THE REDUCE-FRICTION AND EXTREME PRESSURE PROPERTIES OF ONE SYNTHETIC ADDITIVE ON STEEL-STEEL RUBBING PAIRS

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SUMMARY

an organo-copper compound (abbreviated as ZT2) as lubricating additive was synthesized and its thermal degradation was studied by TGA analysis method. TGA test results showed that the organo-copper compound ZT2 had better thermal stability than that of the commercial additive T202 (which mainly contains ZnDDP). The tribological properties of ZT2 in contrast with T202 were studied in detail. After 9 hours test duration under the steel-steel rubbing couple, a load of 600N and a speed of 500rpm, the friction coefficient value of ZT2-containing lubricating oil was about 0.018 and the temperature increase was no more than 10°C. The value of the friction coefficient and temperature increase of T202-containing oil were 0.12, 50°C respectively. Friction experiments’ results showed ZT2 had much more excellent friction-reduced and temperature-decreased characteristics than that of T202. Analyses of the worn surfaces certified that the organo-copper compound as lubricating additive could friction-reduced apparently

Keywords: friction-reduced, temperature-decreased, extreme pressure property, organo-copper compound

1 INTRODUCTION

Friction-reduced additives have received considerable attention, because they exhibit the advantages of energy-saving, oil-saving and low temperature increase and so on. However, most of the commonly available commercial additives, such as T202 (which mainly contains ZnDDP)[1], only registered good anti-wear property but bad friction-reduced property. Due to the energy-saving demand, the development of novel friction-reduced additives is urgently needed. Based on the selective-transmission theory, a new organo-copper compound as lubricating additive was designed and synthesized. At the same time, the thermal stability and the friction properties of this organo-copper compound were researched in the detail.

2 SYNTHESIS OF ADDITIVE

An oil-soluble organo-copper compound (abbreviated as ZT2) as lubricating additive was synthesized in our previous work and the synthesis can be given in brief as below:

$$\text{RCOOH} + \text{CuSO}_4 \rightarrow (\text{RCOO})_2\text{Cu}$$

Therein R is an alkyl group of about 12~18 carbon atoms [2].

3 THERMAL DEGRADATION ANALYSES

Thermal degradation analysis is very important to appraise lubricating oils or additives. TGA and DSC are main methods to study the thermal property of lubricant. In this paper, TGA analysis was used. The TGA curves of commercial additive T202 and the synthesized additive ZT2 were shown in fig.1 and fig.2.

Fig. 1 TGA analysis of commercial additive T202

Fig. 2 TGA analysis of organo-copper compound additive ZT2

From these two curves, the biggest lost weight temperature of ZT2 is about 211°C and it is higher than that of T202 (the biggest lost weight temperature of T202
is about 205°C). The curves also show that the beginning lost temperature of ZT2 (about 115°C) is much higher than that of T202 (about 92°C). So, the thermal stability of the organo-copper compound additive is better than that of the commercial additive T202.

4 FRICTION TEST METHOD

The effects of the organo-copper compound ZT2 and T202, obtained from commercial source, were examined with a SST-ST pin-disc wear tester (made of German). The samples of the rubbing couples were made by 45#-steel and through the same surface treatment. Each test was run with a new set of couples that have the same degree of finish. Each additive was dispersed in mineral oil (kinetic viscosity at 40°C, 45.2~46.8 mm²s⁻¹) and the additive content was 1.0%. Test environmental temperature was about 25 ± 5°C.

5 FRICTION-REDUCED, TEMPERATURE-DECREASED PROPERTIES

Fig.3 depicts the relationship between the friction coefficient and the friction test time for the organo-copper compound additive ZT2 and the commercial additive T202 under a load of 600N, at a speed of 500rpm (sliding velocity is about 0.3m/s).

From fig.3, when the friction coefficient reaches balance, the value of the friction coefficient of the organo-copper compound ZT2 is about 0.018, while the value of the friction coefficient of T202 is about 0.12. The organo-copper compound ZT2 as lubricating additive apparently reduces the friction in contrast with T202.

Fig.4 depicts the relationship between the oil temperature and the friction test time for the two additives. It can be found that after 9 hours test duration, the temperature increase of the ZT2-based lubricating oil is no more than 10°C, while the temperature increase of T202-based oil is about 50°C. From fig.3 and fig.4, we can find that this new synthesized organo-copper compound ZT2 has two important advantages: friction-reduced and temperature-decreased. Co-study with the results of the TGA analyses and the high temperature characteristic of ZT2 and T202 [4], the excellent friction and temperature-reduced properties of ZT2 maybe concluded to its good thermal stability. For the commercial additive T202 (which mainly contains ZnDDP), after 9 hours friction duration, the value of the friction coefficient and the temperature increase are even bigger than that of the mineral oil. Further research works should be carried out to understand the friction mechanism of the two additives, ZT2 and T202 better.

6 ANALYSIS OF THE WORN SURFACES

The morphologies and elemental compositions in the worn surfaces were observed and analysed with the electron microscope and AES respectively. The morphologies of the wear scars were shown in fig.5, fig.6 and fig.7. These morphology photos indicate that sever scuffing and corrosion occurred with the sample oil containing T202, while only very slight friction appeared with the oil containing organo-copper compound additive.

The analyses of the morphologies prove that the organo-copper compound ZT2 as additive is effective for reducing the friction coefficient and the scuffing action on the steel-steel rubbing pairs. Analyses of the elemental compositions were conducted in an attempt to the further understand the frictional mechanism of the organo-copper compound ZT2 as an additive. The relevant results are given in another paper.
7 EXTREME PRESSURE PROPERTY

Extreme pressure property of the organo-copper compound ZT2 as lubricating additive was studied with SST-ST pin-disc tester also. The results were shown in table1.

It is known that if the testing materials and the other test conditions are the same, the friction coefficient of the rubbing couples is mainly depended on what lubricating additives be used. So we can judge the extreme pressure property of one new lubricating agent by studying its friction under different loads. In this paper, the extreme pressure property was defined by load at that value the friction coefficient increased sharply. The test load was respectively 400N, 600N, 700N, 800N, 900N, 1100N, 1200N. From the values of friction coefficient and temperature increase shown in table1. The table data showed that this organo-copper compound additive ZT2 had good extreme pressure property also.

8 CONCLUSIONS

1. TGA analysis was used to study the thermal degradation of the synthesized organo-copper compound ZT2. Both temperature values of the beginning lost weight and the biggest lost weight were higher than that of the commercial additive T202.

2. After 9 hours test duration under the steel-steel rubbing pairs, a load of 600N and a speed of 500rpm, the friction coefficient value of ZT2-containing oil was about 0.018 and the temperature increase was no more than 10°C. The value of the friction coefficient and temperature increase of the commercial additive T202-containing oil were 0.12, 50°C respectively. The friction test results showed that the organo-copper compound ZT2 as lubricating additives had excellent friction-reduced and temperature-decreased properties.

3. The morphology of the worn surface of the upper steel rubbing pair that lubricated by the oil containing ZT2 agent shows that only slight friction appeared. Analyses of the worn surfaces certified that the organo-copper compound ZT2 as lubricating additive could friction-reduced apparently.

9 ACKNOWLEDGEMENT

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10 REFERENCES

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