White Paper

Bearing Lubrication

- **Lubrication of Rolling Bearings**

One of the most important requirements for effective function of bearing arrangements is proper lubrication.

The lubricant forms the layer between metallic bearing surfaces and thus reduces friction among the surfaces, also it acts as a barrier against entry and reach of contaminations or impurities to bearing raceways protects the steel parts. For each of these reasons the lubrication fulfils a key function in each bearing application. A malfunction of the lubrication usually causes an immediate failure of bearing.

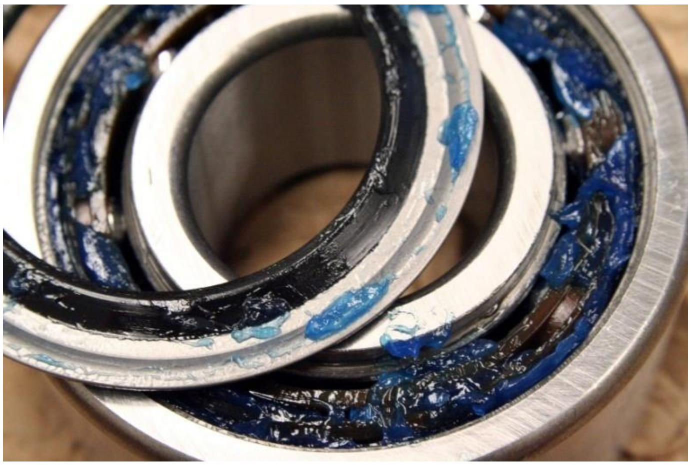
- **Basic Function of Lubrication:**

  - Reduce the friction between contact surface of bearing components
  - Reduce wear of bearing components
  - Carry away heat generated in the bearing due to friction and other causes
  - Prolong bearing life by covering rolling contact surfaces with proper oil film
  - Prevent corrosion and contamination

- **Methods of Lubrication**

Normally three different lubrication methods are used:

a) Grease lubrication
b) Oil lubrication
c) Solid and dry lubrication



- **Grease Lubrication**

In various types of bearings categories 90% of the bearings are grease lubricated.

The main advantages of grease lubricating are:

a) Very simple in application
b) Less maintenance required
c) Additional sealing effect
d) Pre-greased sealed or shielded bearing
e) Simple sealing of bearing positions
f) Large number of different lubricants available
g) Greased “for-life” bearing arrangements possible.

- **Oil Lubrication**

Oil lubrication is generally used when oil is available normally within the respective machine, or where special operating conditions apply (e.g. high speeds and/or loads) that require effective heat dissipation at specific positions or areas.

In some high speed applications accurate applied lubrication to specific areas (e.g. guiding surfaces of cages) may be necessary. The disadvantage of oil lubrication is the relatively high effort required to provide an effective and efficient seal at each bearing position.

- **Solid and Dry Lubrication**

Where applications do not allow the use of oil or grease lubrication for various reasons, other materials, including some metals that are suitable in separating the surfaces of bearings components under contact.

Graphite
- Used as a powder or press formed as a cage.

Molybdenum disulphide (MoS2)
- in the form of powders, with additives.

Polytetraflourethylene (PTFE)
- in the form of powders, with additives.

Metallic coatings
These are usually very thin coatings applied by a galvanizing process (e.g. extremely thin layers of gold or silver). Such metallic coatings are used for example where bearings run under vacuum, i.e. X-ray equipment or other special applications.

Sliding varnish
A solid lubricant in the form of fine powder is dissolved in a suitable solvent or other medium. After applying the mixture, the solvent will vaporize leaving the solid lubricant as a fine film on the surfaces.

Surface treatments
Such surface treatments are usually applied as a protective measure against corrosion, in addition to the normal lubrication, where bearings are exposed to extreme conditions. The most commonly used surface treatment for rolling bearings is bonderizing.

- **Selection of Lubricating Method**

The lubricating method to be used for a particular application is always dependent on individual operating conditions, including the anticipated operating speeds, temperature range and environment. Therefore, decision to select the most suitable lubricating method to be used for any application should be made at the early stage of design as this has an influence on the design of adjacent parts.

- **Significant Values of Lubricants**

  - **Viscosity**

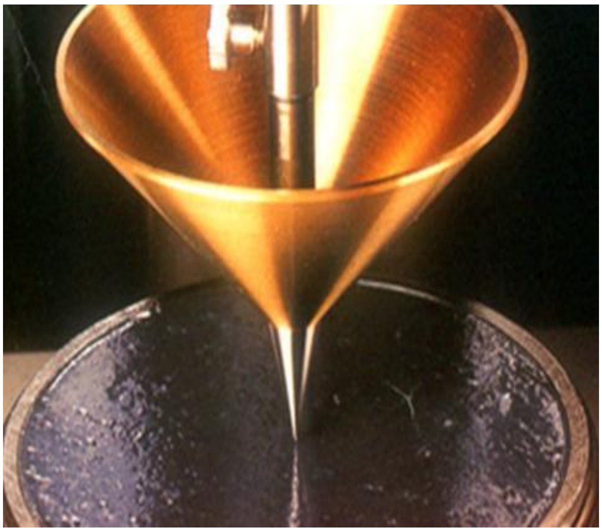
Viscosity indicates the individual layers flowing characteristics of a liquid when in motion. It is one of the most important features when selecting oils. In the case of lubricating greases the viscosity of each base - oil is indicated.

In principle, distinction is made between the nominal viscosity of a lubricant which is a specific reference value and the operating viscosity that results under given operating conditions at the bearings operating temperature.

Because the viscosity of a lubricant is highly dependent on its actual temperature, the nominal viscosity is always indicated together with a defined reference temperature. Usually the indicated nominal viscosity refers to 40°C ,sometimes other reference temperatures are also stated, such as (ʋ 50) or (ʋ100).

  - **Consistency**

The grade of consistency indicates the “stiffness” of grease to defined NLGI-scales according to ASTM D217. Very soft greases, used for high speeds, have low NLGI-grades; stiffer greases have higher NLGI-grades.



For lubricating rolling bearings a grease lubrication to NGLI scales 2 and 3 is normal, occasionally, grease to scales 0 and 1 are also used.

NLGI classes consistence grade (DIN 51818)	Worked penetration [0.1 mm]
000	445 to 475
00	400 to 430
0	355 to 385
1	310 to 340
2	265 to 295
3	220 to 250
4	175 to 205
5	130 to 160
16	85 to 115

Table 5.1 NLGI class consistence grade

- **Amount of lubricant in the bearing**
  - **Forced lubrication**

When bearing runs at high speed, the rolling friction of bearing and churning of lubricant causes heat generation; effecting substantial temperature rise. Forced removal or dissipation of such heat prevents overheating of bearing at great extent. Presence of lubrication film ensures stable and continuous operation of bearing at high speed.

Forced removal of heat is done by forcing large amount of lubricating oil to circulate inside the bearing. In this case amount of lubricant supplied is mostly determined on the basis of actual operating conditions. Important factor to be considered includes the allowable temperature of the system, radiation effect and heat generation caused by oil stirring.

Following empirical equation can be used to estimate the amount of forced lubrication to be circulated.

Q = {0.19x10^ (-6)} d μ n F / (T2 – T1)

$$Q = \{0.19 \times 10^{-6}\}\, d\, \mu\, n\, F / (T2 - T1)$$

Q = Oil supply (ltr/min)
T1 = Oil temperature (C°) at inlet
T2 =Oil temperature (C°) at outlet
d = Bearing bore (mm)
μ = Coefficient of dynamic friction
n = Bearing limiting speed (rpm); F = Load on bearing (N)

Calculated amount of lubricant's flow using above equation is only a guide line and it may vary/ can be modified on account of resistance and inlet / outlet bore.

Bearing Type	Approximate Value of (μ)
Deep Groove Ball Bearing	0.0013
Angular contact Ball Bearing	0.0015
Self-aligning Ball Bearing	0.0010
Thrust ball bearing	0.0011
Cylindrical Roller Bearing	0.0010
Tapered Roller Bearing	0.0022
Spherical Roller Bearing	0.0028
Needle roller Bearings with cage	0.0015
Full Compliment Needle Roller Bearing	0.0025
Spherical Thrust Roller Bearing	0.0028

Table 5.2 Value of friction coefficient for different bearings types

- **Spindle bearing for machine tools and grease filling amount**

Recent trends show the advanced development in the speeds of the spindles of the various machines centers and lathes. The increased machined speed has increased machining efficiency and the accuracy of the machining surfaces. But, the adverse effect of the increased speed has caused increased in the temperature of the spindle which has affected the machining accuracy and efficiency of the spindle.

The spindle bearings having bore 150 mm and less are mostly grease lubricated. The proper amount of the grease should be filled in the bearings, if more amount of grease is filled than required it might adversely affect the performance of the bearing leading to excessive heat generation in the bearing. Excessive filling of the grease may even result in the deterioration of the grease. The spindle bearing needs to be accelerated gradually during its initial operation.

V_{10}= f ×10–5 (D_2–d_2) B

Where, V10: Approximate filling amount (cm3)

D: Nominal outside diameter (mm)

d: Nominal bore (mm)

B: Nominal bearing width (mm)

f=1.7 for 70 and 72 series

f =1.4 for NN series

The grease for high-speed bearings should be good quality grease with synthetic oil as a base. For ball bearings grease with a mineral oil as a base is mostly used.

- **Free space in bearing and grease filling amount for deep groove ball bearings**

With the high quality of the grease and recent improvement in the grease has increased the usage of the grease as the replacement of the oil lubrication. The grease should be selected as per the operating conditions. The proper amount of the grease should be filled in the bearing. If the excess amount of the grease is filled the bearing which may affect the torque of the bearing and may also cause the temperature rise in the bearing during operation. The factors such as construction of the housing, free space in the bearing, quality of the grease and the operating condition should be taken into consideration while filling the grease in the bearing.

1/2 to 2/3 - when the bearing speed is 50% or less of the allowable speed
1/3 to ½ - when the bearing speed is 50% or more.

The amount of the grease required in the bearing depends on the speed of the bearings. Lower the speed of the bearing more will be the quantity of the grease and vice versa. To maintain the proper amount of the torque and the temperature in the bearing, the quantity of the grease varies. To avoid the entry of the dust and water the grease is fully filled in the bearing. To determine the correct filling amount of grease the space available in the housing should be calculated.

The volume of the balls and cage when subtracted from the volume of the space formed between inner and outer rings is defined as the free space of the open type deep groove ball bearing.

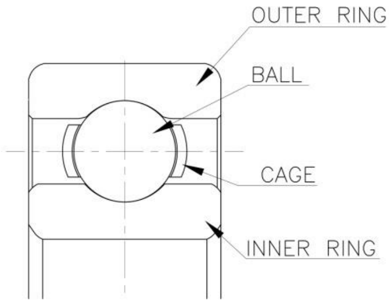


Fig 5.1 Bearing components in deep groove ball bearing

- **Free space of spherical roller bearings**

The spherical roller bearings are designed for carrying heavy misalignment in both radial and axial direction.

In spherical roller bearing mostly oil and grease lubrication is common practice. In case of the grease lubrication sealing facilities should be appropriate in the housing where bearing is going to be mounted. Mostly such types of bearings are mounted in the plumber blocks. There is free space available for the grease lubrication in the SRB types of bearing. The fig shows the various free space available in the different variants of spherical roller bearings.

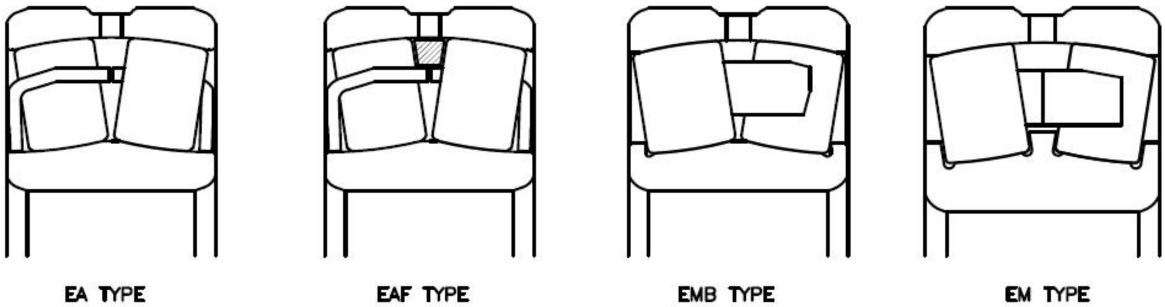


Fig. 5.2 Free space in available in spherical roller bearings

Generally, 1/3 to 2/3 that of the free space is available in the spherical roller bearings for grease lubrication.