EFFECT OF APPLIED DC VOLTAGE TO STAINLESS STEEL PIN AND CNx COATED DISK in PIN-ON-DISK SLIDING TEST ON TRIBOLOGICAL PROPERTIES

Noritsugu UMEHARA
Dep. of Mechanical Science and Engineering, Nagoya University, Aichi, Japan

Takahiro YAMAMOTO
Dept. of Mechanical Engineering, Nagoya Institute of Technology, Aichi, Japan

Yoshio FUWA
Material Engineering Div. I, TOYOTA MOTOR CO., Aichi, Japan

ABSTRACT
The effect of applied DC voltage on the friction and wear of CNx sliding against stainless steel pin in air was clarified. Friction coefficient decreased with the increasing negative voltage to apply to the ball and disk in air. On the other hand, positive voltage increased friction coefficient. Friction coefficient of CNx in air decreased from 0.22 to 0.05 by applying electric voltage of DC -200 V. Specific wear rate was decreased with the increasing applied positive and negative voltage. It was considered that the oxidation of CNx was controlled by electric field.

KEYWORDS
CNx, Friction coefficient, Wear, Electric field, Oxidation

INTRODUCTION
CNx showed ultra low friction that friction coefficient is less than 0.01 sliding against Si3N4 ball in Nitrogen [1]. However the application of such ultra low friction of CNx is limited because CNx showed large friction coefficient as about 0.2 in air [1]. Therefore new novel method for low friction of CNx in air is developed urgently.

When CNx slid in Nitrogen, water vapor prevented from obtaining ultra low friction. If the relative humidity of Nitrogen gas is 65 %, friction coefficient increased from 0.007 up to about 0.2 [2]. Also oxygen has a role to increase friction coefficient of CNx. After obtaining ultra low friction of CNx in Nitrogen gas, we charged oxygen gas gradually to the chamber filled up with Nitrogen. As a result, friction coefficient drastically increased when the concentration of oxygen is more than about 2 vol% [3]. Therefore we believe ultra low friction of CNx in air if we avoid the contact of oxygen and water molecule to CNx surface during sliding.

The effects of electric field on friction of sliding of metal against metal were reported. Some reports showed that applied voltage activated oxidation of metals leads to improve friction and wear properties.

On the basis of these past studies, I believe that if the oxidation of CNx would be inhibited by applied electric voltage, friction and wear properties of CNx would be improved in air.

In order to know the possibility to control friction and wear of CNx by electric field, the effect of applied DC voltage on the friction and wear properties of CNx sliding against stainless steel ball was clarified.

EXPERIMENTAL RESULTS
Figure 1 shows the schematics of pin-on-disk friction tester that can apply external voltage to both a stainless steel pin and a CNx coated Si disk. DC electric voltage against base is applied to the back side of the disk through the carbon brush. The CNx coated Si disk and the stainless steel pin are supported with dielectric parts. Therefore electric potential against stage and base was applied to the pin and the disk. The electric voltage of ball and disk is the same. Applied electric voltage is from -500V DC through +500V DC. Whole pin-on-disk friction tester is in the chamber to change the ambient gas during...
friction test. In order to know the effect of oxidation on friction, low humid air (about 28 %RH) and low vacuum (1kPa air) were chosen as ambient condition. Also the oxygen concentration in transfer layer on the ball was measured with an EDS to know the effect of applied voltage on oxidation of CNx.

RESULTS AND DISCUSSION

EFFECT OF APPLIED VOLTAGE ON FRICTION AND WEAR IN AIR (28%RH)

Figure 2 shows the variation of friction coefficient with sliding cycles under different applied electric voltage in air. Friction coefficient started from high values as 0.18-0.28, and decreased with sliding cycle. Friction coefficient without electric field was returned to the high value as 0.22. However friction coefficient under negative electric voltage keep showing low friction coefficient as 0.02 for a while. DC -200 V keeps low friction up the 15000 of sliding cycles. On the other hand, DC +50 V made the number of the low friction small.

Figures 3 and 4 show the effect of electric field on the friction and specific wear rate of CNx at the 15000 of sliding cycles, respectively. Large negative voltage decreased friction coefficient, while positive voltage increased friction coefficient. On the other hand, the wear of CNx was decreased under not only negative voltage but also positive voltage.

On the basis of EDS analysis of transferred layer on the ball from CNx, it was shown that oxidation can be controlled by applied electric filed.

EFFECT OF APPLIED VOLTAGE ON FRICTION AND WEAR IN VACUUM (1 KPA AIR)

Figure 5 shows the effect of applied voltage on friction coefficient and specific wear rate of CNx in low vacuum (1 kPa air). This figure shows the friction and wear are independent of electric field in low vacuum (1 kPa air).

CONCLUSION

The effect of DC electric field on the friction and wear of CNx sliding against stainless steel ball in air was clarified.

(1) Friction coefficient decreased with the increasing negative voltage to apply to the ball and disk in air. On the other hand, positive voltage increased friction coefficient. Friction coefficient of CNx in air decreased from 0.22 to 0.05 by applying electric voltage of DC -200 V.

(2) Specific wear rate was decreased with the increasing applied positive and negative voltage. Specific wear rate of CNx in air decreased from 2.86x10^-8 mm^3/Nm to 1.10x10^-8 mm^3/Nm by applying electric voltage of DC -200V.

(3) When the ambient for friction test is low vacuum as 1 kPa, applied voltage does not change friction and wear amount of CNx.

REFERENCES