Influence of Working Conditions on Friction Coefficient of Grease

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***Abstract*—A grease without additives was prepared with lithium soap as thickener and polyol ester oil as base oil. The EHD friction behavior of the grease under different working conditions was measured by a mini-traction machine(MTM). The friction coefficient of polyhydric ester oil -lithium grease under different working conditions was measured. The friction characteristics of lithium grease based on polyol ester oil were analyzed.The results show that when the load and ambient temperature remain unchanged,the higher the rolling speed is, the smaller the friction coefficient is. When the rolling speed and ambient temperature remain constant, the higher the load, the smaller the friction coefficient. When the load and rolling speed remain constant, the friction coefficient decreases with the increase of temperature.**

Key words: Grease ;elastohydrodynamic friction characteristics ;mini-traction machine

I. INTRODUCTION

Grease is widely used in bearing lubrication because of its low friction coefficient, corrosion resistance and sealing function. The main function of the bearing is to separate the rolling element from the track, so as to reduce the friction force and prolong the service life [2]. At present, the tribological characteristics of grease in lubricating contact are not completely clear [3].The lubricating grease will be partially degraded in the process of rolling bearing, which may lead to the deterioration of lubrication performance. In extreme cases, lubrication failure may occur. Therefore, the performance of grease is one of the important factors to determine the bearing life [4]. Wedeven et al. put forward the concept of sufficient grease supply: if proper grease is added into the inlet area, the grease film is formed due to the pressure accumulation in the area, and the amount of lubricant continues to increase to the inlet area, and the film thickness does not increase any more, then this state is called the state of sufficient grease supply[4].However, due to the high viscosity of grease at low temperature and low shear, the fluidity is poor [6-8]. Once the grease is pushed to both sides of the contact rail during bearing operation, it is difficult to return to the track without external force [9]. Therefore, most of the bearings are running in the state of lack of grease. In order to simulate the actual working conditions of grease in bearings, researchers have done a lot of experiments on lack of grease.

Wedeven et al. used optical interferometry to observe the lack of oil in the contact area for the first time, which provided a new idea for the later research on the properties of lubricants[5]. Cann and others proposed that the stable layer (residual layer) formed by grease is mainly composed of solid layer and basic oil layer covered on it[10]. The research results of Aihara and Dowson on the double ball tester show that the film thickness in the state of lack of grease is about 70% of that of the base oil in the state of flooded oil[11]. Cann et al. change of oil film thickness with time under constant working conditions, and observe the effects of rolling speed, temperature, base oil viscosity and thickener content on the degree of lack of grease[12]. The results show that the higher the viscosity of base oil, the higher the content of thickener, the faster the rolling speed and the lower the temperature, the more obvious the degree of lack of fat is. The specific explanation is given in reference [13-14].The infrared spectrum analysis shows that thickener can promote the formation of oil film [10]. The experiment only verified the relationship between oil film thickness, friction coefficient and thickener type under the condition of constant sliding / rolling ratio, while the sliding / rolling ratio of lubricating grease changed from time to time during the operation of bearing.Most of the above experiments are carried out under the condition of lack of grease, which is closer to the actual working condition of the bearing. However, at present, there is no consensus on the mechanism of grease film-forming process and the effect of grease composition on the lubrication performance at home and abroad. The grease itself is a non Newtonian fluid, and there are many factors affecting the experimental data under the condition of lack of grease, so the experimental repeatability is very poor, so the conclusion is not universal.Relatively speaking, the lubrication research under the condition of sufficient grease supply is more mature and the repeatability of the experiment is relatively high. As far as the author knows, there are few articles devoted to the study of the effect of working conditions on the friction properties of grease under the condition of sufficient grease supply. It provides a theoretical basis for the selection of grease and subsequent experiments. This experiment mainly studies the influence of various working conditions on the friction characteristics of grease. In order to eliminate the interference of additives to the experiment, all the greases used in the experiment do not contain additives.

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II. TEST

A. *Experimental principle*

The structure of micro traction testing machine is shown in Fig. 1. In the experiment, the raceway of rolling bearing is replaced by ball plate, and the roller in rolling bearing is replaced by steel ball. The experimental disk is fixed on the vertical driving rod with nuts, and the experimental ball is fixed on the inclined downward driving rod with screws. A servo motor is installed on each driving rod to provide power. There is a temperature control box on the testing machine. All experiments are carried out in the temperature control box to ensure that the laboratory is carried out at the set temperature.Working condition setting: the contact load is represented by W, the test temperature is represented by T, and the rotational speed U = (U1 + U2), where U1 and U2 respectively represent the rotational speed of contact point ball disc. Experimental process: install the test ball and disc, evenly spread the grease on four points and put on the polyester device. Before the temperature control box reaches the set temperature, the ball disc idles at the speed of 1m / s.When the set temperature is reached, the rear end of the driving rod of the experimental ball is lifted to apply load on the contact point of the ball disc. When the set load is reached, the ball disc will rotate at the set speed, and by increasing U2 to reduce U1, the ball discs slide between them. The sliding speed Δ U = U2-U1, the resulting friction force is f, the friction coefficient μ = F / W, and the sliding rolling ratio S = Δ U / U. Therefore, by given load, temperature and speed, the relationship between friction coefficient and sliding / rolling ratio can be obtained.

In order to ensure that the contact area is always fully supplied with grease, a polyester device is placed on the track of the disc, which can return the grease on both sides of the track back to the track. The principle is that the contact part between the polyester and the rail is a trumpet type with large ends and small middle. The grease on both sides of the rail is gathered at the large bell mouth and squeezed into the track with rotation.

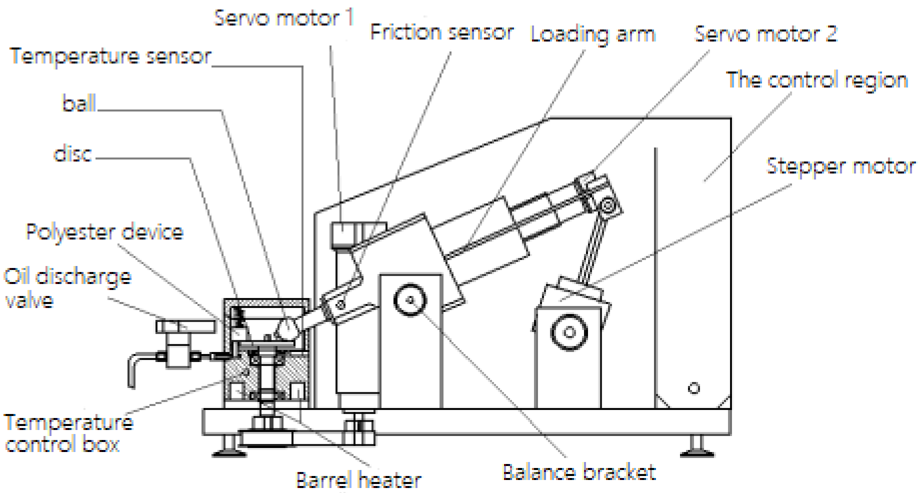

Figure 1 Structure of MTM micro traction testing machine

B. *Test samples and working conditions*

In order to explore the influence of various working conditions on the friction characteristics of grease, the grease without additives was used in the experiment. Ester oil lithium grease was used in the experiment (see Table 1 for specific parameters).

TABLE I. BASIC PARAMETERS OF TEST GREASE

Serial number	base oil	thickener	base oil viscosity	Thickener consistency （0.01mm）
1#	Polyol ester oil	Lithium 12-hydroxystearate	68mm/s2	280

In the test, the range of contact load is 24-70N; the range of Hertzian contact pressure is 0.8-1.2GPa; the rolling speed range is 0.2-3.2m/s; the temperature range is 30-130 ℃.

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III. RESULTS AND ANALYSIS

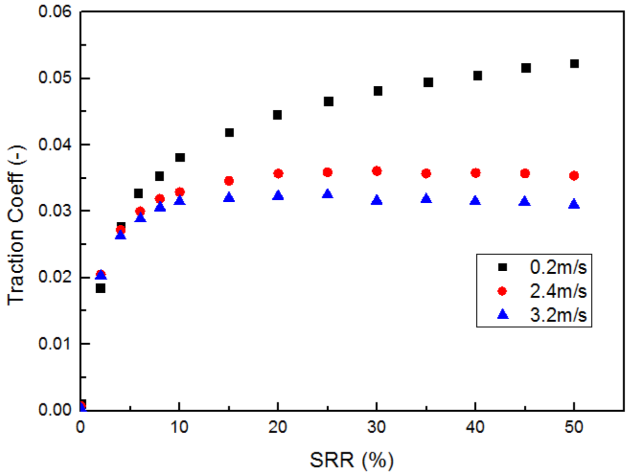

Figure 2 Variation of friction coefficient of three kinds of grease with sliding to rolling ratio

Fig. 2 shows the variation of friction coefficient of polyol ester oil lithium grease with sliding rolling ratio when the ambient temperature is 30 ℃, the load is 24N, and the rolling speed is 0.2m/s, 2.4m/s and 3.2m/s, respectively. It can be seen from Fig. 2 that when the load and ambient temperature remain constant, the higher the rolling speed, the smaller the friction coefficient. This is due to the decrease of the apparent viscosity of grease due to the increase of rolling speed which makes the contact surface temperature rise.

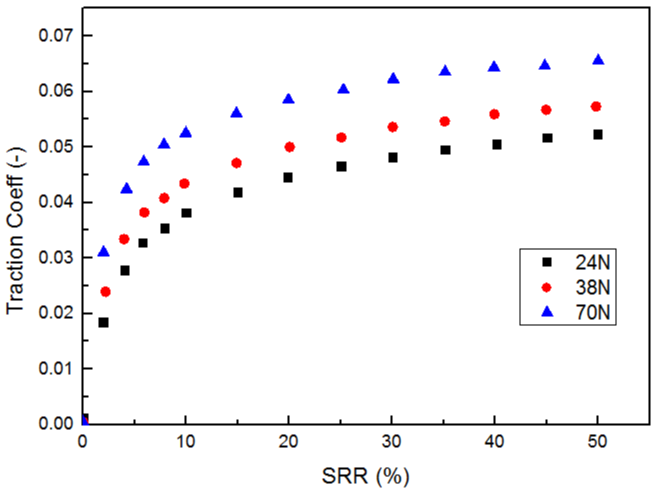

Figure 3 Variation of friction coefficient of three kinds of grease with sliding to rolling ratio

Figure 3 shows the variation of friction coefficient of polyol ester lithium grease with sliding to rolling ratio when the ambient temperature is 30 ℃ and the rolling speed is 0.2m/s and the load is 24N, 38n and 70N respectively. It can be found from Fig. 3 that when the rolling speed and ambient temperature remain constant, the greater the load, the smaller the friction coefficient. This is because the greater the load, the greater the friction resistance of the contact surface, and thus the greater the friction coefficient.

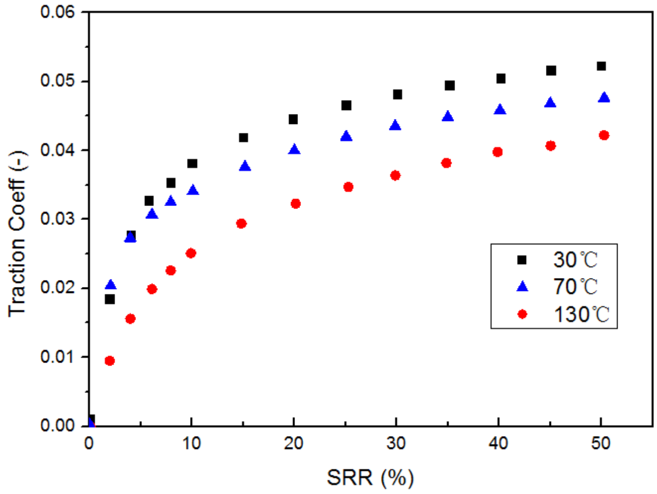

Figure4 Variation of friction coefficient of three kinds of grease with sliding to rolling ratio

Fig. 4 shows the variation of friction coefficient with sliding / rolling ratio of polyol ester oil lithium grease under rolling speed of 0.2m/s, load of 24N and ambient temperature of 30 ℃, 70 ℃ and 130 ℃ respectively. It can be seen from Fig. 4 that when the load and rolling speed remain unchanged, the friction coefficient decreases with the increase of temperature, which is because the apparent viscosity and friction force of grease decrease with the increase of temperature.

IV. CONCLUSION

1.When the load and ambient temperature remain constant, the higher the rolling speed, the smaller the friction coefficient of polyol ester oil lithium grease .

2.When the rolling speed and ambient temperature remain constant, the higher the load, the smaller the friction coefficient .

3.When the load and rolling speed remain constant, the friction coefficient decreases with the increase of temperature.

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