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 advantagesand prelong 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 7-1.** 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.

For some light load applications, such as a silent bearing used in indoor conditioner motor, the bearing life is dominanted by the life of grease as lubricant if it is installed properlly, kept off corrosion and contaiminants. The prediction of grease life can be determined by the formula recently modified by Kawamura etc. The calculated L_{50} (50% reliability) lives for different types of grease are as follows:

Urea-based grease：

$$\log L = -2.02\times10^{-6}\times K\times V - 2.95\times10^{-2}T - 8.36F + 8.50 + K_1 \cdots \quad \text{.....(12-1)}$$

where,

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

Li-based grease：

Table 7-1 Common grease type, properties and characteristics

Code	Brand	Maker	Soup	Base oil	Droping point (℃)	Penetration 25(℃) 60w	Operating temperature range(℃)	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

$$\log L = -1.58\times10^{-6}\times K\times V - 2.18\times10^{-2}T - 9.84F + 6.33 + K_1 \cdots \quad \text{.....(12-2)}$$

where,

10 ≦ dm ≦ 100, dmn ≦400000, 70≦T≦150

L: L_{50} grease life, hour

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

D: outside diameter mm

T: bearing temperature ℃

F: load ratio P/C_r

K_1: compensation factor for base oil type (Table 7-2)

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

Table 7-2(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 7-2(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

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℃ or below -30℃, 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.