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Friction and Wear Properties of Woodceramics at High Sliding Velocity

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Sliding friction and wear of woodceramics (MDF-800) were studied for three kinds of mating ring materials (SF55, SUS304, hard chromium plating) at high sliding velocity. The surface roughness of each ring was varied in the range of ~ 0.4 to ~ 9.0 μ mRmax. Experiments were conducted with a block on ring wear tester under both dry and lubricated conditions. The coefficient of friction was almost constant and lay in the range 0.10 ~ 0.15, irrespective of the mating ring material, the mating surface roughness and the type of lubrication. The only exception was the combination of MDF-800 and SF55 in dry friction. The specific wear rate of woodceramics was (2 ~ 4)x10 $^{-7}$ (mm ^{3} /Nm) in lubricated friction, when sliding against SF55 and SUS304 rings having the surface roughness below ~ 1 μ mRmax.

1.INTRODUCTION

A new material "Woodceramics" has been developed [(1)-(2)] and its practical use has been expected in a industrial world. In order to apply the woodceramics to the machine elements such as clutches, bearings and so on, the friction and wear behaviour of woodceramics have been investigated in detail. Although some works conducted at low sliding velocity have been reported [(3)-(4)],there has been little work at high sliding velocity. In a practical situation, however, most machine elements have operated at high sliding velocity.

Therefore, in this study, the effect of the mating surface roughness on the friction and wear properties of woodceramics at high sliding velocity was studied for three kinds of mating ring materials under both dry and lubricated conditions.

2.EXPERIMENTAL APPARATUS AND PROCEDURE

The experiment was conducted with a block on ring wear tester. The schematic diagram is shown in Fig.1. The ring materials were a forging steel (SF55), a stainless steel (SUS304) and a hard chromium plated steel. The block material was a woodceramics (MDF-800). The properties of specimens are summarized in Table 1. The ring was finished by turning, cylindrical grinding, grinding with emery paper and buffing. The block was finished by grinding with emery paper.

The experimental conditions are summarized in Table 2. The sliding velocity and the load were 10.2m/s and 98N respectively. The experiments were conducted under dry and lubricated conditions. The lubricant was a non-additive turbine oil (ISO VG46). In some cases, a distilled water was also used. The oil was supplied at a flow rate of 23cc/min using a microtube pump. The oil

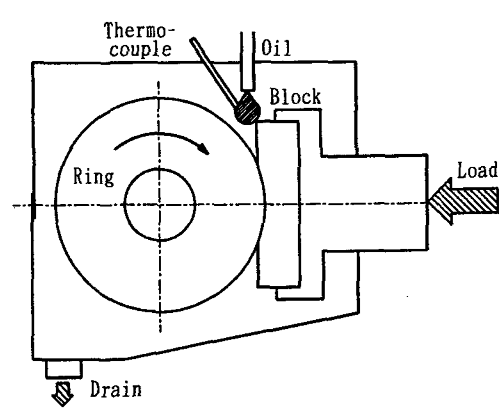

Fig.1 Experimental apparatus.

temperature was kept at 30 ± 3 ℃ with a controller.

The block was pressed softly against the rotating ring at a loading rate of 200N/min. During the test, frictional torque was measured with a torquemeter. Wear volume of the block "V" was calculated by measuring the wear length of block "L" with a universal measuring microscope. The wear volume was calculated by the following expression; $V=L^3 \cdot W/(12 \cdot R)$, where "W" is the width of the block (W=10mm) and "R" is the radius of the ring (R=65mm). The specific wear rate "Ws" was calculated by using the expression: $Ws=V/(P \cdot S)$, where "P" is the applied load and "S" is the sliding distance.

Table 1. Properties of specimens.

	Material	HV	Rmax(μ m)
Block	MDF-800	47~167	45±21
Ring	SF55	189±8	0.5~8.0
	SUS304	191±5	0.4~9.0
	Cr Plating	~700	1.8~2.0

Table 2. Experimental conditions.

Sliding velocity	10.2 m/s
Load	98 N
Sliding distance	18.4 km
Lubricant	Turbine oil(ISO VG46)

3.RESULTS AND DISCUSSION

3.1.Friction property

Fig.2 shows the friction curves obtained in dry friction for the combination with SUS304 ring. The coefficient of friction fluctuates at the initial state of friction for the smooth ring. Thereafter, it becomes constant at ~ 0.15. For the rough ring, it becomes constant soon after the start of testing. Thus, the sliding distance required for the stable friction becomes shorter, as the surface roughness of the ring increases. This is probably because the running-in process proceeds easily due to abrasive action of asperity on the rough surface. For the Cr plating ring, it became constant at ~ 0.11 soon after the start of testing. On the contrary, for SF55 ring, it increased gradually and reached up to ~ 1.0. In this case, transfer from the ring to the woodceramics has occurred commonly [5] . This

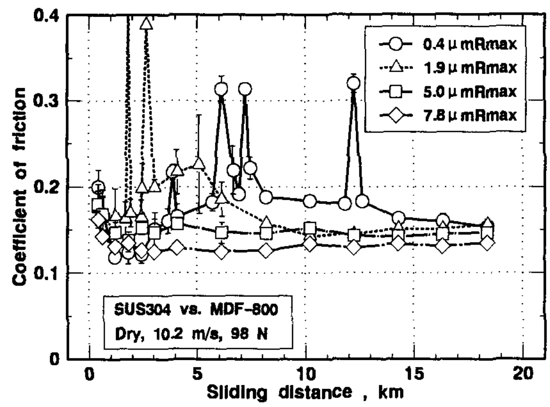

Fig.2. Effect of the surface roughness of the ring on the friction curve in dry friction.

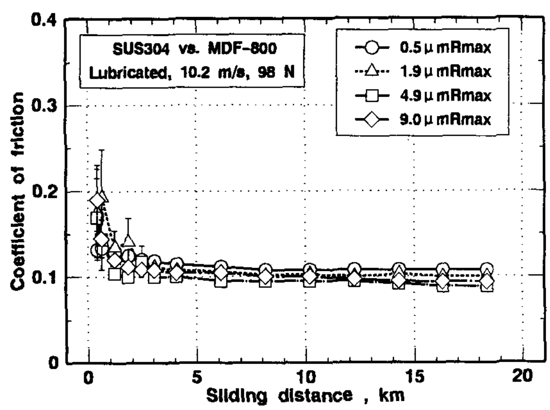

Fig.3. Effect of the surface roughness of the ring on the friction curve in lubricated friction.

probably results from softening of the ring material due to the generation of high frictional heat. Thus, except for the combination with SF55 ring, the coefficient of friction is constant at the steady state. The stable friction is obtainable in combination with the heat-resistant ring material in dry friction.

Fig.3 shows the friction curves obtained in lubricated friction for the same combination. The coefficient of friction becomes constant very soon after the start of testing. It is not dependent on the mating surface roughness and is almost the same at ~ 0.1. For the Cr plating and SF55 rings, the friction behaviour was similar and for the water lubrication, also. Thus, the stable friction is always obtainable in lubricated friction.

All friction data, obtained from the friction curve shown in Figs.2–3, were plotted in relation

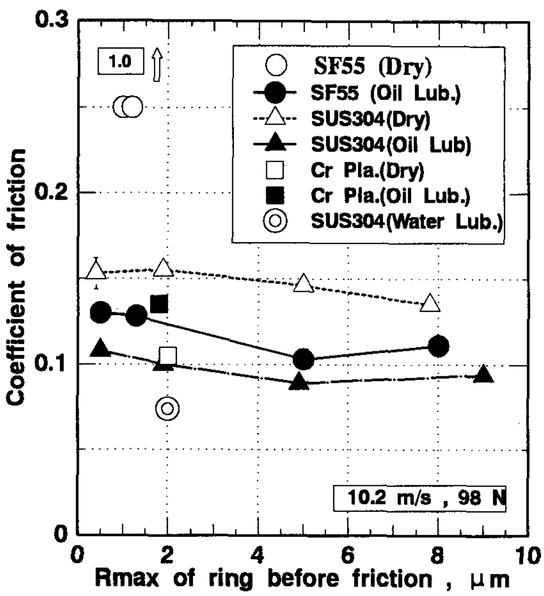

Fig.4. Relationship between the coefficient of friction and the surface roughness of the ring (Rmax) before friction.

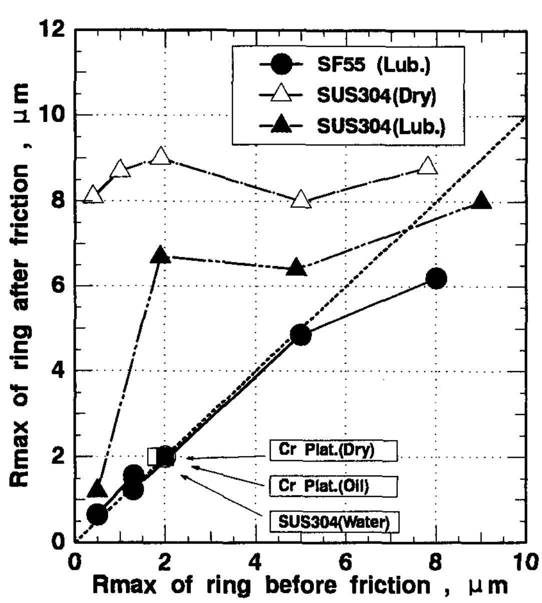

Fig.5. Relationship between the surface roughness of the ring before and after friction.

to the mating surface roughness before friction. The result is shown in Fig.4. Except for the combination with SF55 ring, all friction data lies in the range 0.1 ~ 0.15. Therefore, it is concluded that the coefficient of friction is not dependent on the mating material, the mating surface roughness before friction and the type of lubrication .

Because the woodceramics has porous structure, the lubricant oil does not contribute to reduction of friction due to oil film formation. The oil probably acts for cooling the frictional surface and for washing wear debris out from the surface. Therefore, the coefficient of friction is not dependent on the absence or presence of the lubricant. Further, it is supposed that the transfer from the ring to the woodceramics is prevented and the stable friction is maintained in spite of the combination with SF55 ring. If the shearing strength of graphite having lamellar structure is not dependent on the deepness, the friction behaviour may not depend on the mating surface roughness.

Fig.5 shows the relationship between the surface roughness of the ring before and after friction. For SF55 and Cr plating rings, the surface roughness after friction is almost the same as the initial roughness. In contrast, for SUS304 ring, smooth ring surface becomes rough and rough ring surface keeps above the roughness of 6 μ mRmax, except for the smallest initial roughness of 0.4 μ mRmax in lubricated friction. From the results shown in Figs 4 and 5, it is concluded that low and stable friction is maintained even if the mating surface roughness changes largely during friction.

3.2.Wear property

Fig.6 shows the relationship between the specific wear rate of woodceramics (MDF-800) and the initial surface roughness of the ring. For the combination of SUS304 ring under dry condition, the specific wear rate is large and in the range $6\text{x}10^{-5}$ ~ $2\text{x}10^{-4}$ (mm^3 /Nm). In lubricated sliding, it becomes small. For the rough ring above ~ 1 μ mRmax, it is in the range (7 ~ 9)$\text{x}10^{-6}$. For smooth ring finished up to 0.4 μ mRmax, it is smallest and $4\text{x}10^{-7}$. As sliding against SF55 ring under lubricated condition, the specific wear rate is almost the same at $8\text{x}10^{-7}$ for the rough ring above ~ 1 μ mRmax. For the smooth ring finished up to 0.5 μ mRmax, it is smallest and $2\text{x}10^{-7}$. For the Cr plating ring in both dry and lubricated sliding and SUS304 ring in water lubrication, the

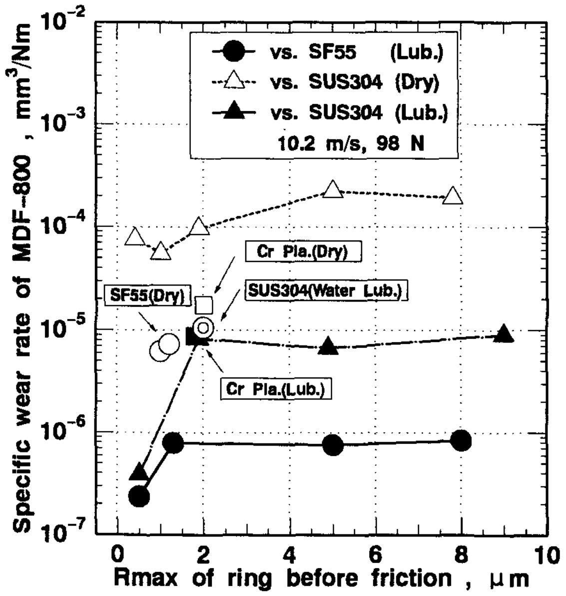

Fig.6. Relationship between the specific wear rate of MDF-800 and the surface roughness of the ring before friction.

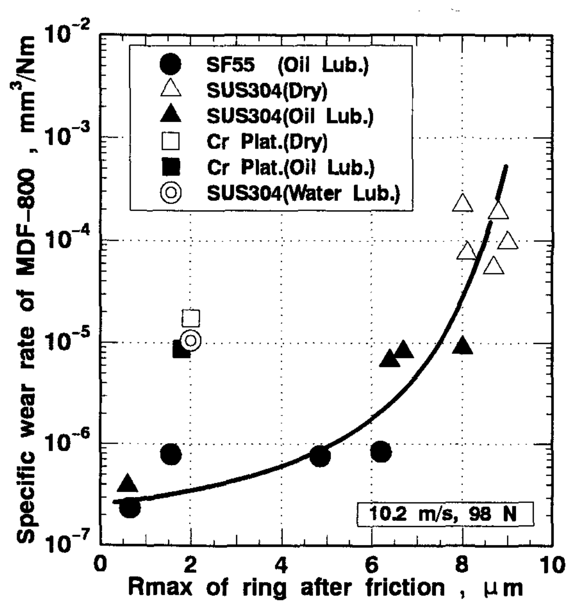

Fig.7. Relationship between the specific wear rate of MDF-800 and the surface roughness of the ring after friction.

specific wear rates are almost the same value and in the range $8x10^{-6}$ ~ $2x10^{-5}$. Thus, the specific wear rate of woodceramics is dependent on the mating material, the initial surface roughness of the ring and the type of lubrication. When sliding against smooth rings of SF55 and SUS304 under oil lubricated condition, the wear rate is smallest. Wear loss of the ring was negligibly small for all tests and could not be determined clearly.

Fig.7 shows the relationship between the specific wear rate of MDF-800 and the surface roughness of the ring after friction. Except for the combinations with Cr plating ring and with SUS304 ring in water lubrication, there is a good correlation. The specific wear rate of woodceramics increases suddenly at the mating surface roughness of ~ 6 μ mRmax. This result suggests that the abrasive action due to surface asperity on mating surface will cause mainly wear of woodceramics. Therefore, it is said the low wear rate in woodceramics can be maintained if the mating material keep the smooth surface during friction.

4.CONCLUSIONS

(1) The coefficient of friction was almost the same and lay in the range 0.10 ~ 0.15, irrespective of the mating material, the mating surface roughness and the type of lubrication. The only exception was the combination of MDF-800 and SF55 in dry friction.

(2) The specific wear rate of woodceramics was (2 ~ 4)$x10^{-7}$ (mm^3/Nm) in the lubricated friction, when sliding against SF55 and SUS304 rings having the surface roughness below ~ 1 μ mRmax.

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