Machine Design –II

Bearings

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Bearing Overview

- Introduction .
- Components of bearings.
- Classifications of bearings .
- Difference between rolling & sliding contact .
- Lubrication in journal bearing.
- Difference between hydrostatic & hydrodynamic lubrication.
- Thermal consideration in journal bearing .
- Material used for sliding contact bearing .
- Design procedure of journal bearing .
- Advantage of rolling contact bearing .
- Static load capacity & dynamic load capacity of rolling contact bearing .
- Life of bearing .
- Bearing Designation .
- Selection procedure for rolling contact bearing from catalogue.
- Designation of ball bearing .
- Failure of rolling contact bearing

Bearing

A Bearing is a device that support load and reduces the friction of motion between moving machine parts.

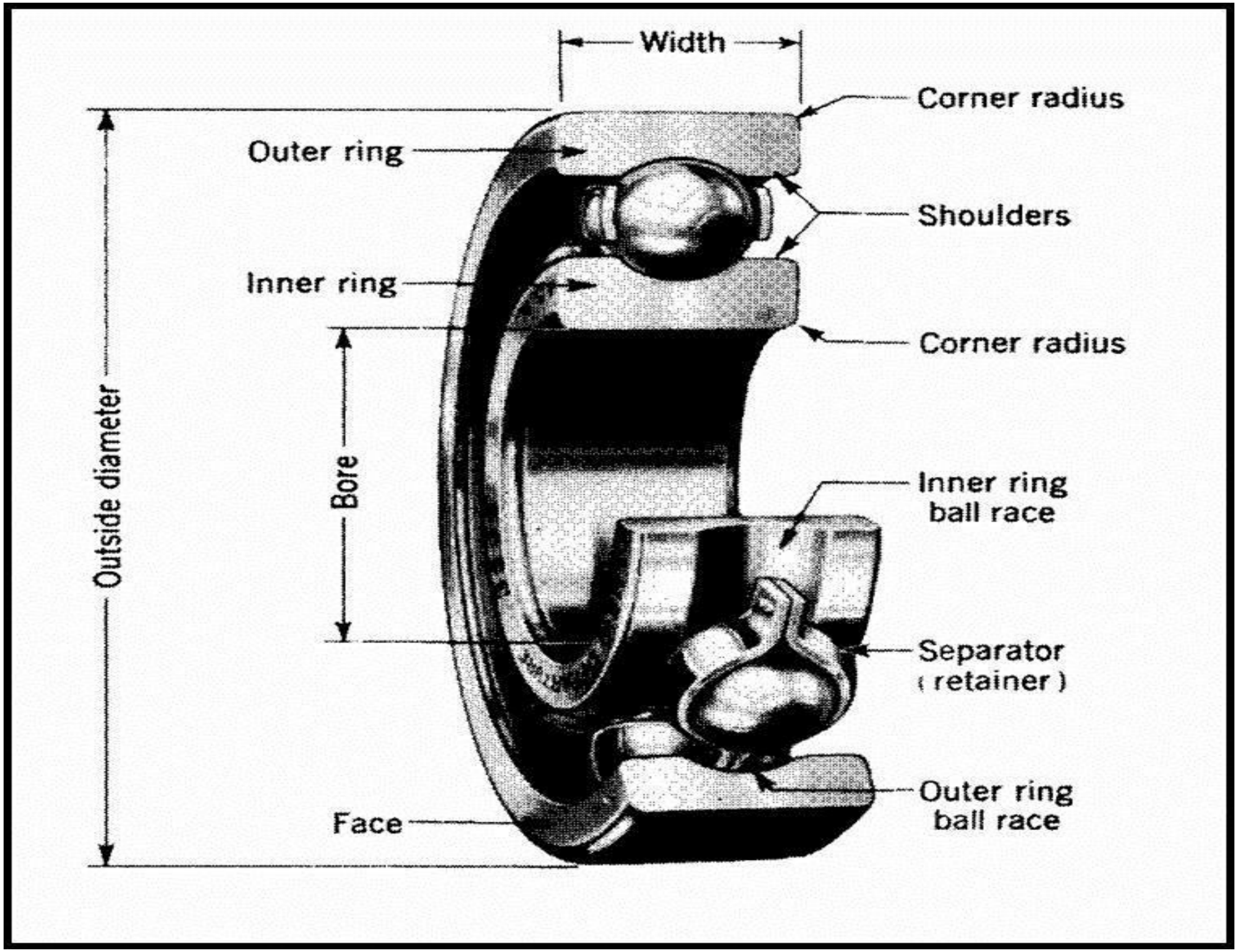
Bearing Function.

1. Bear load

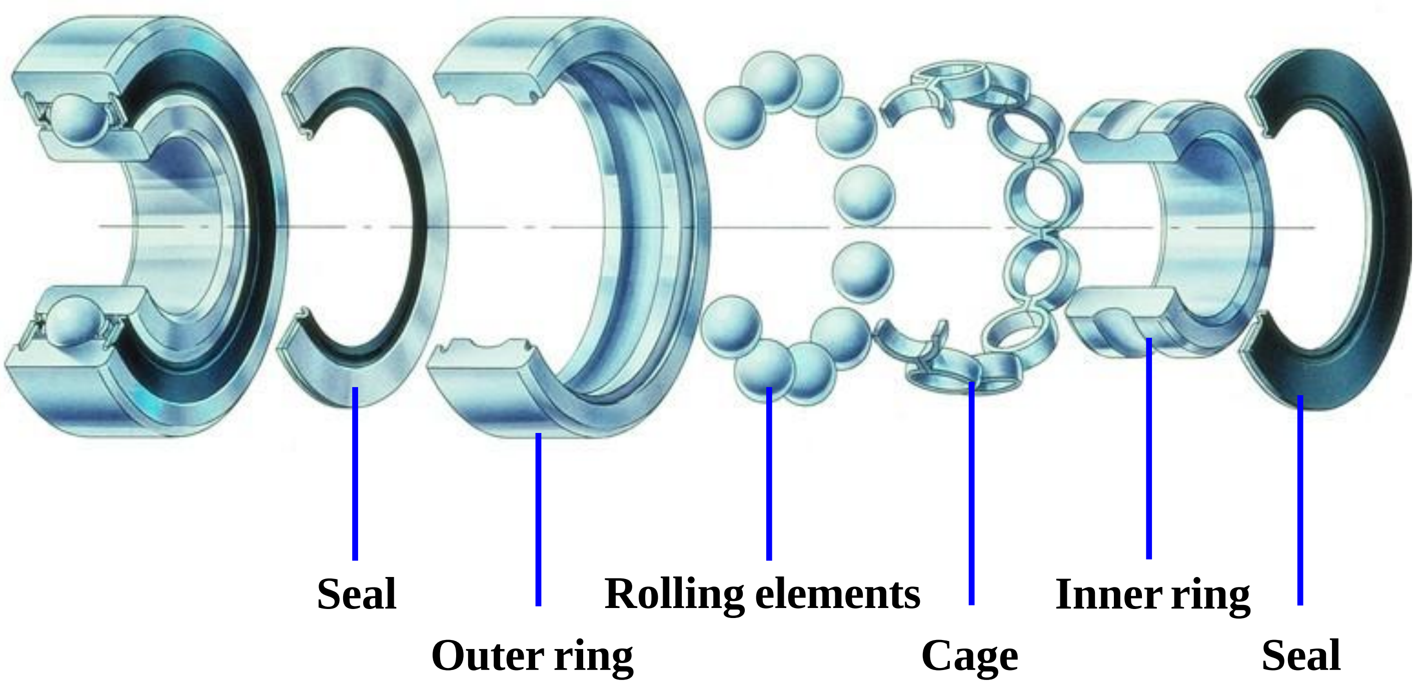
2. Guide moving parts (in linear or rotary direction)

3. Reduce friction

Components of Bearing



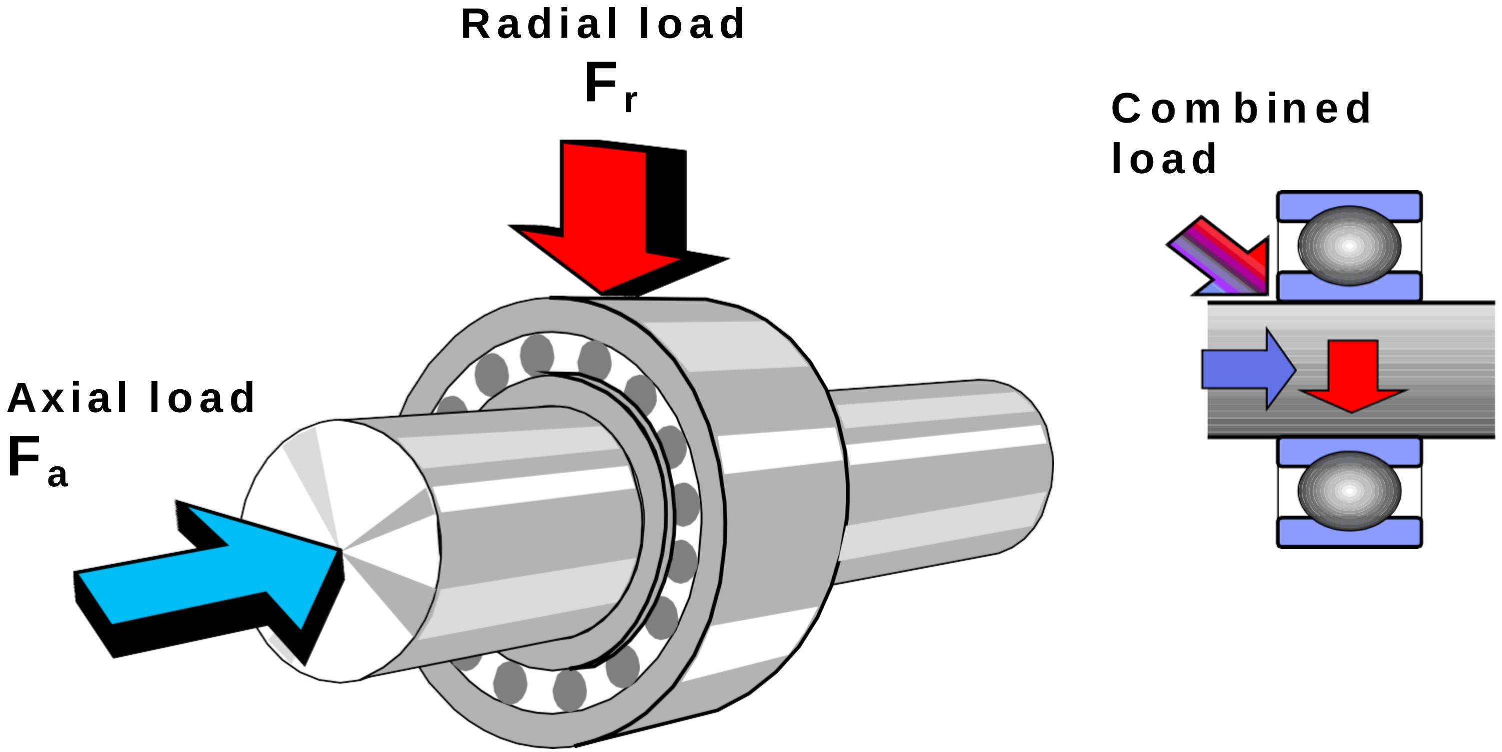
Components of Bearing



Classification of Bearing

According to Load Applied
Thrust bearings (Axial bearing)- load acts along the axis of rotation .

Radial bearing- load acts perpendicular to the axis of rotation

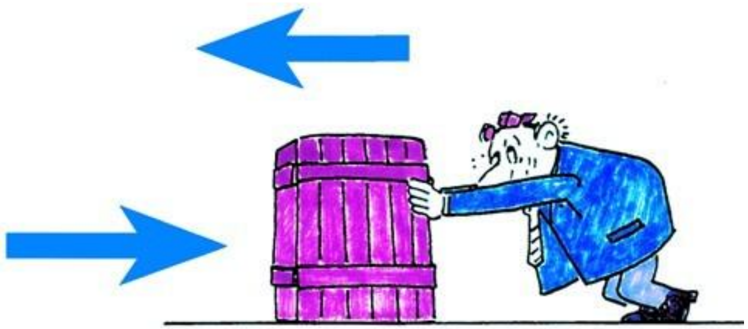


Classification of Bearing

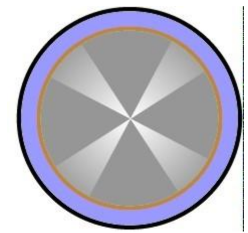
According to contact between parts

Sliding contact (Plain)

Rolling contact (Anti friction)

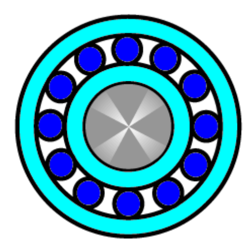


Plain bearings sliding



μ

Rolling bearings rolling friction



μ

Classification of Bearing

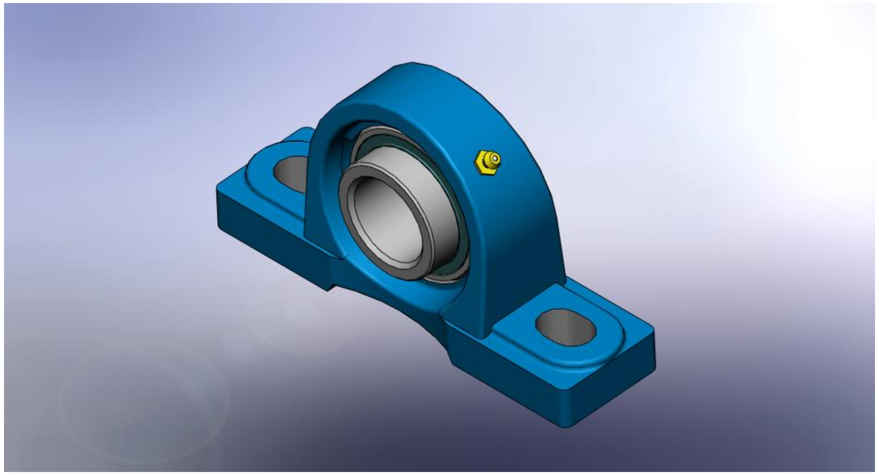
Sliding Contact bearings **or** Journal bearing **or** Plain bearing

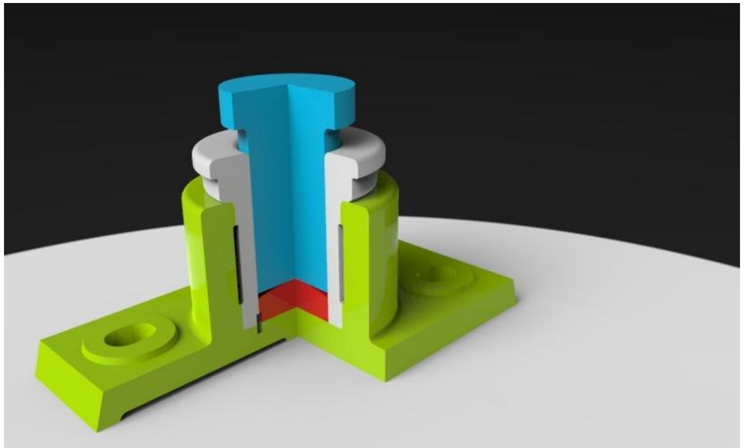
- Full Journal bearing
- Partial Journal bearing
- Fitted bearing

Classification of Bearing

Sliding Contact bearings **or** Journal bearing **or** Plain bearing

- Footstep bearing
- collor bearing



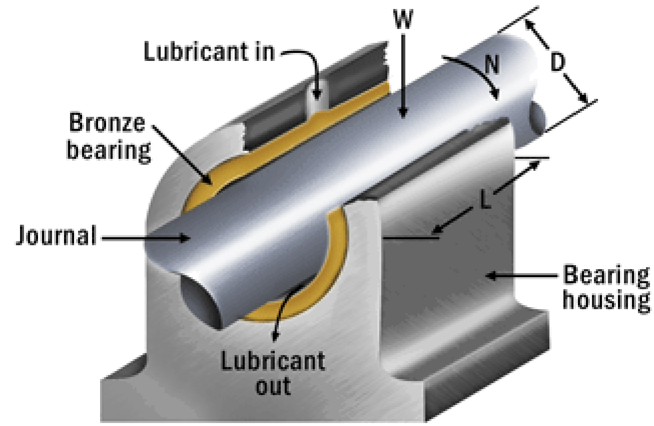


Lubrication of sliding bearing

Sliding Contact bearings **or** Journal bearing **or** Plain bearing

- Thick film (hydrodynamic)
- Thin film
- zero film

- Hydrostatic lubricated .



Lubrication of sliding bearing

Lubricants
Liquid – oil having more viscosity
semi liquid -grease
solid – graphite

Function
- reduce friction
- carry away heat generated

Properties of lubrication
-viscosity
-viscosity index
-flash point
-fire point
-Density

Terms in hydrodynamic bearing

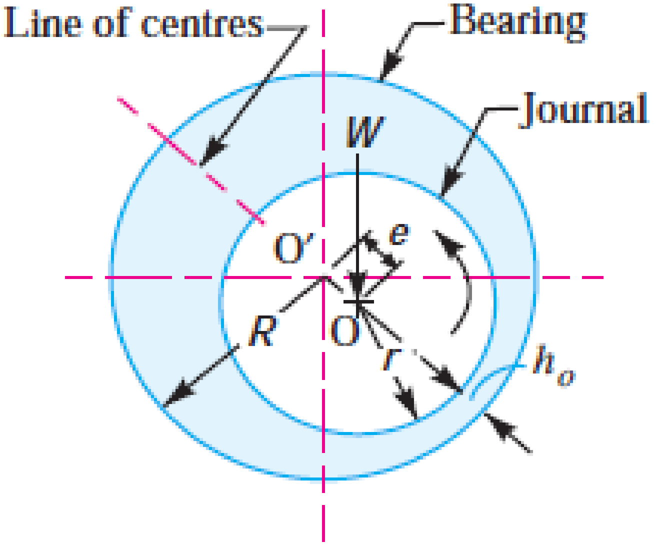
Diametral Clearance

Radial clearance

Eccentricity

Short or long bearing (L/D)

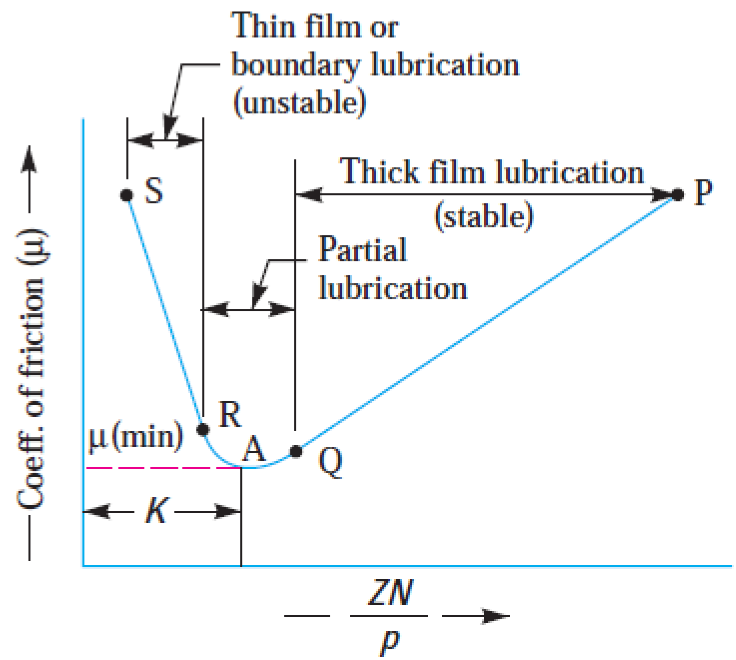
Minimum oil film thickness (c/4)



Bearing Characteristic Number & Bearing module

Coefficient of friction depend on
Bearing Charateristic number
Bearing module

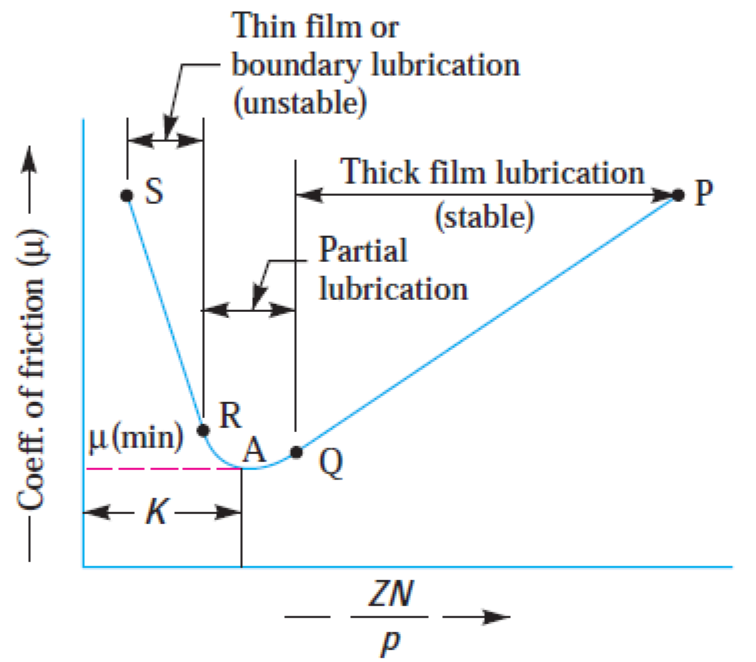
Z= absolute viscocity
p = Max bearing pressure
N = rpm
d = dia of journal
c = Diametral clearance
V= rubbing velocity
Heat geneated (H) = μ.W.V
W= load on bearing



Thermal consideration in sliding bearing

Coefficient of friction
depend on
Bearing Characteristic number
Bearing module

Z= absolute viscosity
p = Max bearing pressure
N = rpm
d = dia of journal
c = Diametral clearance
V= rubbing velocity
Heat generated (Q) = μ.W.V
W= load on bearing



Design procedure For Journal Bearing

Steps

1. Assume Diameter & Determine bearing length from Design Data book (Design values for Journal bearing)

2. check the bearing pressure . p = W/l.d . (Safe or not)

3. Assume lubricant from design data

4.Determine value of ZN/p

V = Rubbing velocity in m/s $= \frac{\pi d . N}{60}$, d is in metres, and

N = Speed of the journal in r.p.m.

5. Assume c/d

6.calculate $\mu = \frac{33}{10^8}\left(\frac{ZN}{p}\right)\left(\frac{d}{c}\right) + k$

7. Calculate heat generated (Qg): $Q_g = \mu . W . V$

8. Calculate heat dissipated (Qd)= $Q_d = C . A \, (t_b - t_a)$ J/s or W

9. check weather external cooling is required or not

Numerical for sliding contact bearing

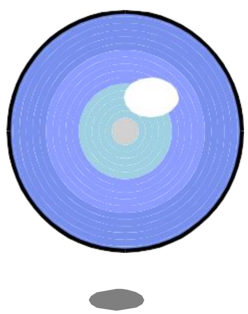
10. The load on the journal bearing is 150 kN due to turbine shaft of 300 mm diameter running at 1800 r.p.m. Determine the following :
Length of the bearing if the allowable bearing pressure is 1.6 N/mm^2, and
Amount of heat to be removed by the lubricant per minute if the bearing temperature is 60°C and viscosity of the oil at 60°C is 0.02 kg/m-s and the bearing clearance is 0.25 mm.

11. A 80 mm long journal bearing supports a load of 2800 N on a 50 mm diameter shaft. The bearing has a radial clearance of 0.05 mm and the viscosity of the oil is 0.021 kg / m-s at the operating temperature. If the bearing is capable of dissipating 80 J/s, determine the maximum safe speed.

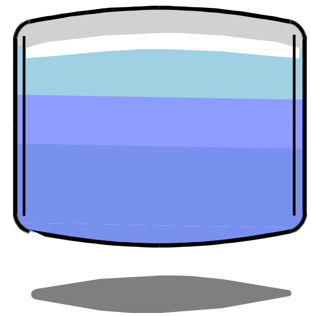
Classification of Bearing

Rolling contact (Anti friction)

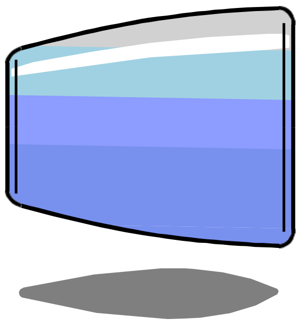
Ball



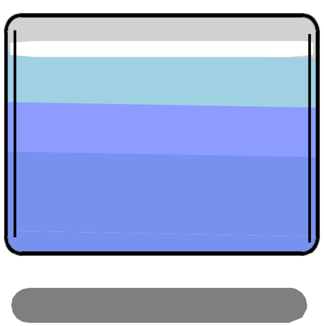
Spherical roller (symmetrical)



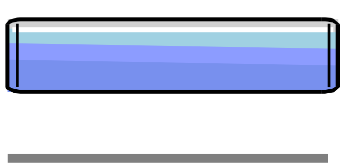
Spherical roller (asymmetrical)



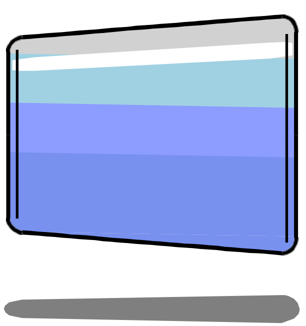
Cylindrical roller



Needle roller



Taper roller



Classification of Bearing

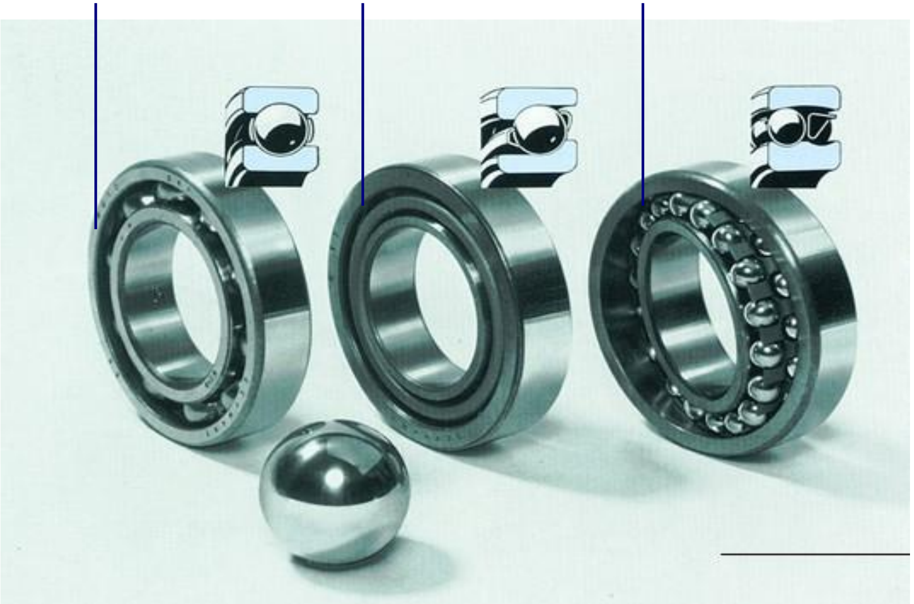
Radial rolling bearings

Ball bearings + **Roller bearings**

Deep groove ball bearing

Angular contact ball bearing

Self-aligning ball bearing



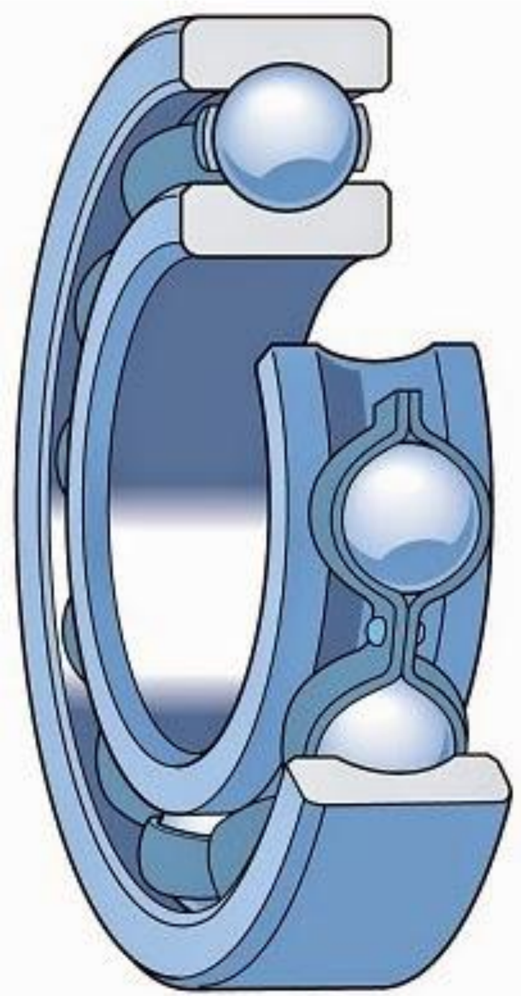
Cylindrical roller bearing

Taper roller bearing

Needle roller bearing

Spherical roller bearing

Classification of Bearing



Deep groove ball bearing

Radial + axial

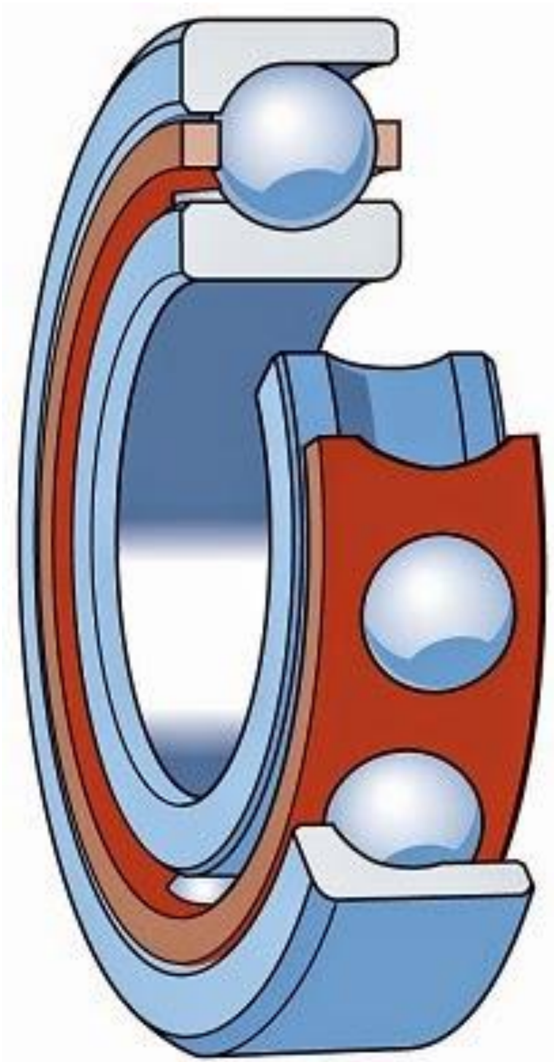
High load carrying capacity

Less noise

Not self alignment

Fail under miss allignment

Classification of Bearing

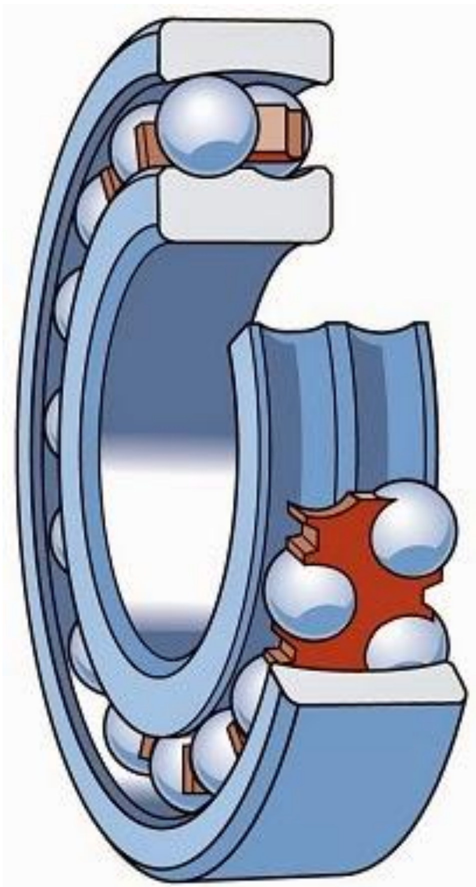


Angular contact

Radial + axial

High load carrying capacity then deep groove ball bearing

Classification of Bearing



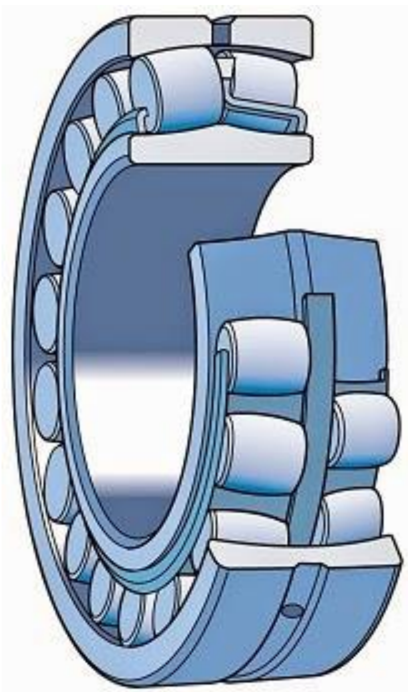
Self aligning

Radial + axial

High load carrying capacity

Less noise

Classification of Bearing



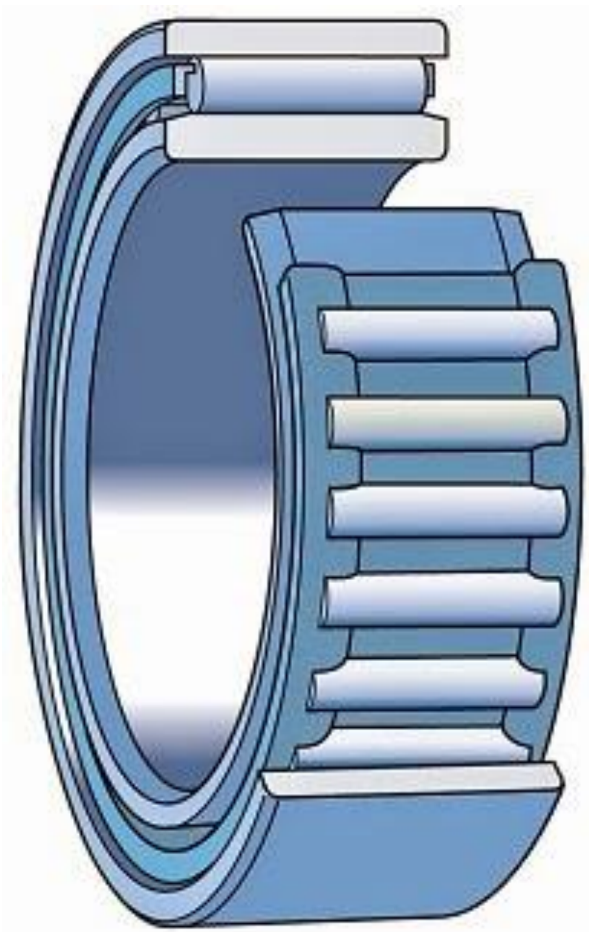
Spherical roller

Large Radial + large axial

High load carrying capacity then deep groove ball bearing

Can tolerate miss alignment

Classification of Bearing



Needle roller

Less space

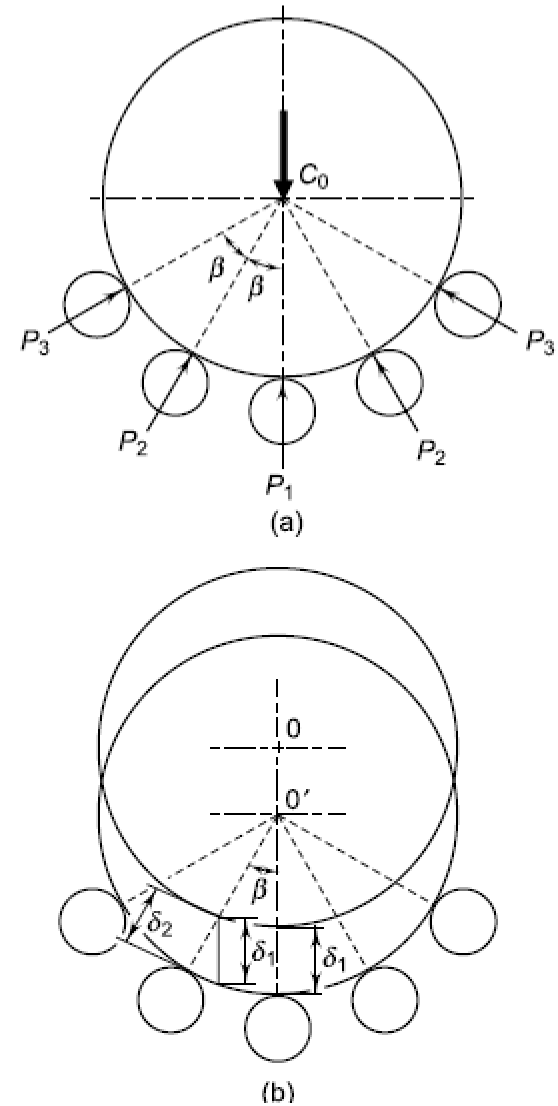
Exellent radial load capacity

Static load capacity (C_0)of roller contact bearing

Load acting on bearing when shaft is stationary

Given by stribeck's equation .

$$C_o = \frac{kd^2 z}{5}$$



Dynamic load capacity (C) of roller contact bearing & life of bearing

Number of revolution before actual evidence of crack in rolling element or Race under fatigue load .

$$L_{10} = \left(\frac{C}{P}\right)^p$$

Minimum Life / Life Rating /catalogue life

where,

L_{10} = rated bearing life (in million rev

C = dynamic load capacity (N), and

p = 3 (for ball bearings)

p = 10/3 (for roller bearings)

B_{10} or L_{10},

$$L_{10} = \left(\frac{C}{P}\right)^p$$

Or number of hours for given constant speed under fatigue load for one million revolutions .

$L_{10\,h}$

$$L_{10} = \frac{60 n L_{10h}}{10^6}$$

Selection of rolling contact bearing from catalogue

1. Calculate Radial & axial Load

$$P = XVF_r + YF_a$$

$P =$ equivalent dynamic load (N)
$F_r =$ radial load (N)
$F_a =$ axial or thrust load (N)
$V =$ race-rotation factor

2. Determine X & Y from data book depends on (F_a /F_r) & (F_a /C_0) for light duty first by assuming values of X & Y .

3. Determine dynamic load carrying capacity

4. Selection of bearing from data book

Selection of rolling contact bearing from catalogue

14. A single-row deep groove ball bearing is subjected to a pure radial force of 3 kN from a shaft that rotates at 600 rpm. The expected life L10h of the bearing is 30 000 h. The minimum acceptable diameter of the shaft is 40 mm. Select a suitable ball bearing for this application.

15. A single-row deep groove ball bearing is subjected to a radial force of 8 kN and a thrust force of 3 kN. The shaft rotates at 1200 rpm. The expected life L10h of the bearing is 20000 h. The minimum acceptable diameter of the shaft is 75 mm. Select a suitable ball bearing for this application.

16. A single-row deep groove ball bearing No. 6002 is subjected to an axial thrust of 1000 N and a radial load of 2200 N. Find the expected life that 50% of the bearings will complete under this condition.

1. Calculate Radial & axial Load

Bearing Designation for Ball bearing

Always read from Right to left .

1st & 2nd Digit multiply by 5 gives you ID of bearing

3rd digit : 1 – Extra light duty use
2- light duty use
3- medium duty use
4- heavy duty use

4th & or 5th digit : type of bearing

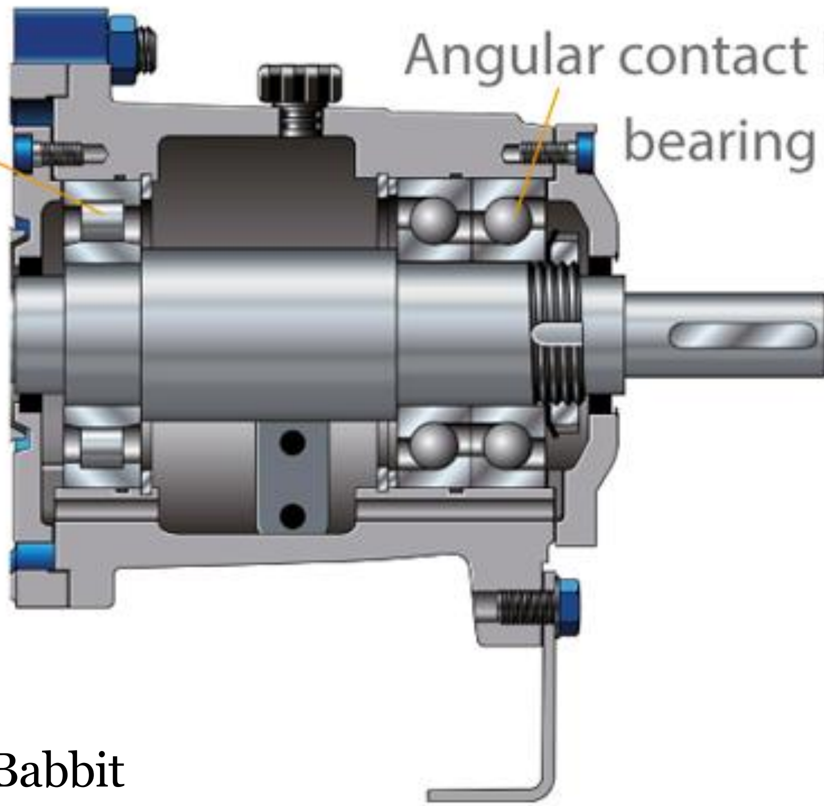
number 6 indicates – deep groove ball bearing

Example : 6211 Deep groove ball bearing for light duty use having 55 mm ID.

Bearing Applications & Material

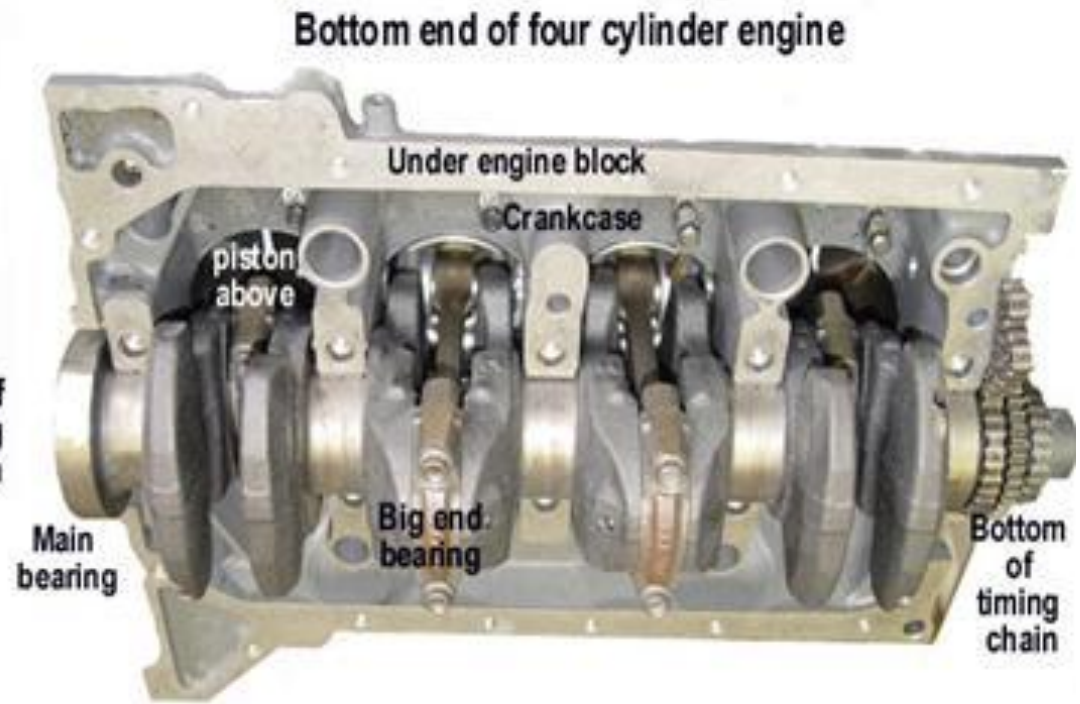
Grade 90 Babbit

Bearing Applications & Material



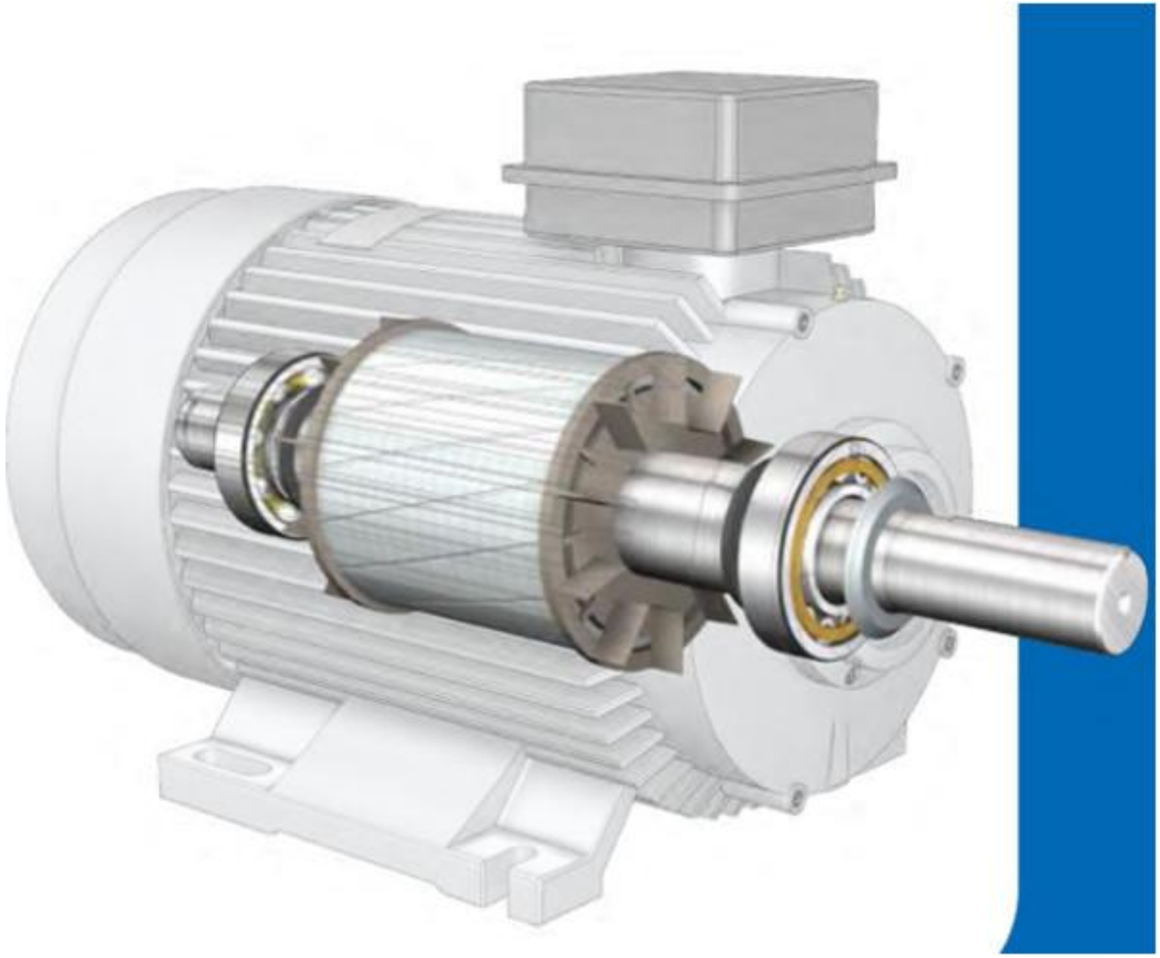
Grade 75 Babbit

Bearing Applications & Material



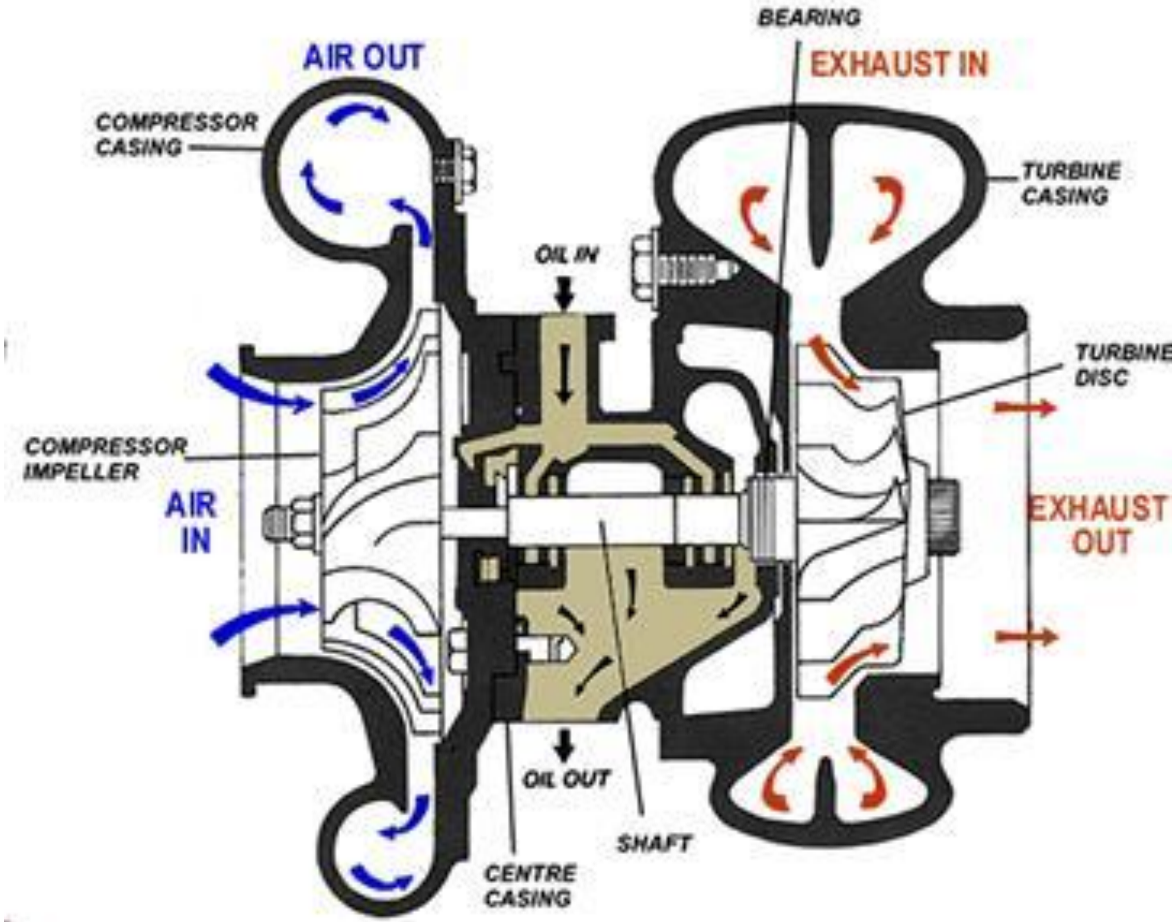
Grade 90 Babbit

Bearing Applications & Material



Grade 60 Babbit

Bearing Applications & Material



Bearing Applications & Material

Material Properties :

Do not stick with each other (metal to metal contact)
High compressive strength
Conformability
Embedddability
Corrosion resistance
Least cost

Materials used in bearing
Babbit (white metal) (alloy – lead and tin)
Bronze
Copper
Aluminum alloys

Bearing Failures

Scoring ,

Pitting

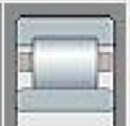
Abrasive wear

Corrosion

Distortion

Miss alignments

The table compares the performance of different bearing types with regard to load, accuracy, speed, noise and friction.

Bearing type		Radial load	Axial load	Compensation of misalignment	Accuracy	High speed	Low noise	Low friction
Deep groove ball bearing		Good	Normal	Normal	Normal	Very good	Very good	Very good
Single row angular contact ball bearing		Good	Good (in one direction)	Unsuitable	Normal	Very good	Good	Good
Spindle bearing		Good	Good (in one direction)	Unsuitable	Very good	Very good	Very good	Very good
Cylindrical roller bearing with cage		Very good	Unsuitable ... good *)	Sufficient	Good	Good	Sufficient	Good
Tapered roller bearing		Very good	Very good (in one direction)	Sufficient	Sufficient	Normal	Good	Good
Spherical roller bearing		Very good	Good	Very good	Unsuitable	Normal	Sufficient	Good
Axial spherical roller bearing		Sufficient	Very good (in one direction)	Very good	Unsuitable	Good	Sufficient	Unsuitable
Plain bearing		Very good	Sufficient	Normal	Sufficient	Good	Normal	Sufficient

***) N and NU design: Unsuitable, NUP design: Good, NJ design: Good (in one direction)**