Development of Motor Bearing Greases

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JTEKT has developed many bearings to meet the diversified performance demands of various motors. The influence of grease properties on bearing performance is extremely high, and therefore JTEKT has developed numerous greases to meet the various performance demands. The latest greases developed are KVC, KAM5, and ES804 greases. These newly developed greases exhibit characteristics of long life under high-temperature operation. In addition, KVC grease has superior anti fretting wear properties, KAM5 grease is superior in reducing noise, and ES804 grease is superior in lowering torque and anti fretting wear properties. This report explains the details of the developed greases.

***Key Words**: bearing, motor, grease, life, noise, torque*

1. Introduction

In recent years, the demand for electric motors for automobiles, household appliances, office automation equipment and industrial machinery has grown. At the same time, requirements for improving quietness, durability and efficiency in these motors have become increasingly stringent. In accordance with these trends, rolling bearings have been required to have higher performance.

Since required performance for motor bearings such as noise, vibration, service life and torque greatly depends on grease performance, R&D efforts have been done to develop greases that meet such performance requirements. Grease is composed of base oil, thickener and additives; it is important to select optimum composition for such performance requirements.

This report presents the greases which JTEKT has developed to satisfy such diverse performance requirements for a wide variety of applications.

2. Performance Requirement for Bearings

Performance requirements for bearings are low noise operation, high-temperature and high-speed durability, low torque and anti-fretting properties. As the bearing performance depends to a great extent on the property of grease filled in the bearing, the motor performance is greatly influenced by the grease performance. **Table 1** shows various motor types and required bearing performance to satisfy the trends toward higher motor performance. Typical motors are shown in **Figs. 1**, **2** and **3**[1].

Fig. 1 Appearances of fan motor and bearing

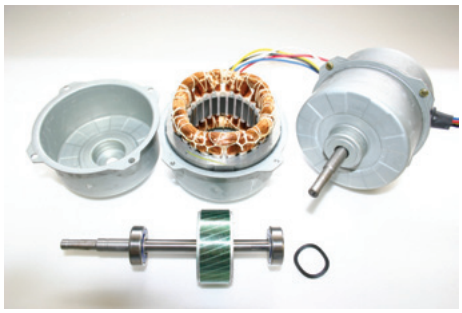

Fig. 2 Appearances of air conditioner motor and bearing

Fig. 3 Appearances of automotive stepping motor and bearing

Table 1 Motor performance and bearing performance requirements

	Motor type	Fan motor	Servo motor	Cleaner motor	Air conditioner motor	Automobile stepping motor	EPS motor*2
Motor performance*1	High temperature durability	○	○	○	○	○	○
	High-speed performance	○	○	○	–	–	–
	Quietness	○	–	–	○	○	○
	High efficiency	○	–	–	–	–	–
	Vibration durability	–	○	–	–	○	○
	Low temperature starting property	–	–	–	–	○	–
General operating conditions	Rotational speed, min^{-1}	2 000～8 000	2 000～10 000	30 000～50 000	300～3 000	1 000～2 000	20～2 000
	Temperature, ℃	60～70	60～120	80～120	80～120	−40～200	−30～130
Required performance for bearing*1	Low noise performance	○	–	–	○	○	○
	High temperature durability	○	○	○	○	○	○
	High-speed durability	○	○	○	–	–	–
	Low torque performance	○	–	–	–	○	–
	Anti-fretting performance	–	○	–	–	○	○

*1 ○: Required, −: Not required

*2 Motor for electric power steering

2. 1 Low Noise Performance

Foreign matter (contamination) found in grease and the cage is two contributors to bearing noise and vibration.

Grease noise is caused by dust contaminated in the grease manufacturing process, coagulation of thickener or solid particles of additives, etc. To prevent the grease noise, grease should be manufactured under clean environment, and particles of thickener and additives should be ground finely and homogeneously.

Cage noise is supposedly caused by self-excited vibration due to sliding friction of the cage riding surface, and it is more likely to occur at low temperature. Because, at low temperature, fluidity and oil separation of grease decrease due to the decrease of penetration (hardening) of grease and the increase of base oil viscosity, the cage riding surface area becomes inadequately lubricated and cage noise is more likely to occur. The cage noise can be controlled by use of grease with low viscosity synthetic base oil by its good fluidity.

2. 2 High-temperature, High-speed Durability

Motor service life can be affected by excessive noise and torque; grease used in the bearing has a great influence on motor service life. The grease life is often judged as the functional life of the motor.

Factors associated with accelerating the deterioration of grease may be based on chemical, physical and other forms of contamination. Furthermore, in each category, there is a wide range of subcategories. Among them, there are grease oxidation deterioration due to heat generation and shearing of the thickener due to high-speed rotation and vibration. In order to prevent the oxidation deterioration, it is important to select the proper base oil and thickener. In order to prevent shearing due to high-speed rotation and vibration, it is important to select a thickener with superior micellar structure.

2. 3 Low Torque Performance

Bearing torque generally depends on the load and the rotational speed. In the case of motor bearings, bearing torque largely depends on the rotational speed and is greatly influenced by the viscosity of the base oil of grease. To reduce the torque, grease with low base oil viscosity should be used to keep the agitation resistance of grease to a low level. In addition, the bearing torque is also affected significantly by the quantity and method

to fill the grease in the bearing, which needs to be well engineered.

2. 4 Anti-fretting Wear Performance

Fretting wear on the bearing raceway is minute wear found due to removal of lubricant at the contact area between the raceway and rolling element where minute reciprocal sliding occurs under repetitive radial, axial or moment loading when the bearing is stationary. Once fretting wear develops on the raceway, the bearing vibration and torque increase, and the bearing loses the functionality of the motor. Therefore, it is necessary to ensure that the grease or separate base oil can easily penetrate into the contact area of the bearing. As a result, grease with lower base oil viscosity, smaller amount of thickener and higher cone penetration (softer) properities is more desirable.

3. Greases Developed by JTEKT

This section presents performance and application examples of the various greases developed by JTEKT to satisfy performance requirements for bearings.

3. 1 Performance of KVC Grease

The KVC grease (hereinafter referred to as KVC) which is superior in high-temperature/high-speed rotation durability, low torque and anti-fretting performance has been developed by JTEKT and adopted in high-temperature motors and vacuum cleaner motors. **Table 2** shows the properties and features of the KVC in comparison with the conventional grease. The motor mounted in a vacuum cleaner is used under high-temperature and high rotational speed conditions (about 100℃ and 30 000 min^{-1} or higher). In recent years, further improvement in durability has been required. In such severe conditions, conventional greases are unable to satisfy the performance requirements. The KVC improved the durability of bearing under high temperature/high speed rotation and satisfied various performance requirements. Comparative test results on high-temperature durability, high rotational speed durability and low running torque are shown in **Figs. 4**, **5** and **6**, respectively. In both durability tests at 150℃ and high-speed tests, the KVC showed 5 times longer life compared with the conventional grease, whereas its torque at low temperature was comparable to that of lithium soap base greases for multi-purpose motors. In addition, the KVC has lower base oil viscosity and higher cone penetration compared to the conventional grease to improve anti-fretting performance.

Table 2 KVC grease property comparison and features

Grease name	KVC grease	Conventional grease
Thickener	Diurea	Diurea
Base oil	Poly α olefin, ester	Poly α olefin, mineral oil
Kinematic viscosity of base oil @40℃, mm^2/s	47	56
Worked penetration	250	242
Dropping point, ℃	260 Mini.	250 Mini.
Evaporation loss, mass% 99℃ × 22 h	0.17	0.13
Oil separation, mass% 100℃ × 24 h	0.2	0.5
Operating temperature range, ℃	−40～150	−40～150
Applications	High temperature motors, vacuum cleaner motors	
Performance requirement	High temperature/high-speed durability, low torque performance, anti-fretting performance	

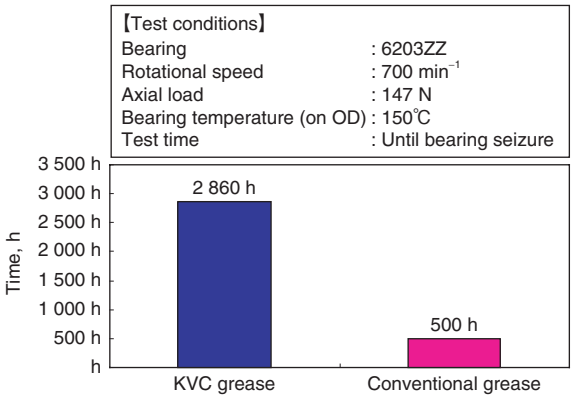

Fig. 4 Result of endurance test of KVC grease

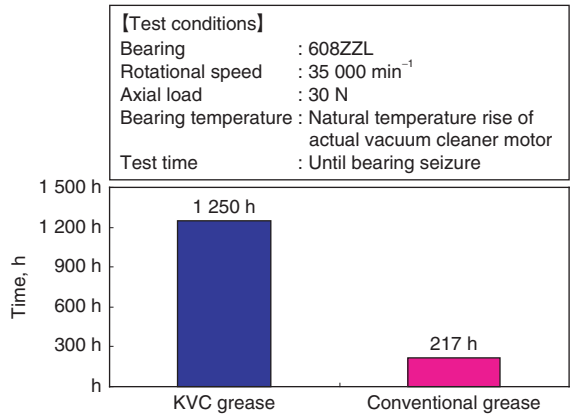

Fig. 5 Result of KVC grease high-speed test

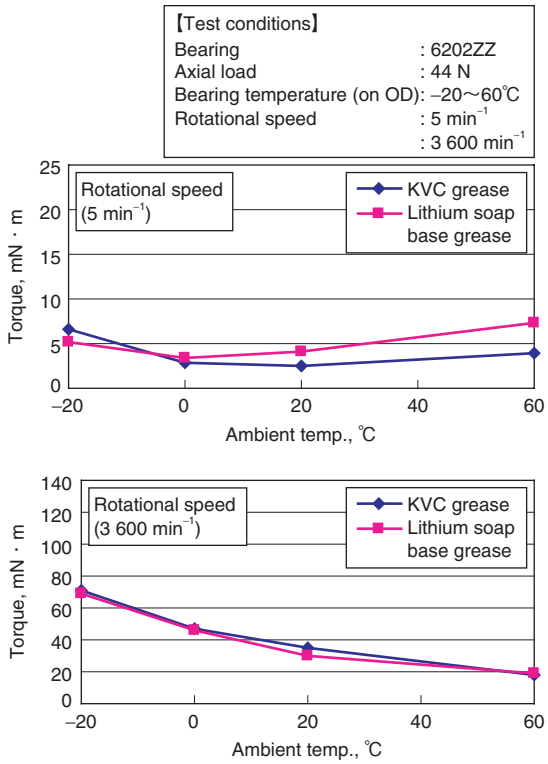

Fig. 6 Result of bearing torque test

3. 2 Performance of KAM5 Grease

The KAM5 grease (hereinafter referred to as KAM5) featuring low noise and high-temperature durability has been developed and successfully adopted in multi-purpose motors and air-conditioner motors. The properties and features of the KAM5 and the conventional grease are shown in **Table 3**. The motors installed in the air conditioners are roughly classified into two types: those for in-door equipment and those for out-door equipment. As the motor bearings for the in-door equipment are used at around 100℃ in a living space, demands for lower noise are more stringent.

With conventional grease, the bearing noise was evident in the early stage of service due to lack of oil film strength at high temperatures, this problem has been solved by use of the KAM5. **Figure 7** shows chronological changes in noise with the KAM5 filled bearing. The figure shows that the increase in noise of bearing filled with KAM5 at 100℃ is more moderate than that with the conventional grease.

Table 3 KAM5 grease property comparison and feature

Grease name	KAM5 grease	Conventional grease
Thickener	Lithium soap grease	Lithium soap grease
Base oil	Ester Ether	Ester
Kinematic viscosity of base oil @40℃, mm^2/s	53	26
Worked penetration	265	250
Dropping point, ℃	186	190
Evaporation loss, mass% 99℃ × 22 h	0.2	0.3
Oil separation, mass% 100℃ × 24 h	1.3	1.2
Operating temperature range, ℃	−30～140	−40～130
Applications	Multi-purpose motor, air conditioner motor	
Performance requirement	Low noise performance, high-temperature durability	

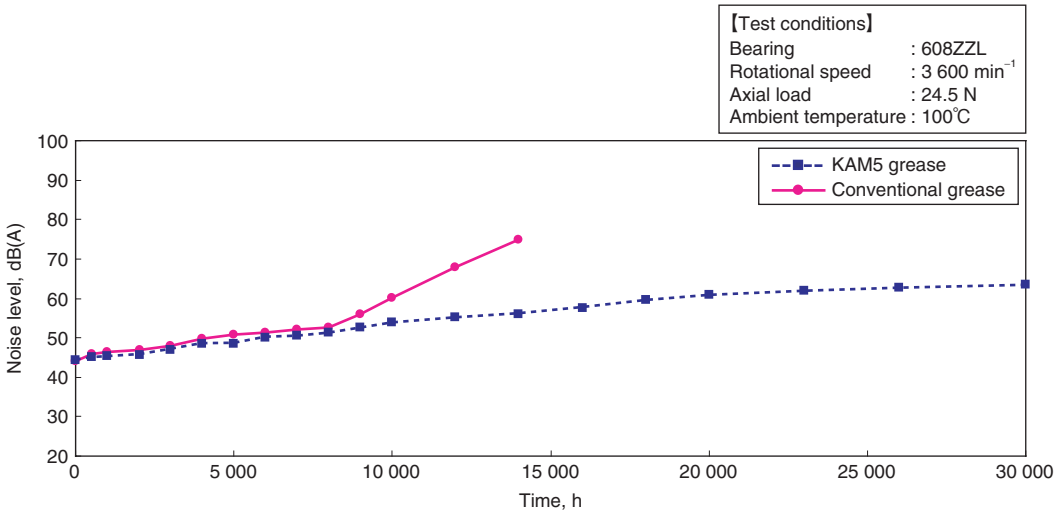

Fig. 7 Noise level change over time

3. 3 Performance of ES804 Grease

The ES804 grease (hereinafter referred to as ES804) featuring low noise, high-temperature durability, low torque and anti-fretting performance has been developed and used in automotive stepping motors. The properties and features between the ES804 and conventional grease are shown in **Table 4**. The electronically controlled throttle motor installed in an automobile engine room and stepping motors called EGR have the function of accurately controlling the opening and closing of the valve. If its functions are damaged, the vehicle will result in inferior performance which could potentially lead to an accident. That is why the bearing for this application is required to have high-temperature durability, low torque and anti-fretting performance, and thus grease that can satisfy these requirements is required.

ES804 satisfies these requirements by selecting and using perfluoro-polyether with excellent high-temperature durability as the base oil. Comparative test results on the running torque, the anti-fretting property and the noise property are shown in **Figs. 8**, **9** and **10**, respectively. Compared with the conventional grease, ES804 has achieved lower torque at –40℃ (around 1/3 of the torque of conventional grease) and smaller fretting wear (half the raceway wear depth of conventional grease), showing much improvement in such performance. Furthermore, noise property has also been improved to half the level of noise by use of a liquid type rust preventive additive instead of a conventional solid type additive.

Table 4 ES804 grease property comparison and features

Grease name	ES804 grease	Conventional grease
Thickener	PTFE	PTFE
Base oil	Perfluoro-polyether	Perfluoro-polyether
Kinematic viscosity of base oil @40℃, mm^2/s	68	90
Worked penetration	333	280
Evaporation loss, mass% 200℃ ×24 h	1.3	1.0
Oil separation, mass% 200℃ ×24 h	12.2	5.4
Operating temperature range, ℃	−40～200	−40～200
Applications	Automotive stepping motor	
Performance requirement	High temperature durability, low torque performance, anti-fretting performance	

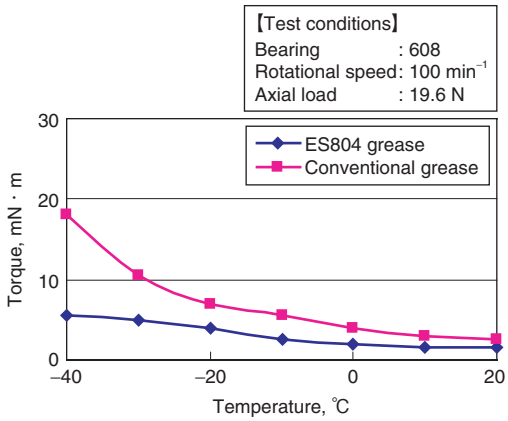

Fig. 8 Result of bearing torque test

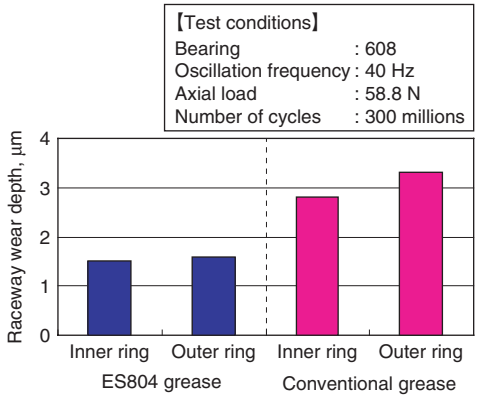

Fig. 9 Result of raceway fretting wear test

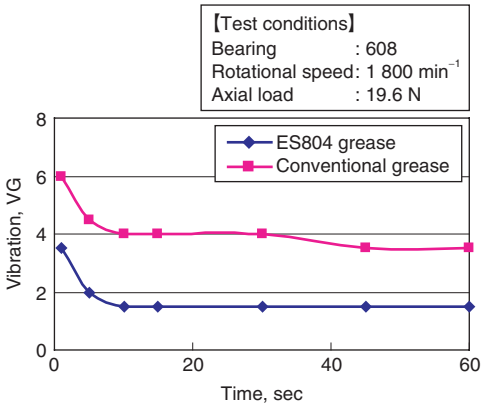

Fig. 10 Result of bearing vibration test

4. Conclusion

The use of motors is expected to grow more and more not only in the automobile industry but also in every industry. Along with the growth, operating conditions will become severer, and the performance requirements will be more diversified and intensified, which will ultimitely require better performing grease.

We would like to continue our efforts to enhance our technology and develop advanced greases that will exceed future requirements.

References

1) Technical Committee on Lubricating Greases, Japanese Society of Tribologists: Fundamentals and Applications of Lubricating Greases (2007).


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