Lubrication

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Summary

- Rolling bearings are lubricated with grease or oil
- It serves to reduce friction and wear and tear
- The lubrication method chosen must be adapted to the operating conditions
- No or insufficient lubricant in the bearing leads to rolling bearing damage and / or premature bearing failure
- Grease is used more often than oil as a lubricant (easier handling)
- In special cases, solid lubricants are used instead of grease or oil

Nothing works without lubrication: Every bearing runs with grease or oil lubrication, which is the basic prerequisite for avoiding metallic contact of the bearing components, (rolling elements, bearing rings and cage). In special cases, bearings can also be lubricated with a solid lubricant. Along with friction and wear, lubrication belongs to the field of *Tribology*. Probably the most important function of lubrication is to keep friction and wear as low as possible. In addition to this, lubrication also brings other advantages, which can be seen in the list.

Functions of lubrication:

- Reduction of friction and wear
- Dissipation of frictional heat
- Extending the bearing life
- Prevention of rust
- Protection against contaminant ingress

Optimal lubrication is the basic prerequisite for long bearing life.

The lubricant selection

Depending on the bearing, the lubrication method varies between grease and oil. It is also important to ensure that there is not too much or too little lubricant in the bearing. Did you know that, statistically, problems with lubrication are the main cause of failure of rolling bearings?

The lubrication method chosen must be adapted to and satisfy the operating conditions (especially the speed and operating temperature of the bearing) to ensure the lubrication is most effective. It is also important that the lubricant used is a quality lubricant and that the correct amount of lubricant is used. Another key requirement is that the bearing design is resistant to contaminant ingress while also preventing leakage of lubricant. For this purpose, rolling bearing manufacturers such as NTN offer types with contact seals for some series. Another configuration is that bearings are sealed externally, with various seal types available. When selecting the seal type, the resulting change in limiting speed must be taken into account (frictional heat of the seal).

	Grease lubrication	Oil lubrication
Handling	Very good	Acceptable
Reliability	Good	Very good
Cooling effect	Unsuitable	Good*
Sealing variants	Good	Acceptable
Friction loss	Good	Good

Environmental impact	Good	Acceptable
High speed	Acceptable	Good

The choice of lubricant must always be weighed up. Generally what one lubrication method can't do, another one can do better.

** Oil recirculation circuit required*

Grease lubrication

Grease is the most widely used lubricant and is generally relatively simple and inexpensive to use. The properties of all greases are mainly determined by the type of base oil used and by the combination of thickeners and various additives. The base oil used is mainly mineral oils, synthetic oils (such as ester oil), synthetic hydrocarbon oil and essential oils. A distinction is made between greases with low viscosity base oil, which are suitable for low temperatures and high speeds, and greases with high viscosity base oil. The latter are used in applications with high temperatures and high loads. Thickeners added to the base oil can be divided into the two basic types of metal soaps and non-metal soaps. The different properties of a grease, such as temperature range, mechanical stability, water resistance, etc. depend mainly on the type of thickener used. Depending on the intended use, various additives are included to further adjust its properties. Typical additives are antioxidants, high pressure additives (EP additives), rust inhibitors and corrosion inhibitors.

The amount of grease the bearing is filled with also depends on the speed. However, the quantity of grease to be used under the respective operating conditions generally depends on several factors at once, relating to the size and shape of the housing, the space available and the type of grease used. As a rule of thumb for most applications, bearings should be filled to 30% to 40% of the bearing internal free space and the housing to 30% to 60%. At high speeds and minimal temperature rises, it is advisable to use a reduced amount of grease. However, too high a grease quantity can lead to a rise in temperature, which softens the grease and as a result, grease leakage can occur. Also, oxidation and deterioration can lead to an impairment of the lubricating effect.

When using grease lubrication, it is extremely important to observe the relubrication schedule, as the lubricating performance of a grease decreases over time. This means that bearings must be regreased at certain intervals. Relubrication intervals are not uniform, because they sometimes depend on the type of grease, the type of bearing, the temperatures and the speed. It is also possible to fill with grease once (lifetime greasing) if the relubrication interval is longer than the lifetime of a bearing, for example, or if the bearing is sealed and relubrication would be too costly. With regard to the miscibility of different greases, the manufacturer's instructions must be observed. As a rule, however, mixing is not advisable due to different basic substances and additives of individual greases, as there is a risk that a chemical reaction of the different components will occur.

Oil lubrication

The most common alternative to grease lubrication is oil lubrication. This is the ideal, but more expensive choice and is preferred to grease lubrication, especially for rolling bearings with line contact. Oil lubrication is mainly used in applications where the heat generated by the bearing or other sources must be dissipated from the bearing and discharged to the outside. At the same time, high demands are often placed on the sealing and filtering of the oil, which is associated with greater design effort. In the context of rolling bearings, mineral oils such as machine oil, spindle oil or turbine oil are used in the temperature range -30°C to 150°C. At other temperatures, bearings are lubricated with synthetic oils such as ester oil, silicone oil and fluorinated oil. It is also generally true for oils that a mixture of different oils should be avoided or a detailed compatibility analysis should be carried out. An important property of lubricating oils is the kinematic viscosity v which is used to measure the lubricity of an oil.

Bearing type	Kinematic viscosity mm^2/s
Ball bearings, cylindrical roller bearings, needle roller bearings	≥13
Spherical roller bearings, tapered roller bearings, axial needle roller bearings	≥20
Axial spherical roller bearings	≥30

Generally, higher viscosity oils are used for roller bearings than for ball bearings, as the former run at lower speeds and carry heavier loads.

If possible, lubrication should reach an elastohydrodynamic (EHD) state, which leads to a complete separation of the rolling surfaces. The rolling of the rolling elements on the raceway with EHD lubrication can be compared, for example, with a water skier who needs a certain speed to glide on the water instead of sinking. Thus, the lubricity of the oil must not be too high or low, because, for example, if there is insufficient oil film between the rolling elements and raceway, then damage is usually not too far away.

Formula 6 is used to calculate the required oil quantity.

Formula 6

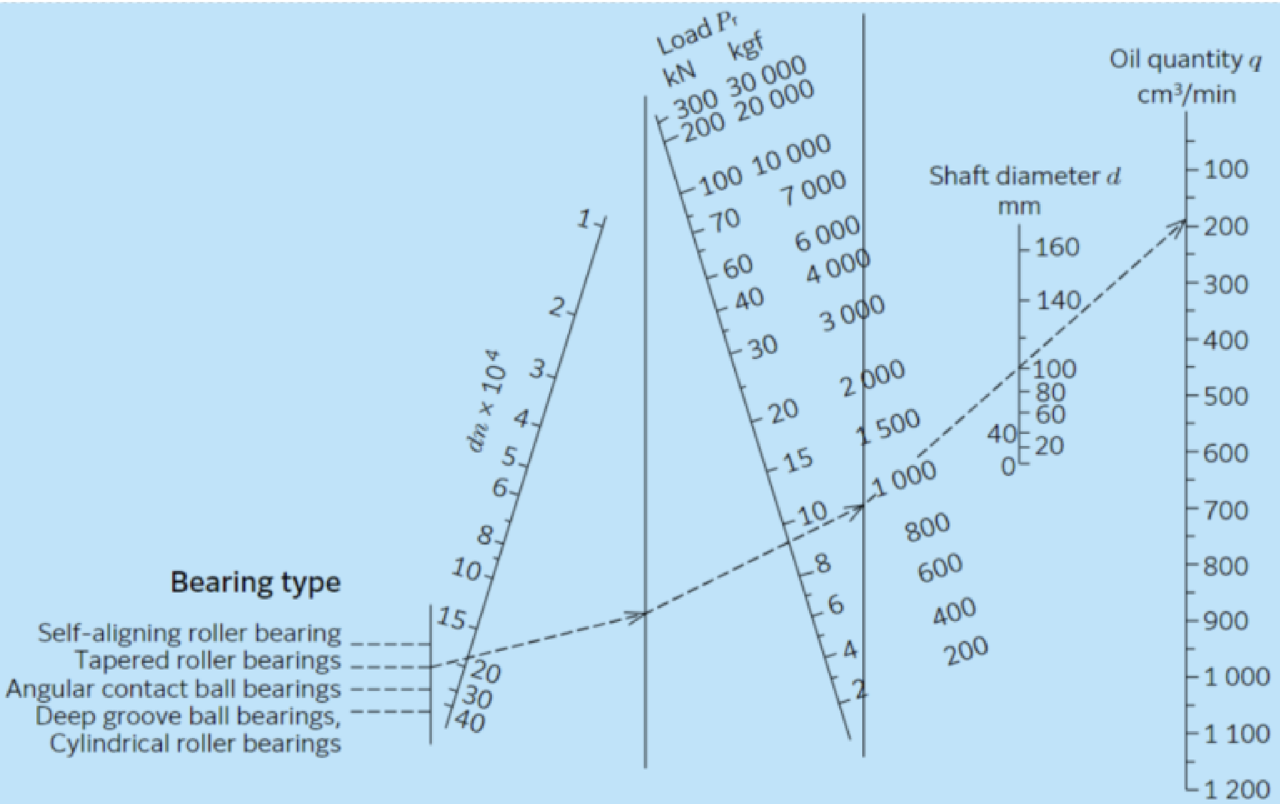
$$Q = K \times q$$

Q	Oil quantity per bearing (cm^3/min)

This is the key to determining the required oil quantity, for this the permissible oil temperature rise factor is multiplied by the lubricant quantity.

K	Permissible oil temperature rise factor
q	Lubricant quantity according to diagram (cm^3/min)

The amount of oil required must be calculated to ensure that the heat dissipated by the lubricating oil is approximately equal to the amount of heat generated by the bearing and other sources. In practice, the calculated quantity is then multiplied by a safety factor of 1.5 to 2.0 because the radiated heat of the housing varies depending on the design.



The diagram shows the guidelines for oil quantity: The lubricant quantity varies depending on the bearing *type. Procedure: Start on the left with the bearing type and then go through the diagram using the parameters dn, P_r and d (from left to right). The intersection with the vertical line with no scale always represents the new starting point.*

Regular checking of the oil quantity and cleanliness is essential. The intervals for replacing the lubricating oil vary depending on the operating conditions, oil quantity and type of oil. As a rough guideline, the oil should be changed once a year at operating temperatures of up to 50°C and at three-monthly intervals at temperatures between 80°C and 100°C. In addition, it must be noted that the lubricant service life decreases by approximately 50% every 10°C from temperatures of 80°C onwards.

Solid lubrication

In special cases, for example when grease or oil lubrication is not possible, solid lubricants are used as an alternative. Solid lubricant consists of a oil, which has the same viscosity as a conventional oil, and an ultra-high polymer polyethylene. The two components are mixed in a liquid phase. After heating and cooling, this substance solidifies so that a large amount of lubricant is absorbed into the polymer structure. Even with strong vibrations or centrifugal forces, the lubricant does not escape from a rotating bearing. In addition, solid lubrication is used in applications where dirt can enter the bearing or ordinary lubricant is simply washed out, because this way the dirt is blocked by the solid lubricant as it fills the available bearing internal free space. Solid lubrication is also used in the food industry, where there would otherwise be a risk of escaping lubricant contaminating the food. So far quite advantageous, isn’t it? On the other hand, solid lubrication is not suitable for applications with high speeds due to the increased friction in the bearing. Therefore, it is crucial speed is taken into account when considering a solid lubricant.

The Kappa value

To conclude this chapter, we’ll explore the kappa value, another important parameter in the field of lubrication. This has to be determined individually for each lubricant and the operating conditions and is also required for the determination of a_{ISO}, the life modification factor for the adjusted rating life of a rolling bearing. The Kappa value represents the viscosity ratio of actual kinematic viscosity v and nominal viscosity v_1 and describes the lubrication conditions in a rolling bearing during operation. The type of rolling bearing, size, lubricant, speed and temperature play a role here.

The Kappa value can be divided into three lubrication conditions. A value of $\kappa \leq 0.1$ indicates boundary lubrication where an EHD lubricating film is not formed. This leads to solid body contact and increased friction or wear. A kappa value of $0.1 < \kappa \leq 4$ is referred to as mixed friction. Due to insufficient lubricant film thickness, there is still partial solid body contact, so that the roughness peaks interlock sporadically. In this case, however, the friction is already reduced. Only at $\kappa > 4$ is there so-called “full lubrication“ and thus a full EHD lubricating film is present, which completely separates the contact surfaces of the solid bodies.

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