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Effect of Ultrasonic Vibration on the Behavior of Antifriction and Wear Resistance of Al2O3/Al2O3 Ceramic Friction Pairs under Oil Lubrication

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Abstract

The behavior of antifriction and wear resistance of Al2O3/Al2O3 ceramic friction pairs lubricated by four different lubrication oils under ultrasonic vibration was studied. The surface morphologies of wear scare was analyzed by metallographic microscope. The effect mechanism of ultrasonic vibration on frictional pairs under different lubrication oils was discussed. The studied results showed that, ultrasonic vibration would improve the behavior of antifriction and wear resistance of the Al2O3/Al2O3 ceramic friction pairs under various lubrication oils.The improving would be dramaticer when the viscosity of lubrication oil was low. Ultrasonic vibration decreased the friction coefficient and wear volume 12.9% and 38.7% respectively, when the lubrication oil was 6#,the viscosity of which is 39.77 mm2/s. When the lubrication oil was 150BS, the viscosity of which is 549.69 mm2/s, ultrasonic vibration made friction coefficient and wear volume decreased 4.6% and 11.6% respectively.The effect of ultrasonic vibration on the behavior of antifriction and wear resistance of Al2O3/Al2O3 ceramic friction pairs was determined by the formation and the destruction of oil film on the friction surface and the upward floatage created by ultrasonic vibration.

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Keywords: ultrasonic vibration; friction and wear;oil lubrication; behavior of antifriction and wear resistance

1. Introduction

In recent years, domestic and foreign scholars found that ultrasonic vibration change the friction and wear of the friction pairs. Japanese Professor Akio Kumada(Ultrasonic Vibration [J],1986) found that the frictional resistance would be reduced to about 1/10 to 1/30, due to the suspension effect generated by the ultrasonic vibration. Wu

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Boda(Wu Boda,Chang Ying,Yang Zhigang,Tian Fengjun,2004) found that the ultrasonic vibration make the friction coefficient,which would be reduced larger in the amplitude of less than 5 μm,decreased rapidly. Yang Shanlin(YANG shan – lin, ZANG yan, QIAO yu – lin,2011) found that ultrasonic vibration would improve the behavior of antifriction and wear resistance of the GCr15/45# steel friction pairs under different loads. These studies indicate that the ultrasonic vibration can effectively reduce the friction coefficient of the friction pairs. Qiao Yulin(QIAO yu – lin, YANG shan – lin, ZANG yan, DONG xin – yu,2011)found that the influence of ultrasonic vibration on friction reduction and anti-wear properties of the GCr15/45# steel friction pairs was different under various lubrication oils. When the viscosity of lubrication oil was low， ultrasonic vibration would reduce the friction coefficient and wear volume of the GCr15/45# steel friction pairs. However, ultrasonic vibration would increase the friction coefficient and wear volume of the GCr15/45# steel friction pairs when the viscosity of lubrication oil was high. In this paper, the effects of ultrasonic vibration to the behavior of antifriction and wear resistance of Al2O3/Al2O3 ceramic friction pairs under different lubricating oils was studied, the mechanism of ultrasonic vibration on the friction and wear of Al2O3/Al2O3 ceramic friction pairs under different lubricating oils was explored.

2. Experimental Materials and Methods

The upper samples used for this investigation is Al_2O_3 ceramic ball with a diameter of 6 mm, hardness of 1650 HV, and the lower samples were Al_2O_3 ceramic box with 24 mm × 24 mm × 6 mm, hardness of 1650 HV .6#,20#,MVI900 and 150BS, the viscosity of which is as shown in Table 1,were used as the liquid lubricants..

Table 1. The viscosity of different lubrication oils

Lubrication oils	6#	MVI900	20#	150BS
Viscosity（mm^2/s）40℃	39.77	170.65	242.90	549.69

The experiment was done on the MFT-R4000 reciprocating friction and wear tester. The ultrasonic transducer was bonded to the liquid paraffin, and the ultrasonic power lead it to generate ultrasonic vibration, at last the oil groove,the liquid paraffin and the lower samples would also generate ultrasonic vibration, so the friction of friction pair under the conditions of ultrasonic vibration and oil lubrication. During the test, the upper samples was fixed, the lower disc was reciprocating. All of the friction and wear test were performed with the same diameter (5mm) of tracks on the disks. The frequency of ultrasonic vibration was 0KHz and 38KHz. All the experiment results were the average of three times. After ultrasonic cleaning in acetone solution, the wear scars were used for analyzing the wear-resistance mechanism. The wear volume of the wear scars of the lower samples were tested by the MFT-R4000 reciprocating friction and wear tester. The morphology of the wear scar of the wear surface of the lower samples were observed and analyzed by the OLYMPUS PMG3 metallographic microscope.

3. Results and discussion

3.1. Effect of ultrasonic vibration on the behavior of antifriction of the Al_2O_3/Al_2O_3 ceramic friction pairs under four different lubrication oils

Fig 1 gives the effect of the ultrasonic vibration on the friction coefficient of Al_2O_3/Al_2O_3 ceramic friction pairs under four different lubrication oils. It showed that, ultrasonic vibration would improve the behavior of antifriction and wear resistance of the Al_2O_3/Al_2O_3 ceramic friction pairs under various lubrication oils. When the lubrication oils were 6 #, MVI900, 20 # and 150BS, the average friction coefficient were reduced by 12.9%, 7.0%, 6.6% and 4.6%. Further analysis found that the higher the viscosity of the lubrication oil, the smaller the effect of ultrasonic vibration on the friction coefficient of Al_2O_3/Al_2O_3 ceramic friction pairs.

Fig 2 shows the wear volume of the lower samples of the Al_2O_3/Al_2O_3 ceramic friction pairs under four different lubrication oils at the frequency of ultrasonic vibration were 0KHz and 38KHz. It can be seen that ultrasonic vibration would reduce the wear volume of the lower samples of the Al_2O_3/Al_2O_3 ceramic friction pairs under various lubrication oils. With the increase in viscosity of the lubrication oils, the reduction were 38.7%, 20.0%, 11.9% and 11.6%, respectively. In summary, ultrasonic vibration would improve the behavior of antifriction and wear resistance of the Al_2O_3/Al_2O_3 ceramic friction pairs under various lubrication oils.The improving would be dramaticer when the viscosity of lubrication oil was low.

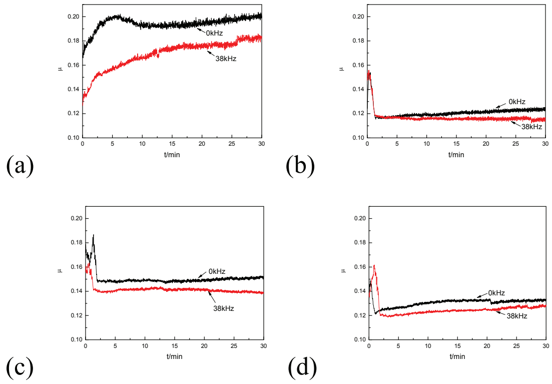


Fig.1 The effect of ultrasonic vibration on friction coefficient of Al_2O_3/Al_2O_3 ceramic friction pairs under different lubrication oils (a) 6#;(b)MVI900; (c)20#; (d)150BS

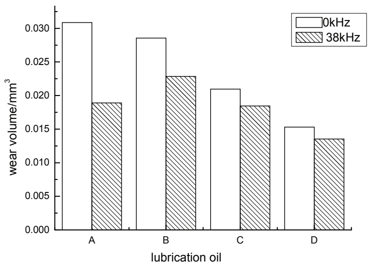


Fig.2 The effect of ultrasonic vibration on wear volume of Al_2O_3/Al_2O_3 ceramic friction pairs under different lubrication oils

3.2. Morphologies of worn scars

Fig 3 gives the micrographs of Al_2O_3/Al_2O_3 ceramic friction pairs under 6# lubrication oil with or without ultrasonic vibration. It can be found that there are many large-areaed spalling pits on the surface of the wear scar under the conditions of no ultrasonic vibration.But there are small amount of small-areaed spalling pits on the surface of the wear scar under the conditions of ultrasonic vibration.It is consistant with the effect of ultrasonic vibration on the behavior of antifriction and wear resistance of Al_2O_3/Al_2O_3 ceramic friction pairs under low viscosity lubrication oil.

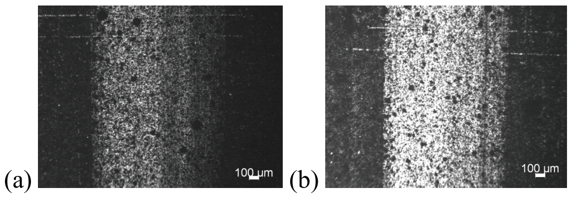


Fig.3 micrographs of Al_2O_3/Al_2O_3 ceramic friction pairs under 6# lubrication oil with or without ultrasonic vibration(a) 0 KHz; (b) 38 KHz

Fig 4 gives the micrographs of Al_2O_3/Al_2O_3 ceramic friction pairs under 150BS lubrication oil with or without ultrasonic vibration. As can be seen, the surface of the wear scar are relatively smooth, and the spalling pits are fewer then which is under 6# lubrication oil. The worn morphology are not significantly different, which is related to the effect ,which is not significant,of ultrasonic vibration on the behavior of antifriction and wear resistance under high viscosity lubricant oil.

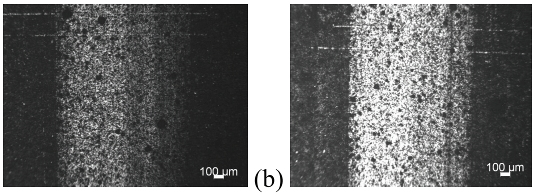
(a) (b)


Fig.4 micrographs of Al_2O_3/Al_2O_3 ceramic friction pairs under 150BS lubrication oil with or without ultrasonic vibration(a) 0 KHz; (b) 38 KHz

4. Conclusions

Ultrasonic vibration would improve the behavior of antifriction and wear resistance of the Al_2O_3/Al_2O_3 ceramic friction pairs under various lubrication oils.The improving would be dramaticer when the viscosity of lubrication oil was low. Ultrasonic vibration decreased the friction coefficient and wear volume 12.9% and 38.7% respectively, when the lubrication oil was 6#,the viscosity of which is 39.77 mm^2/s. When the lubrication oil was 150BS, the viscosity of which is 549.69 mm^2/s, ultrasonic vibration made friction coefficient and wear volume decreased 4.6% and 11.6% respectively.

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