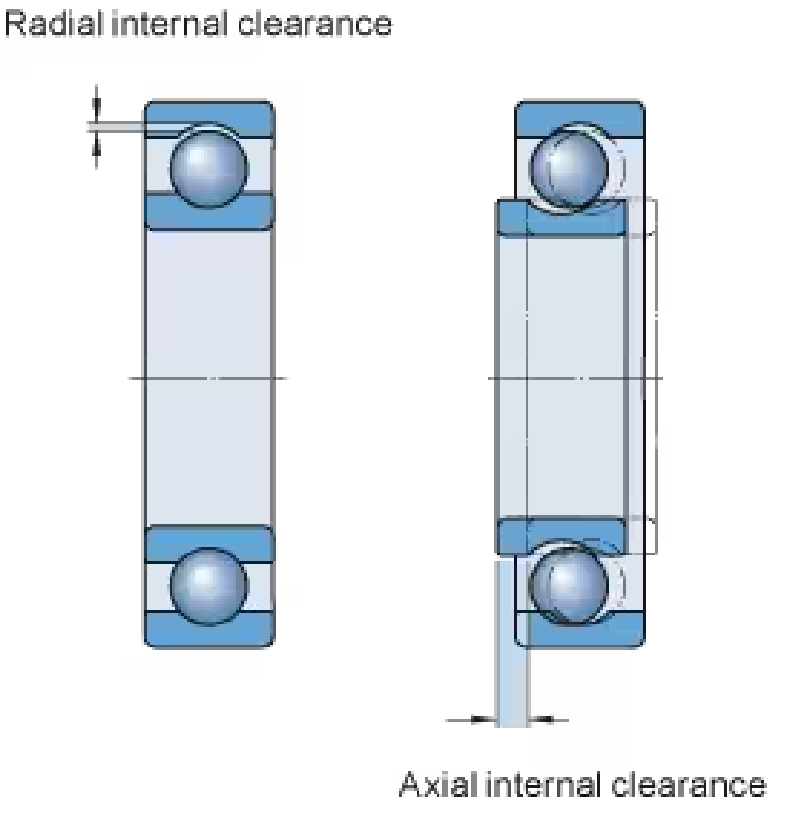
4.3.3 Apply the concept of adjuting clearance during installation

- Selecting the correct bearing internal clearance and determining whether preload is needed for a particular application is critical to obtaining the desired bearing performance.

Description of Internal Clearances

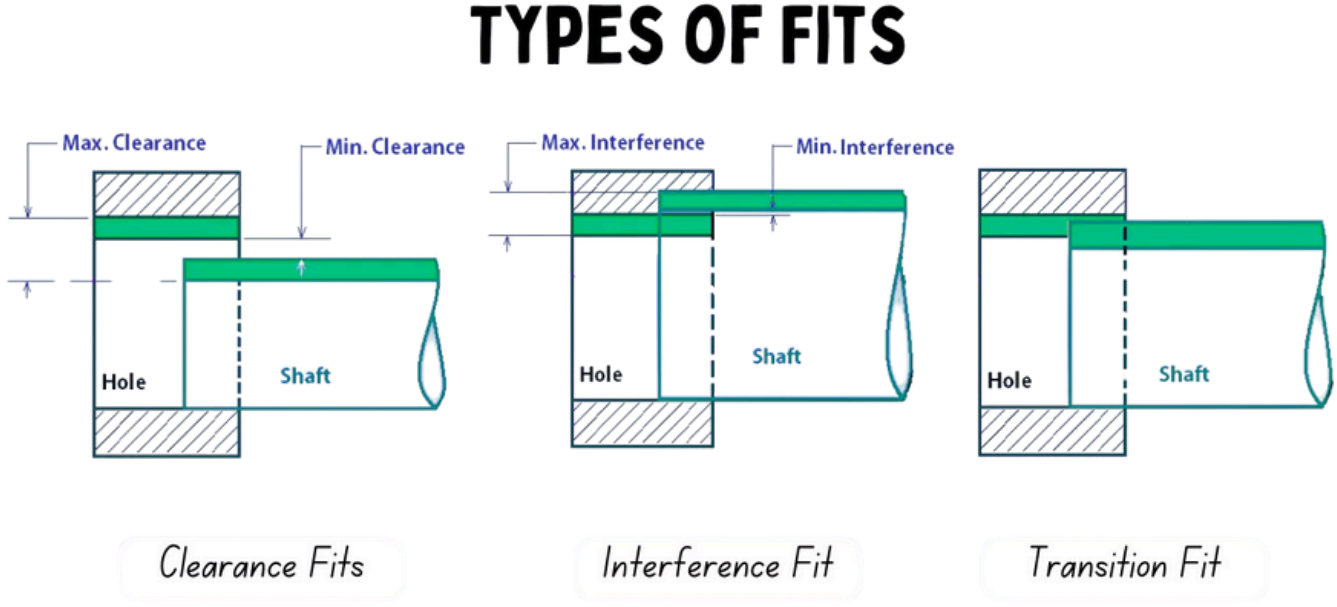
- Bearing internal clearance is described as being either radial or axial and is the total distance that either the inner or outer ring can be moved in the radial or axial direction while the other ring is held stationary.
- With only a few exceptions, bearing internal clearance is normally discussed in terms of radial clearance. Matched pairs of angular contact ball bearings are specified in terms of axial internal clearance. Also, when two single row tapered roller bearings are setup opposing each other, the clearance value between the rows is an axial measurement.
- Clearance prior to mounting is generally referred to as the original clearance. This initial clearance value is what is provided in the bearing at the time of shipment.

- After the bearing is fitted on a shaft and into housing, the original clearance is reduced due to contraction or expansion of the rings and is called the residual clearance or mounted clearance. Effective clearance is the residual clearance after taking into account changes from temperature differentials within the bearing.
- Operating clearance is defined as the effective clearance with the additional effect of elastic deformations from application loading. Successful bearing performance depends on having the appropriate “operating clearance” to avoid premature bearing damage and reduced fatigue life.



Fit Selection Considerations

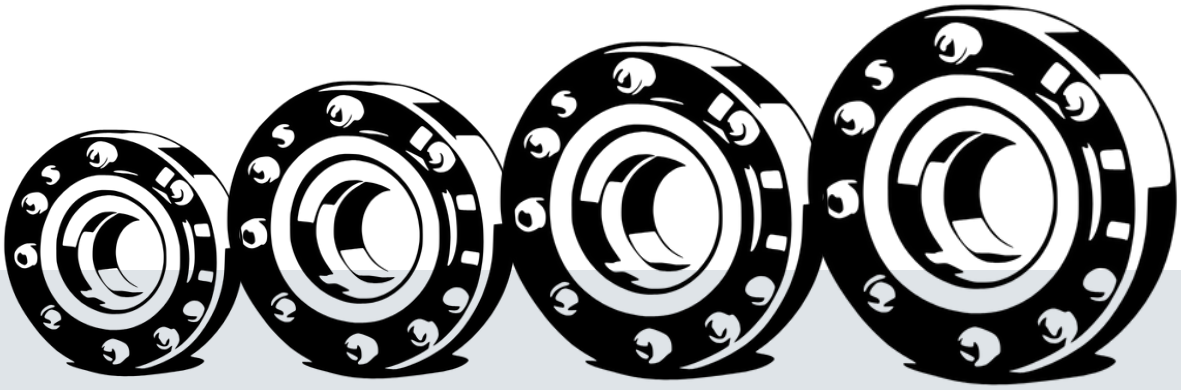
- As previously pointed out, there are other operating conditions to consider in addition to knowing which ring will be rotating when trying to determine the proper fits to use. The operating conditions that should be considered when determining bearing ring fits are the following:
    1. Load characteristics
    2. Load magnitude
    3. Temperature effects
    4. Effect on bearing internal clearances
    5. Finish of mating surface
    6. Shaft and housing material & section thickness
    7. Mounting design and fixed and float considerations
    8. Bearing type and size



4.3.4 Classify mounting methods likes cold mounting, temperature mounting, mounting tapered-bore bearing, dismounting of bearing, hydraulic method

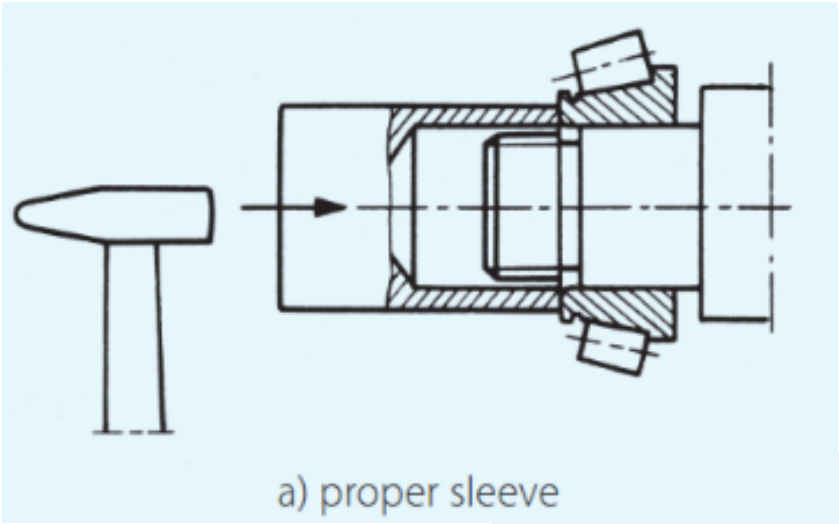
Cold Mounting Methods

- Mounting a bearing without heating is the most basic and direct mounting method. If the fit is not too tight, small bearings may be driven into position by applying light hammer blows to a sleeve placed against the bearing ring face having the interference fit. The blows should be evenly distributed around the ring to prevent the bearing from tilting or skewing.
- Cold mounting is suitable for cylindrical bore bearings with an outside diameter up to 4 inches. In some cases if the interference specified for a cylindrical bore bearing is great enough, the use of one of the other mounting methods is warranted.

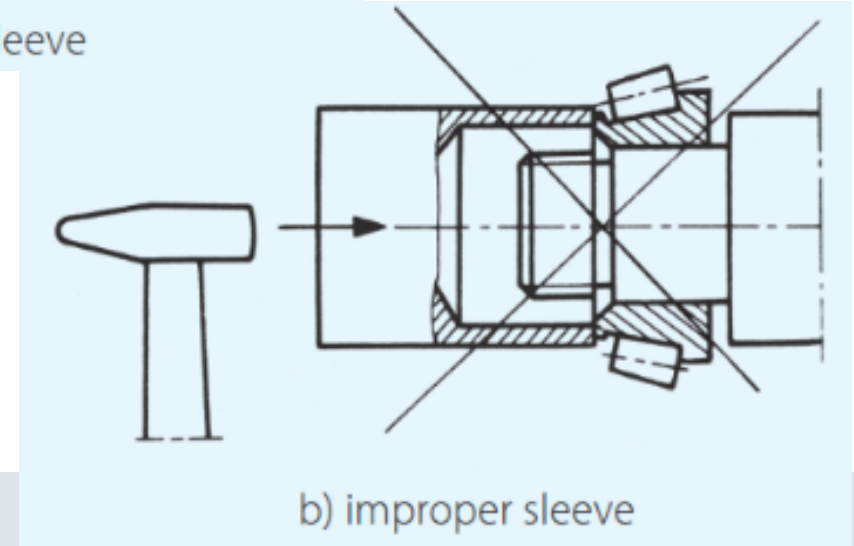


Cold Mounting Process

- With separable bearings, the inner ring can be mounted independently of the outer ring ,which simplifies mounting, particularly where both rings are to have an interference fit. When installing the shaft, with the inner ring already in position, into the housing containing the outer ring, make sure that they are correctly aligned to avoid scoring.



a) proper sleeve



b) improper sleeve

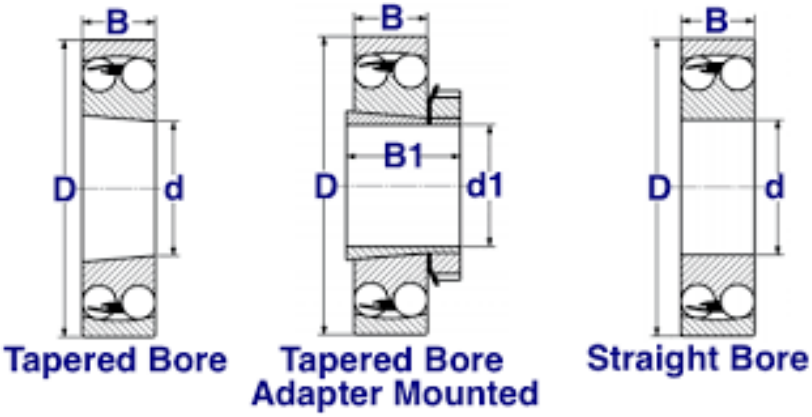
Temperature Mounting Method

- Commonly used for large bearings and bearings with a heavy interference fit.
  a) Immersion of the bearing in heated oil is the most common method. Use clean oil and suspend the bearing in the oil with a wire or support it underneath using a metal screen in order to avoid uneven heating of bearing elements.
  b) The temperature to which the inner ring should be heated depends upon the amount of interference fit i.e. the diameter of the interference fit surfaces.
  c) To prevent gaps from occurring between the inner ring and shaft shoulder, bearings which have been heated and mounted on the shaft should be held in place until they have cooled completely.

Heat mounting reduces risk of bearing or shaft damage during installation because the bearing can be easily slid onto the shaft.

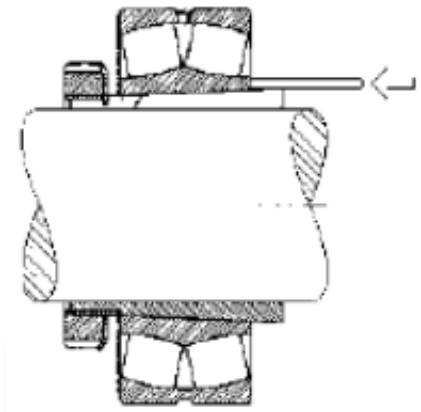
Mounting Tapered-Bore Bearing

- Bearings with tapered bore are either fitted directly on the tapered shaft journal or, if the shaft is cylindrical, on an adapter sleeve or a withdrawal sleeve.
- The oil film applied to the washed out bearing bore, shaft and sleeve should be very thin. A heavier coating would reduce friction and thus ease mounting; however, in operation the lubricant would be gradually forced out from the joint with a slackening effect on the tight fit, causing the ring or sleeve to creep and corrosion to develop on the surfaces.
- Forcing the bearing onto the tapered seat expands the inner ring and reduces radial clearance. Therefore the reduction in radial clearance can be used as a measure of the seating condition of the inner ring.

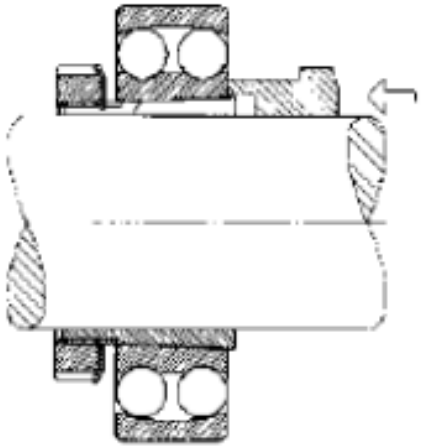


Dismounting Of Bearing

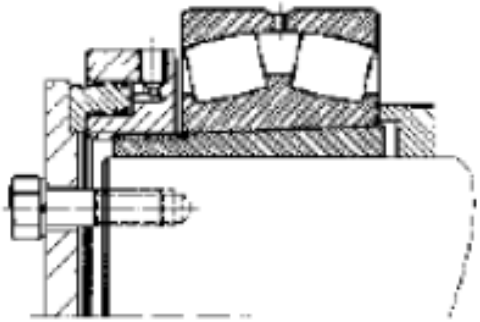
- Dismounting of Adapter Sleeve Mounted Bearings.
  1. For dismounting bearings directly seated on the tapered shaft or an adapter sleeve, loosen the locking device of the shaft or sleeve nut. Loosen nut by an amount corresponding to the drive-up distance.
  2. Drive inner ring off the adapter sleeve or tapered shaft seat by gentle hammer taps, using a soft metal or, even better, a piece of tubing.
  3. When a press is used, support the adapter sleeve or the loosened adapter sleeve nut and withdraw the bearing from the sleeve.



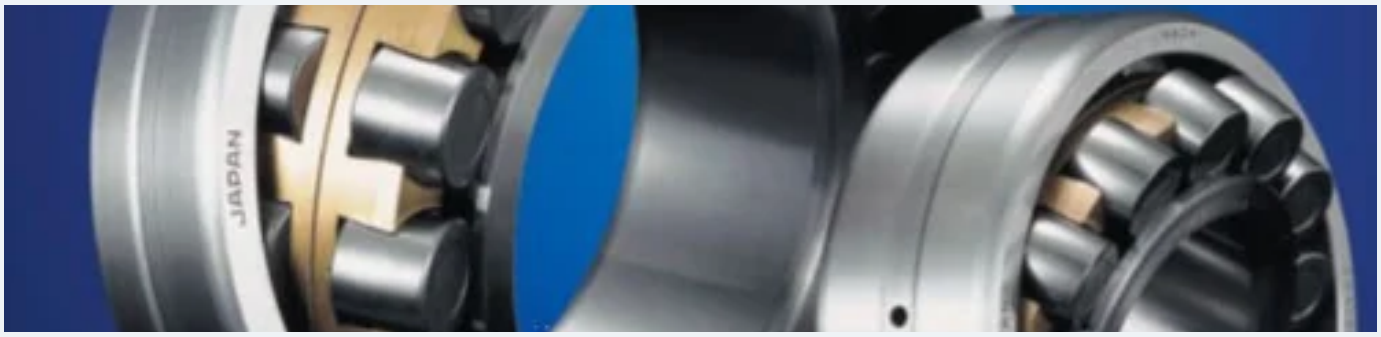
Dismounting of a small, adapter sleeve mounted spherical roller bearing. The inner ring is driven off the sleeve by means of a metal drift.



Dismounting of an adapter sleeve mounted self-aligning ball bearing. The use of a piece of tubing prevents damage to the bearing.

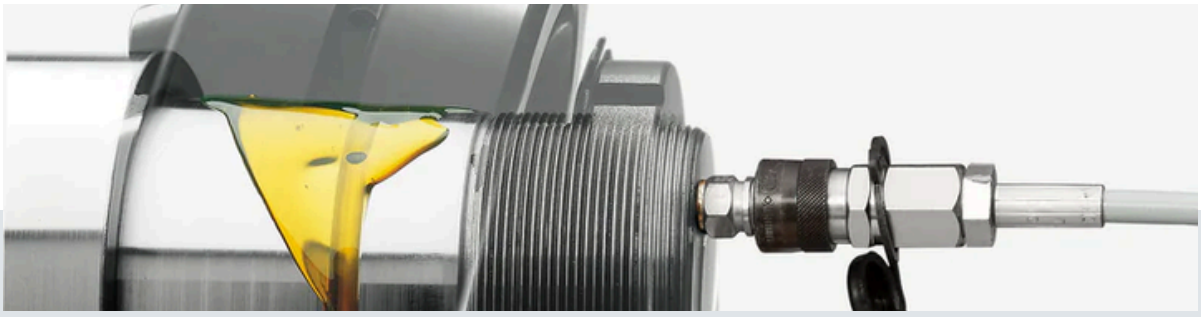


Hydraulic nut for dismounting an adapter sleeve mounted spherical roller bearing.
Adapter sleeves can be released with a hydraulic nut provided the bearing rests against an angular support ring. The nut should take support on a plate or the like figure beside.



Dismounting Of Hydraulic Method

- With the hydraulic method, oil is injected between the mating surfaces. The oil film greatly reduces the friction between the mating parts which can then be conveniently displaced in relation to one another without the risk of damaging the mating surfaces .
- The hydraulic method is suitable for dismounting bearings with tapered and cylindrical bore. In both cases, oil grooves, ducts and threaded connections for the pump must be provided. Larger adapter and withdrawal sleeves feature the corresponding grooves and holes.
- The incidence of fretting corrosion may render dismounting more difficult. In this case, a rust-dissolving hydraulic oil should be used, especially for bearings of long service. For a seized withdrawal sleeve, the extra force required to set it moving can be applied through the withdrawal nut. If the withdrawal nut features thrust bolts a plate or washer should be inserted between the bolts and the bearing, to avoid damaging the lips of the bearing ring.



4.4 Perform analysis on bearing damage.

4.4.1 Produce a check list of bearing damage maintenance, failure symptoms.

- When a bearing is used under ideal conditions, it should meet or exceed its predicted service life and will eventually be damage by rolling fatigue. Damage from rolling fatigue can occur prematurely if operating conditions are severe or the wrong bearing was selected for the application. However, as indicated by the following statements, the majority of premature bearing failures are caused by improper lubrication, bearing mounting and handling issues.
- If damage is found on a bearing during inspection, it is important to document the bearing's operation history properly to identify the causes, even if the damage is very small. Also, it is essential to examine not only the bearing but also the shaft, housing and lubricant.

Flaking

- Flaking is damage where material is removed in flakes from a surface layer of the bearing raceways or rolling elements due to rolling fatigue.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Flaking occur at an initial stage	• Too small internal clearance • Improper or insufficient lubricant • Excessive loading • rust	• Provide proper internal clearance • Select proper lubricating method or lubricant
Flaking on one side of radial bearing raceway	• An excessive large axial load	• Fitting between outer ring on the free side and housing should be changed to clearance fit.

Cracking / Chipping

- Usually referred to as spalling is a fracture of the running surfaces and subsequent removal of small discreate particles of material.

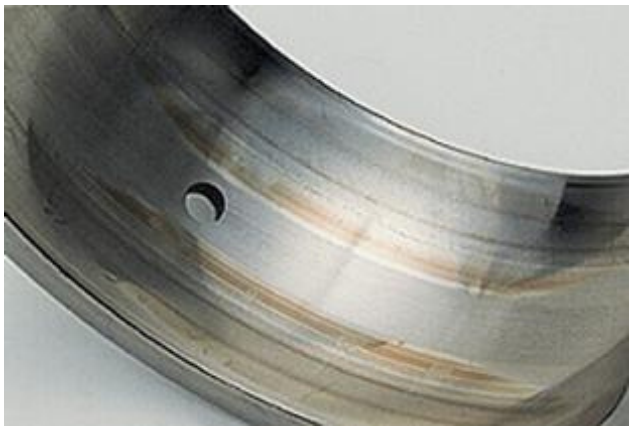
DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURE
Cracking on rolling elements	• Heavy impact load • Advanced flaking	• Improve mounting and handling procedure • Re-examine load conditions
Cracking on the rib	• Impact on rib during mounting • Excessive axial impact load	• Improve mounting procedure • Re-examine load conditions

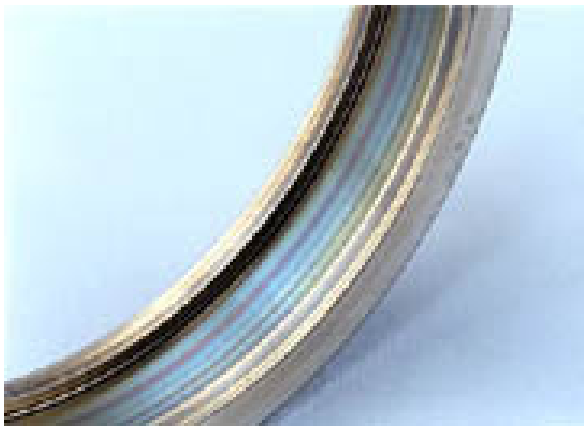
Brinelling , Nicks

- Brinelling is a small surface indentation generated either on the raceway through plastic deformation at the contact point between the raceway and rolling elements, or on the rolling surfaces from insertion of foreign matter, when heavy load is applied while the bearing is stationary or rotating at low rotation speed.
- Nicks are those indentations produced directly by rough handling as hammering.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Brinelling on the raceway or rolling contact surface	• Entry of foreign matter	• Clean bearing and its peripheral parts
Nicks on the raceway or rolling contact surface	• Careless handling	• Improve mounting and handling procedure

Pear Skin, Discoloration

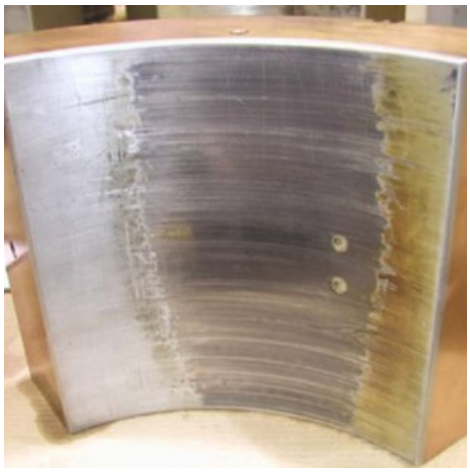




- Pear skin is damage which minute Brinell marks cover the entire rolling surfaces, caused by contamination.
- Discoloration is damage in which the surface color changes because of staining or heat generation during rotation. Color change caused by rust and corrosion.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURE
Indentation similar to pear skin on the raceway and rolling contact surface.	• Entry of minute foreign matter	• Clean the bearing and its surrounding parts. • Improve sealing device
Discoloration of the raceway, surface rolling contact surface, rib face, and cage riding land	• Too small bearing internal clearance • Improper or insufficient lubricant • Deterioration of lubricant due to aging	• Provide proper internal clearance • Select proper lubricating method • Amount and lubricant type

Scratch and Scuffing



- Scratch are relatively shallow marks generated by sliding contact, in the same direction as the sliding.
- Scuffing refers to marks, which are partially melted due to higher contact pressure and therefore a greater heat affect.

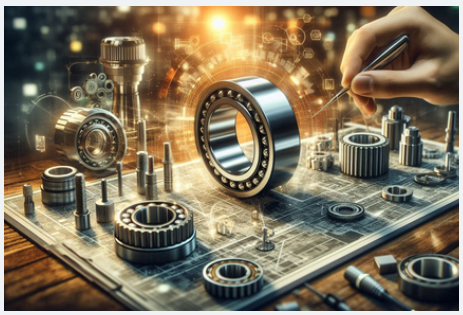
DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Scratches on raceway or rolling contact surface	• Insufficient lubricant during start-up • Careless handling	• Apply lubricant to the raceway and rolling contact surface when mounting • Improve mounting procedure
Scuffing on rib face and roller end face	• Improper or insufficient lubricant • Improper mounting • Excessive axial load	• Select proper lubricating method or lubricant • Correct centering of axial direction

Smearing

- Smearing is damage in which clusters of minute seizures cover the rolling contact surface. It caused by high temperature due to friction.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Smearing on raceway or rolling contact surface	• Improper or insufficient lubricant • Slipping of the rolling elements. This occurs due to break down of lubricant film when an abnormal self-rotation causes slip of the rolling elements on the raceway	• Select proper lubricating method or lubricant • Provide proper preload



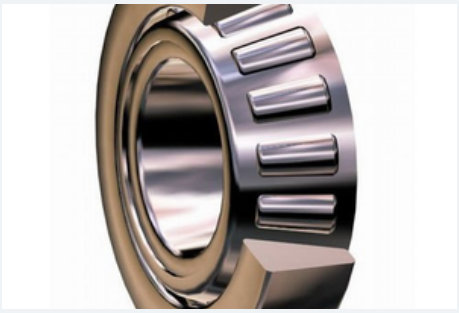


Rust, Corrosion

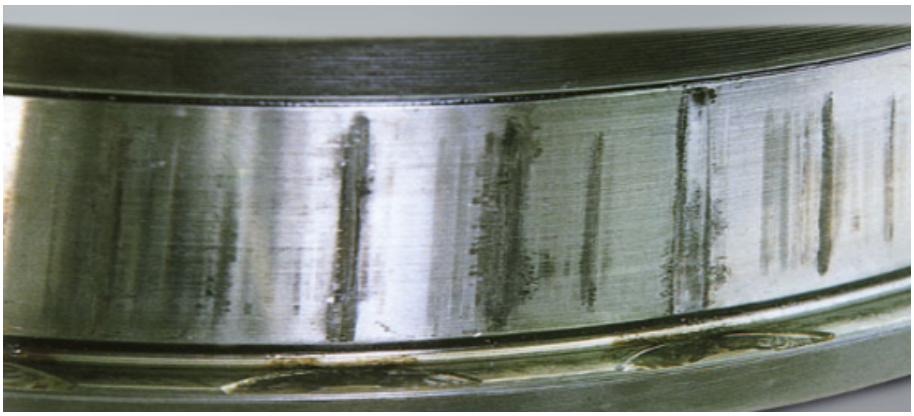

- Rust is a film oxides, or hydroxides, or carbonates formed on a metal surface due to chemical reaction.
- Corrosion is damage in which a metal surface is eroded by acid or alkali.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Rust partially or completely covering the bearing surface	• Improper storage condition • Condensation in atmosphere	• Bearing should be stored in dry area. • Improve sealing devices • Provides a preservative oil treatment before long cessation of operation
Rust and corrosion at the same interval as rolling element spacing	• Contamination by water or corrosive matter	• Improve sealing devices





Wear



- Wear is observed on sliding contact surfaces such as roller end faces and ribs faces, cage pockets and cage riding lands. It caused by foreign material and corrosion affect.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Wear on the contact surfaces (roller end faces, rib faces, cage pockets)	• Improper or insufficient lubricant	• Select proper lubricating method or lubricant • Improve sealing device • Clean the bearing and surrounding application component parts and housing
Wear on raceways and rolling contact surfaces	• Entry of contaminants • Improper or insufficient lubricant	



Fretting

- Fretting occurs to bearing which are subject to vibration while in stationery condition or which are exposed to slight axial movement.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Rust-colored wear particles generated on the fitting surface (fretting corrosion)	• Insufficient interference fit	• Provide greater interference fit • Apply lubricant to the fitting surfaces
Brinelling on the raceway surface at the same interval as rolling element spacing (false brinelling)	• Vibration and oscillation when bearings are stationary	• Improve fixing method of the shaft and housing • Provide means to insulate machine from vibration and movement • Provide preload to bearing

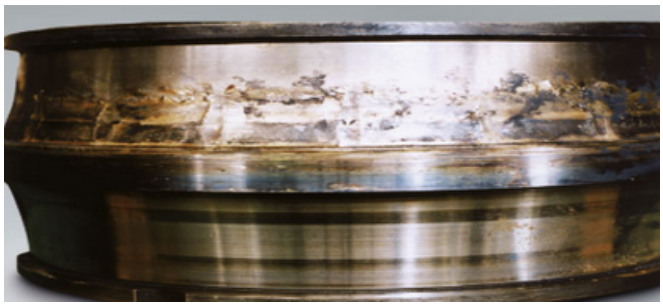


Creeping

- Creeping is phenomenon in which bearing rings move relative to the shaft or housing during operation.

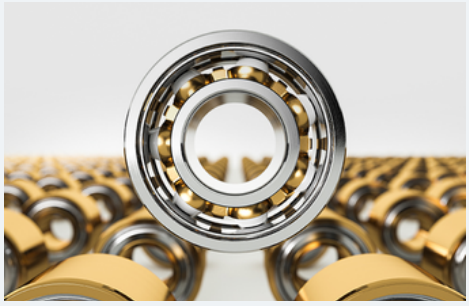
DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Wear, discoloration and scuffing, caused by slipping on the fitting surfaces	• Insufficient interference fit • Insufficient tightening of sleeve	• Provide greater interference fit • Proper tightening of sleeve

Seizure



- Seizure is damage caused by excessive heating in bearings.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Discoloration, distortion and melting together of bearing components	• Too small internal clearance • Improper or insufficient lubricant • Excessive load	• Provide proper internal clearance • Select proper lubricating method or lubricant • Re-examine bearing types • Review maintenance and re-lubrication schedule


Cage Damage

- Large chipping and cracks are often accompanied by deformation, which may reduce the accuracy of the cage itself and may prevent the smooth movement of rolling elements. The bearing raceways also should be examined for misalignment.

DAMAGE	POSSIBLE CAUSES	PREVENTIVE MEASURES
Flaws, distortion, chipping, cracking, and excessive wear in cages. Loose or damaged rivets.	• Considerable vibration, impact loading • Improper or insufficient lubricant • Improper mounting (misalignment) • Dents made during mounting • Rapid acceleration and very high speeds	• Re-examine load conditions • Select proper lubricating method or lubricant • Minimize mounting deviations and clearances • Re-examine cage types • Improve mounting



4.4.2 Record observations for preventive maintenance

a. Fatigue, vibration and wear

Symptoms:

- Pitting or flaking on the surface of bearing raceways or rolling elements.
- Increased noise and vibration during operation.
- Excessive wear causing loose fit or misalignment.

Causes:

- Prolonged usage beyond the bearing's design life.
- Excessive or uneven loads.
- Misalignment or shaft deflection.

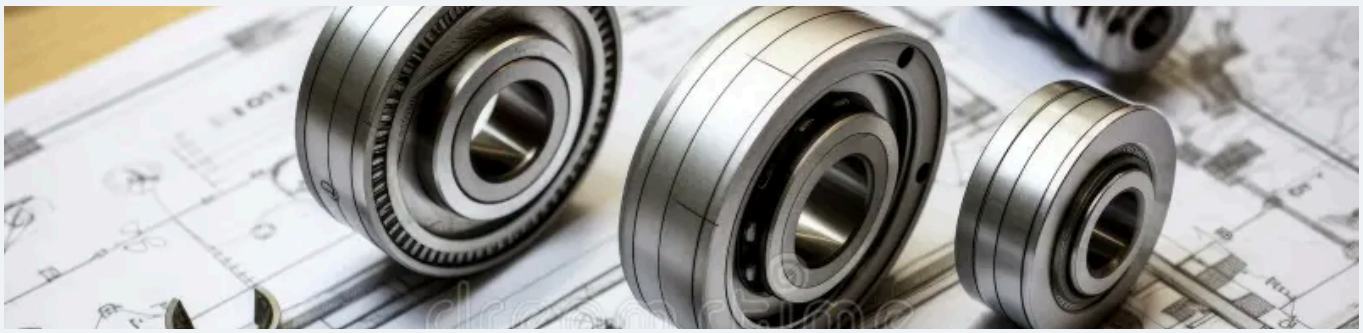
b. Corrosion damage

Symptoms:

- Rust or discoloration on bearing surfaces.
- Surface pitting caused by moisture or chemical exposure.
- Degraded performance and reduced load capacity.

Causes:

- Exposure to water, humidity, or aggressive chemicals.
- Poor sealing or storage conditions.
- Contaminated lubricant.



c. Scuffing and sliding mark

Symptoms:

- Scratches or smearing on the bearing raceways or rolling elements.
- Discoloration due to heat generation from friction.
- Rough operation or binding in movement.

Causes:

- Inadequate lubrication leading to metal-to-metal contact.
- High-speed operation without appropriate lubrication.
- Overloading during use.

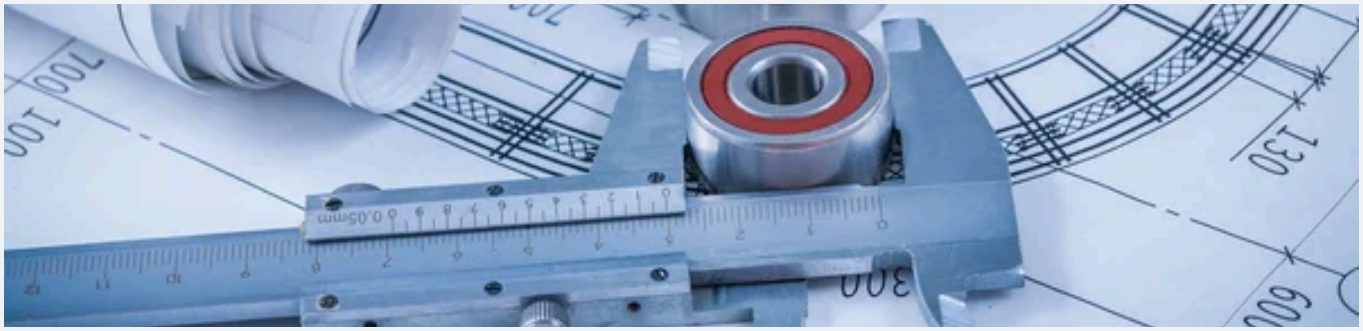
d. Local indentations the raceway

Symptoms:

- Visible dents or depressions on the raceways.
- Noise and vibration during operation.
- Increased localized stress causing early failure.

Causes:

- Foreign particles trapped inside the bearing.
- Impact during mounting or operation.
- Mishandling during installation or maintenance.



e. Faulty mounting and defective installation method

Symptoms:

- Uneven loading and premature wear.
- Loose or excessively tight fit causing distortion.
- Misaligned bearings leading to additional stress.

Causes:

- Improper installation tools or techniques.
- Non-standard or defective components.
- Failure to follow manufacturer’s guidelines.

f. Poor lubrication and fault in design

Symptoms:

- Dry or insufficient lubrication observed during inspection.
- High operating temperature and thermal damage.
- Excessive wear and reduced lifespan.

Causes:

- Using incorrect or contaminated lubricant.
- Inadequate lubrication intervals.
- Design flaws that lead to improper load distribution or insufficient cooling.

4.4.3 Produce Bearing Maintenance Procedures

For properly identifying the cause of bearing damage in an application, the following procedure and investigation is recommended.

1. Handle with care

- Bearings are delicate enough to get damaged quickly

2. Check the bearing housing and shaft

- Always use a soft cloth to wipe the surfaces clean and make sure any nicks and burrs are removed.

3. Mount the bearings correctly

- For example, bearings with cylindrical bores are generally mounted through a press fit method.

4. Avoid preheating or overheating

- If they are heated above the permitted limit, they can permanently deform or soften the bearing steel, lowering load carrying capacity and resulting in a failure.

5. Always use the proper tools

- Specialized tools like bearing pullers, bearing fitting tool kits, oil injector kits, hydraulic nuts, or induction heaters should be used in the mounting and dismounting processes

6. Avoid corrosion

- It is crucial that you should not expose bearings to the presence of water for a long time, as it will lead to rust and corrosion

7. Proper lubrication

- The correct lubricant depends on the environmental conditions, temperature, speed and load

4.5 Explain the bearing failures, diagnosis and troubleshooting.

4.5.1 Diagnose the bearing failures.

- A bearing failure occurs when the bearing fails to meet their expected life or performance levels, often causing a machine shaft to fail, and the machine it is apart of can break down. The consequences of bearing failure are far-reaching for your facility

Abnormal Bearing Temperature

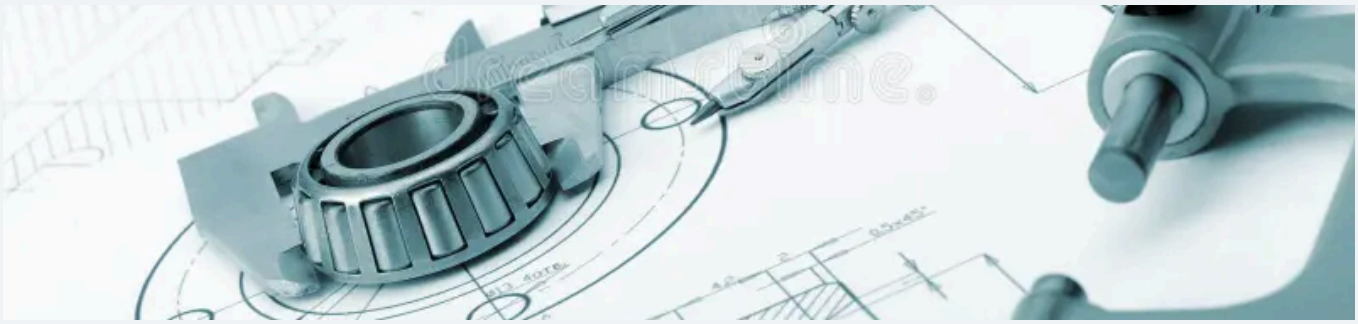
- In a caution condition, the bearing temperature may be between 180 and 200 degrees F
- Other factors that can cause higher temperatures include increased bearing friction (poor lubrication, high load, high speed, etc.), excessive lubrication (grease overpressure), high oil level (oil churn) and misalignment.

Noise Of Rotating

- The excess noise that you're hearing is created when the raceways of the bearing have become damaged, causing the rolling elements to bounce or rattle during rotation.

Vibration Of Rotating Bearing - wear and tear of bearing material

- The variation of the contact deformation between the ball and the raceway when the ball passes over a defect causes a sudden change in the contact force, which causes periodic vibration of the bearing.



4.5.2 Diagnose And Troubleshoot The Bearing Failure Above

Proper Mounting and Alignment of Bearings Matters

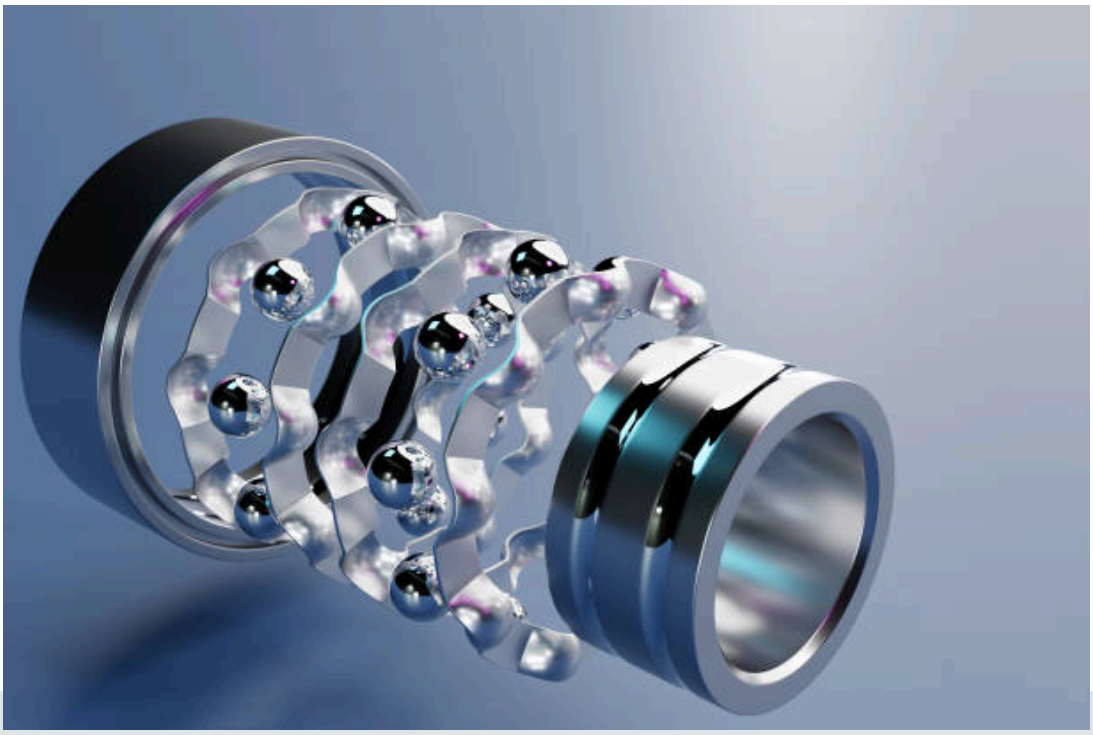
- It's imperative that the proper tools, ovens, and induction heaters are used during the mounting and installation process of bearings.
- Be considerate of avoiding misalignment or shaft deflection, as this is significant in mounting bearings with separate parts. Without proper alignment between components, the bearings will end up experiencing abnormal wear.

Lubricate According to Manufacturers' Guidelines

- Lubrication is used on bearings to cover the rolling completely and sliding surfaces with a thin oil film to prevent metal-to-metal contact.
- Grease is more commonly used because it's easy to handle, while oil lubrication is frequently used with high-temperature or high-speed applications.
- Common lubrication failures occur due to:
    1. Using the incorrect type of lubricant
    2. Too little grease/oil or too much grease/oil
    3. Mixing grease/oil
    4. Contaminating the grease/oil by objects or water

Prevent Operational Stress

- Operational stress on a bearing can impact bearing life.
  - If the load is too low on a bearing, it will result in skidding and improper loading of the rolling elements.
  - If the load is too high, it could result in overloading and early fatigue.
- Normally, the first sign of issues like these is unusual noises and/or elevated temperatures. The desirable bearing temperature is somewhere below 100 degrees Celsius.



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