

12. Lubrication

12.1 Lubrication of rolling bearings

The purpose of bearing lubrication is to prevent direct metal to metal contact between the various rolling and sliding elements. This is accomplished through the formation of a thin oil(or grease) film on contact surfaces. However, for rolling bearings, lubrication has the following advantages:

- (1) Friction and wear reduction
- (2) Friction heat dissipation
- (3) Prolonged bearing life
- (4) Prevention of rust
- (5) Protection against harmful elements

In order to achieve the above advantages and prolong the bearing life, the most effective lubrication method and lubricant has to be selected for each individual operating conditions.

12.2 Grease lubrication

Grease type lubricants are relatively easy to handle and require only the simplest sealing devices—for these reasons, grease is the most widely used lubricant for rolling bearings. Lubricating grease are composed of either a mineral oil base or a synthetic oil base. To this base a thickener and other additives are added. Thickening agents are compounded with base oils to maintain the semi-solid state of the grease. Various additives are added to greases to improve various properties and efficiency. The properties of all greases are mainly determined by the kind

of base oil used and by the combination of thickening agent and various additives.

Thickening agents is critical to grease performance., particularly with respect to temperature capability, water-resistance, and oil-bleeding characteristics. They are divided into two broad class: metallic soaps and non-soaps. Metallic soap thickeners include: lithium, sodium, calcium, etc. Common greases type, property and their characteristics are listed in **Table 12-1**. As performance characteristics of even the same type of grease will vary widely from brand to brand, it is best to check the manufacturers' data when selecting a grease.

在一些輕負荷的應用, 如使用靜音軸承之室內空調送風機等, 若安裝正確, 有效隔離侵蝕、異物侵入, 則潤滑脂的壽命是影響軸承使用壽命的主要因素。滑脂之壽命預測計算式可參考 Kawamura 等提出之修正式, 計算所得之壽命為 L_{50} (信賴度 50%)如下:

Urea-based grease:

$$\log L = -2.02 \times 10^{-6} \times K \times V - 2.95 \times 10^{-2} T - 8.36 F + 8.50 + K_1 \dots \dots \dots (12-1)$$

where,

$$10 \leq dm \leq 100, dmn \leq 400000, 70 \leq T \leq 180$$

Li-based grease:

$$\log L = -1.58 \times 10^{-6} \times K \times V - 2.18 \times 10^{-2} T - 9.84 F + 6.33 + K_1 \dots \dots \dots (12-2)$$

where,

$$10 \leq dm \leq 100, dmn \leq 400000, 70 \leq T \leq 150$$

L : L_{50} grease life, hour

Table 12-1 Common grease type, properties and characteristics

Code	Brand	Maker	Soup	Base oil	Dropping point (°C)	Penetration 25(°C) 60w	Operating temperature range(°C)	characteristics
1K	Multemp PS NO.2	KYODO YUSHI	Li	Diester & mineral	190	265~295	-55~+130	General use, low temperature, low torque
2A	Alvania NO. 2	SHELL	Li	mineral	182	273	-25~+120	General use, light load
3E	Beacon 325	ESSO	Li	synthetic	193	265~295	-50~+120	General use, low temperature, low torque
5C	RPM SRI 2	CALTEX	Urea	mineral	243	265~295	-30~+177	General use, high temperature
5K	Multemp SRL	KYODO YUSHI	Li	synthetic	191	240~270	-50~+150	General use, long life

K : compensation factor for outer ring rotation (if inner ring rotation: $K=1$; if outer ring rotation: $K=$ inner ring rotating speed calculated from the cage orbital speed when inner ring rotation condition is assumed/ outer ring rotating speed)

V : dmn value

$$dm: \text{pitch diameter} \approx \frac{d + D}{2}$$

D : outside diameter mm

T : bearing temperature °C

F : load ratio P/C_r

K_1 : compensation factor for base oil type (Table 12-2)

Reference: T. Kawamura, M. Minami and M. Hirata, "Grease Life Prediction for Sealed Ball Bearings," Tribology Transactions, 44, 2, pp 256-262, (2001).

12.3 Oil lubrication

Oil lubrication is suitable for applications requiring that bearing-generated heat or heat applied to the bearing from other sources be carried away from the bearing and dissipated to the outside.

Under normal operating conditions, spindle oil, machine oil, turbine oil, and other mineral oils are widely used for the lubrication of rolling bearings. However, for temperatures above 150 °C or below -30 °C, synthetic oils such as diester oil, silicone oil, and fluorocarbon oil are used.

For lubricating oils, viscosity is one of the most important properties and determines an oil's lubricating efficiency. If viscosity is too low, formation of the oil film will be insufficient, and damage will occur to the load carrying surfaces of the bearing. If viscosity is too high, viscous resistance will also be great and result in temperature increases and friction loss.

Table 12-2(1) K_1 value for urea based grease

Base oil type	compensation factor K_1
mineral	-0.08
PAO	-0.05
ester	-0.21
ether	0.18
mineral +PAO	-0.06
mineral + ester	-0.16
PAO+ ester	0
PAO+ ether	0
ester + ether	0.07

Table 12-2(2) K_1 value for Lithium based grease

Base oil type	compensation factor K_1
mineral	-0.29
PAO	-0.05
ester	0.42
diester	-0.5
Silicon	0.54