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Development of low torque and low noise grease for ball bearings in electric motors

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ABSTRACT – Grease lubricated ball bearings are strongly required to improve low torque and quietness, but influence factors of grease on these performances have not been clarified. In this study, we investigated the factors influencing these two performances. As a result, it was clarified that the viscous transition stress of grease has a great influence on low torque property. Regarding quietness, it was revealed that the particle diameter and Young's modulus of the thickener has a great influence.

1. INTRODUCTION

Improvement of energy efficiency is a challenge for automobiles and various industrial machines due to the worldwide awareness of energy conservation. Efficiency is regulated in industrial motors, and further reduction in torque is required for ball bearings used in these motors. In addition, although quietness is required for motors used in living rooms such as air conditioners, in recent years, with the promotion of EV shift, motors used in automobiles are also required to be quiet. Therefore, ball bearings used in these applications are strongly required to be quiet more, and, for this purpose, it has been known from previous studies that grease is an important factor [1, 2]. In this study, we clarified the factors that influence these performance and established guidelines for designing the grease composition.

2. METHODOLOGY

2.1 Bearing torque measurement method

Evaluation was carried out using diurea grease having different molecular structures of thickener. To determine the loss energy of the rolling bearing, torque measurement was carried out using a rotating torque tester. The structure of the torque tester is shown in Figure 1. The value obtained by subtracting the bearing rotation torque at the base oil from the bearing rotation torque at the grease was defined as caused by the stirring resistance. Further, the value obtained by integrating the torque caused by the stirring resistance with the evaluation time was defined as the loss energy of the rolling bearing. Measurement was also performed by defining the stress at which the complex elastic modulus G * = G "/ G '= 1 using a rotary rheometer as the viscous transition stress. Outline of the rotary type rheometer is shown in Figure 2.

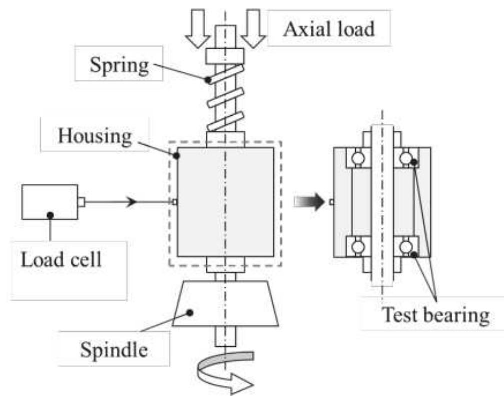


Figure 1 Bearing rotation torque measurement method.

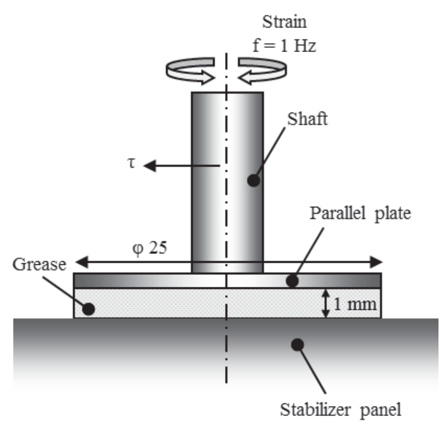


Figure 2 Viscous transition stress measurement method.

2.2 Bearing noise measurement method

The bearing noise value was evaluated by bearing vibrational acceleration. A certain quantity of grease was sealed in the bearing (62022RU), and the axial load was loaded with 20 N. Then, the vibration acceleration in the radial direction when the bearing inner ring was rotated at 1800 min^{-1} was measured. The value of vibration acceleration was measured 1 second after the start.

In order to investigate the relationship between bearing noise and oil film variation, oil film thickness measurement by optical interference method was carried out. Oil film thickness measuring equipment is shown in Figure 3. Grease is applied to the under surface of the chromium coated glass disk at a thickness of about 1 mm. Then, the thickness of the oil film was measured when the circular plate was rotated by pressing a steel ball from below. The rotation linear speed was set at two levels of 5 mm/s and 100 mm/s.

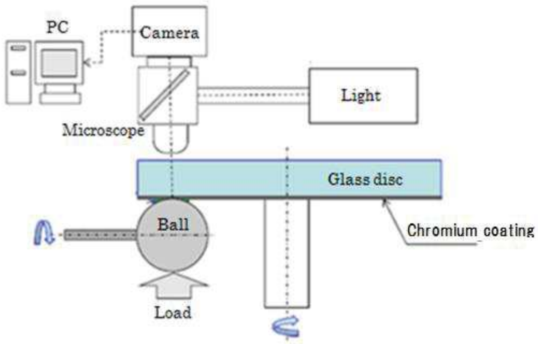


Figure 3 Oil film thickness measuring equipment.

3. RESULTS AND DISCUSSION

3.1 Low torque technology

The relationship between viscous transition stress and stirring loss energy is shown in Figure 4. There was a correlation between the two, and it was found that the stirring loss energy is smaller as the viscous transition stress is larger.

The specific surface area of the thickener particles was measured with a particle size distribution meter in order to clarify the control factor of the viscous transition stress. Figure 5 shows the results of investigating the correlation between the specific surface area of thickener and the viscous transition stress. As a result, it was clarified that viscous transition stress increased as the specific surface area of the thickener increased.

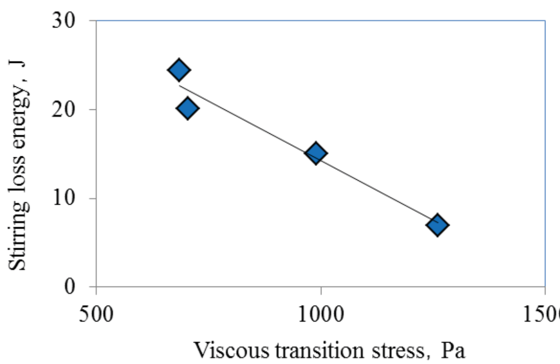


Figure 4 Relationship between viscous transition stress and stirring loss energy.

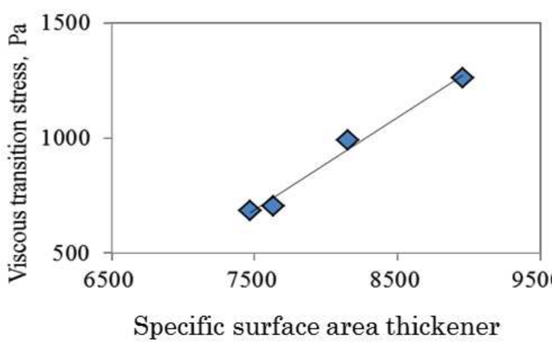


Figure 5 Relationship between specific surface area of thickener and viscous transition stress.

3.2 Low noise technology

The thickener was extracted from the grease and the Young's modulus of the thickener was measured. The results are shown in Figure 6. From these results, it was found that the Young's modulus varies greatly depending on the molecular structure, aliphatic has low Young's modulus and excels in quietness.

Figure 7 shows relationship between Young's modulus of thickener and vibrational acceleration. As a result of comparison using grease with the same particle diameter of the thickener, a high correlation was found between the Young's modulus of the thickener and the vibrational acceleration. From this result, it became clear that aliphatic having low Young's modulus is excellent in quietness.

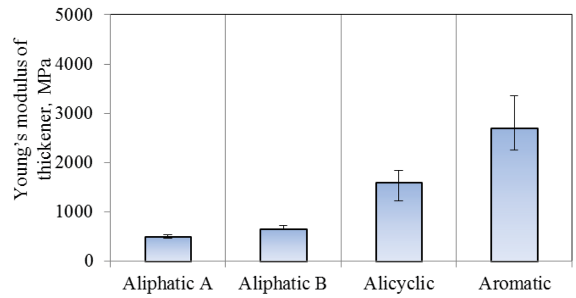


Figure 6 Measuring result of Young's modulus of thickener.

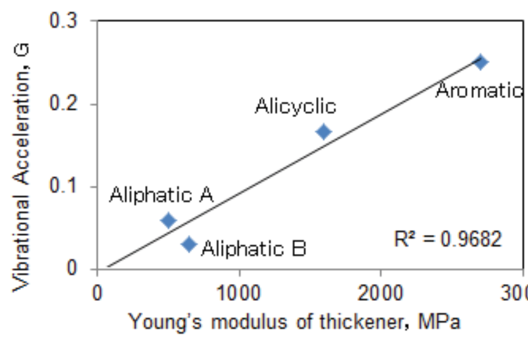
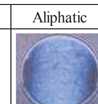
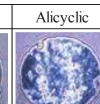
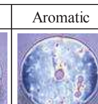


Figure 7 Relationship between Young's modulus of thickener and vibrational acceleration.

The results of investigating the effect of the thickener composition on the oil film thickness variation are shown in Figure 8. From this result, it was confirmed that the aliphatic thickener having a low Young's modulus induces only small fluctuation of the oil film thickness. Also, as shown in Figure 9, it became clear that there is a high correlation between oil film thickness variation and ball bearing acoustic value.

Thickener	Aliphatic	Alicyclic	Aromatic
Interference image			
Young's modulus of thickener	0.7GPa	1.6GPa	2.7GPa
Variation range of oil film thickness ※1	550～690nm	550～790nm	550～800nm
Variation amount of oil film thickness ※2	140nm	240nm	250nm

※1 : Oil film thickness at the center part (Max～Min)
※2 : Maximum oil film thickness － Minimum oil film thickness

Figure 8 Influence of thickener on oil film thickness variation.

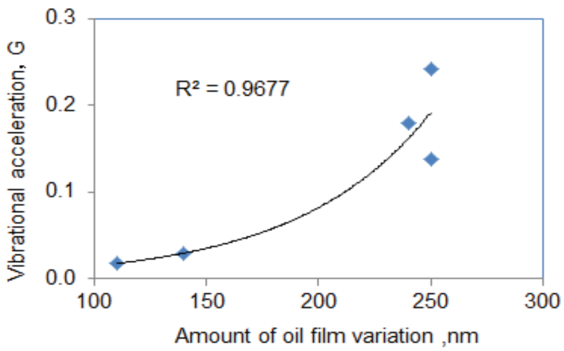


Figure 9 Relationship between oil film thickness variation and bearing vibration value.

4. CONCLUSION

The influence factor of the rotational torque and quietness of grease lubricated ball bearings has been clarified. Also, a material design method for grease that can improve each performance has been established.

REFERENCES

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