The Method for Selection of Industrial Enclosed Gear Oils in China

Like their international counterparts, the Chinese are taking appropriate measures to establish high-quality standards for selecting proper gear oils.

By Xiaoling Wu, Zhengzhou University, Zhengzhou, Henan, China, Wenzheng Qi, Zhengzhou Research Institute of Mechanical Engineering, Zhengzhou, Henan, China and Xuehuei Gan, Donghua University, Shanghai China

Editor's Note: *The following article is an interesting history of China's efforts to develop an industrial standard for selecting oils for gearboxes. Like the United States and other countries, China found it necessary to provide industrial guidelines for selecting gear oil in order to avoid gear failures and obtain reliable gearboxes.*

China wisely formed a national standardization committee with interdisciplinary membership including universities, industrial OEMs and customers. They also prudently chose to utilize existing knowledge by basing their standard on American and German lubrication standards. As a result, they developed innovative guidelines that address all the parameters necessary for selecting the proper gear oil.

Robert Errichello
Consultant, Geartech
Townsend, Mont.

Since 1987 the method for selecting oils for industrial enclosed gears has been formulated in China. Based on the achievements of research work and other international standards, the Chinese standard (ZBJ17003-89) was established in 1989. The newly revised edition (JB/T8831-2001) of the standard was published in 2001. In the standard, lubricants are classified as general industrial gear oils and high-speed gear oils. The oil selection procedures are divided into two steps. The first step is to choose the category such as L-CKB, L-CKC, L-CKD of gear oil depending on the gear surface stress. The second step is to choose the viscosity according to the pitchline speed and ambient temperature.

Introduction

With rapid advancement of gear design and manufacturing technology, gearboxes have become smaller, and output power has increased significantly. The net result is higher contact stresses and higher operating temperatures. Therefore, selecting the right gear oil becomes more and more important. Nowadays, there are many gear lubrication standards such as DIN51509-Teil1, USS224, AGMA250.01, AGMA250.02, AGMA250.03, AGMA250.04 and ANSI/AGMA9005-D94 that give guidance for selecting gear oils in which Chinese lubrication engineers strive to keep up with the state-of-the-art of lubrication technology.

In this article, the strategy and course of developing a lubrication standard is described, and the characteristics of the Chinese standard (JB/T8831-2001) are explained.

Necessity for standard formulation

In China before 1990, there weren't any national standards or specifications for selecting gear oil, and the importance of gear lubrication was not appreciated. Gear scuffing and pitting happened frequently because incorrect lubricants were used. For example, a main gear reducer in a steel mill failed because the wrong oil was used. Despite a high contact stress of 519 MPa, a mineral oil without EP additives rather than EP gear oil was used. Consequently, the gears were severely damaged. Following the guidelines of ZBJ1700-89, the lubricant was changed to medium load (L-CKC) oil, and the gear damage was prevented.

With the development of gear design and manufacturing technology, gearboxes are smaller, transmit higher power and sometimes operate in aggressive environments. Therefore, gear lubrication becomes an important consideration. In the late 1990s, with the advanced rolling mill from Germany and Japan introduced into China, gearboxes in these applications required high quality oil and a high level of oil application technology. Through research and development, the major oil refineries, under the guidance of China petroleum and chemical corporation (Sinopec), produced high quality gear oil matching the standards of AGMA250.04 and USS224 to meet the needs of gearbox lubrication in the rolling mills.

Table 1. The category selection of general industrial enclosed gear oils.

Condition		Recommended gear oil
Contact stress of gear surfaces σ_H MPa	Working condition	
<350	General transmission	R&O oil (L-CKB)
350-500 (Light duty)	General transmission	R&O oil (L-CKB)
	Shock loads	Medium load (L-CKC)
500-1100[1)] (Normal duty transmission)	Mining, Cement, Chemical, Hydropower Metallurgy, Shipping and port, etc	Medium load (L-CKC)
>1100 (Heavy duty transmission)	Steel rolling, Excavating, High temperature and shock loads, Moisture condition	Heavy-load (L-CKD)
<500	In the extreme temperature and Light load condition	Extreme temperature (L-CKS)
≥500	In the extreme temperature and Heavy load condition	Extreme temperature and heavy-load (L-CKT)

Note: When the stress is slightly smaller than 1100, the L-CKD is recommended in the high temperature and moisture condition.

As knowledge of tribology and lubrication improved, the need for a reliable method to select gear oil became apparent. Chinese OEMs and consumers urgently needed a method for selection of industrial enclosed gear oils.

Strategy of standard formulation

The formation of standard (ZBJ17003-89)

During the sixth "five-year national development plan," which was a national main science and technology development plan, the project of industrial gear oil application technology was carried out under the guidance of the ministry of the machine-building industry. This project found a relationship between the category of gear oil and the gear surface stress level. Further, surface stress is fundamental to the method for choosing industrial enclosed gear oils.

In 1987 the standard group for developing the method for selecting industrial enclosed gear oils was organized by the Chinese Gear Standardization Committee (CGSC). The members of the CGSC come from universi-

With the development of gear design and manufacturing technology, gearboxes are smaller, transmit higher power and sometimes operate in aggressive environments.

CONTINUED ON PAGE 26

CONTINUED FROM PAGE 25

Table 2. The category selection of high-speed gear oils.

Condition		Recommended gear oil
Load factor of gears K (MPa)	Application condition	
Gear surface with HRC ≥ 45: K<2 Gear surface with HB ≤ 350: K<1	General transmission without moisture, steam and ammonia	Antirust steam turbine oil
	With moisture, steam and seawater	Antirust steam turbine oil
	In ammonia environment	Anti-ammonia steam turbine oil
Gear surface with HRC ≥ 45: K<2 Gear surface with HB ≤ 350: K<1	The higher load capacity is required in the field of power machine, industrial transmission set and shipping	EP steam turbine oil

ties, research institutes, OEMs and customers. The objective of the standard is to assimilate features of international standards such as DIN51509-Teil1, USS224, AGMA250.01, AGMA250.02, AGMA250.03, AGMA250.04 and ANSI/AGMA9005-D94, while using the research achievements in China. Drafting the standard took more than a year, and in 1988 the draft was approved by the CGSC.

The standard was confirmed as the method for selection of industrial enclosed gear oils (ZBJ1700-89) by the National Standardization Bureau (NSB) in 1989 and published and brought into effect on Sept. 1, 1990. This standard mainly took the DIN51509-Teil1 and AGMA250.04 as references while considering Chinese applications.

Amending the standard (ZBJ17003-89)

After using the standard for eight years, many experiences were accumulated. The review of the standard indicated that the viscosity of gear oil chosen, according to ZBJ17003-89, was unreasonably high. In 1998 the CGSC finished the review of the standard of ZBJ17003-89 and the NSB changed its designation to JB/T8831-1999. It was not until 1999 that a new standard group was organized to revise the old method for selection of industrial enclosed gear oils.

The main change of the draft of the new standard is using ANSI/AGMA9005-D94 as the reference standard rather than DIN51509 Teil1 while considering Chinese applications. The new standard (JB/T8831-2001) was confirmed by the Chinese Mechanical Industrial Union and published Oct. 1, 2001.

Features of method for selection of industrial enclosed gear oils (JB/T8831-2001)

The standard (JB/T8831-2001) provides a method for selecting industrial enclosed gear oils including the selection of the category, viscosity of the lubricant and lubricant application. Compared to ANSI/AGMA9005-D94, the new contents are as follows:

Selection of category of lubrication oil

The categories of general enclosed gear oils are R&O industrial gear oil (L-CKB), medium-load industrial gear oil (L-CKC), heavy-load industrial gear oil (L-CKD), extreme temperature industrial gear oil (L-CKS) and extreme temperature and heavy-load industrial gear oil (L-CKT). The selection of oil categories is shown in Table 1 (*see page* 25) as a function of contact stress and operating conditions.

Selection of lubrication oils for high-speed gear

The high-speed gear oils usually used in China are antirust steam turbine oil, anti-ammonia steam turbine oil and EP steam turbine oil. According to the load factor, K, of gears and application, the categories selection of high-speed gear oils are shown in Table 2.

The factor, K, is calculated by the formula:

$$K = \frac{F_t}{bd_1}\frac{u+1}{u} \qquad (1)$$

K = The load factor of gears, MPa

F_t = The nominal tangent force on the transverse reference circumference, N

b = The gear surface width, mm

d_1 = The reference diameter of pinion, mm

u = The ratio of gear teeth, $u = Z_2/Z_1$

Lubrication of circular-arc gear transmission

The circular-arc gear transmission is widely used in China. After several years of application, it's clear that the original standard of JB/T8831-1999 is basically practical for circular-arc gear transmissions.

The viscosity selection of industrial enclosed gear oils

Table 3 shows the method of JB/T8831-2001 for selecting viscosity for industrial enclosed gear oils.

Conclusion

Development of the Chinese standard (JB/T8831-2001 or ZBJ1700-89) required more than 10 years. There are two advantages to the standard. First, it's rooted on the foundation of the research project in China. Secondly, it incorporates features of advanced international standards.

The Chinese standard selects oil type based on the contact stress of gear surfaces and selects oil viscosity based on pitchline speed. This method is suitable for not only general industrial enclosed gears, but also high-speed and circular-arc gears.

With continued development of gear manufacturing and lubrication technology, the method for selecting industrial enclosed gear oils should be improved continually. **<<**

Xiaoling Wu is the supervisor of doctor at Zhengzhou University in Zhengzhou, Henan, China. He can be reached at **xiaolingwu@zzu.edu.cn.**

Table 3. The viscosity selections of industrial enclosed gear oils.

Cylindrical and Bevel gear transmission		Viscosity[1], $\nu_{40°C}$, mm²/s Environment temperature, °C		
Pitchline speed of low speed stage[2], m/s	-40°C~-10°C	-10°C~10°C	10°C~35°C	35°C~55°C
≤5	100	150	320	680
5~15	100	100	220	460
15~25	68	68	150	320
25~80[3]	32	46	68	100
	Synthetic oil required for this temperature range			

Note: (1.) Pitchline speed ≤ 25m/s, viscosity of industrial enclosed gear oils; Pitchline >25m/s, viscosity of steam turbine oil. With the severe impact load, the viscosity will increase one stage. (2.) For the bevel gear, the calculation of pitchline speed is based on the geometry parameters of equivalent cylindrical gear at the midpoint of the gear surface width. (3.) Pitchline speed >80m/s, the viscosity should be recommended by OEM.

References

(1) DIN Standard, (1976), "DIN 51509-1, *Selection of Lubricants for Gears: Gear Lubricating Oils*," DIN German Institute for Standardization. Berlin, Germany.

(2) AGMA Standard, (1981), "AGMA 250.04, *Lubrication of Industrial Enclosed Gear Drives*," American Gear Manufacturers Association. Alexandria, Va.

(3) American National Standard, (1994), "ANSI/AGMA 9005-D94, *Industrial Gear Lubrication*," American Gear Manufacturers Association. Alexandria, Va.