Effect of Load and Sliding Speed on Corrosive Wear of Metals in Seawater

T. KAWAZOE [1], A. URA[1], A. NAKASHIMA[1] and H. Moritaka[1]

[1]*Department of Mechanical System Engineering, Nagasaki University*
1-14 Bunkyo-machi, Nagasaki-City, JAPAN

The objective of this study is to evaluate corrosive wear resistance of metals used for bearings and gears in seawater. Sliding wear test of ferrous and copper materials against Al_2O_3 were carried out in artificial seawater using an electrochemical potentiostat. As the results, the wear rate and the coefficient of friction of the copper materials are lower than those of the ferrous materials. The corrosive wear of stainless steel is remarkably affected by normal load and sliding speed in view of tribological characteristics including adhesion and corrosion products.

Keywords : Corrosive Wear, Tribocorrosion, Friction, Marine Corrosion, Corrosion Potential

1. INTRODUCTION

Corrosive wear caused by corrosion, mechanical wear and the interaction between them occurs in machine parts sliding in seawater, and leads to degradation of its life and performance of marine machinery[1-2]. This study was conducted with the aim of investigating the effect of load and sliding speed on corrosive wear resistance and clarifying the damage behavior of metals commonly used for seawater. Four metals including stainless steel and bronze casting rubbed against Al_2O_3 in artificial seawater were investigated using a ball on disk type wear test machine and a potentiostat.

The obtained results shows that the corrosive wear resistance of the copper materials are superior to the ferrous materials and stainless steel is subjected to heavy surface damage under severe load and high sliding speed.

2. Experimental method

Corrosive wear test were carried out using rotating ball-on-disk type test rig under the electrode potential where many sliding parts are in the most use for seawater. A disk of $^{\Phi}30$x $^{t}5.5$ mm rubbed against a ball of $^{\Phi}19.05$ mm in circulating artificial seawater. The material properties of test specimen are given in Table 1. The normal load and the sliding speed were varied over ranges of P=0.1~29.4(N) and Vs=0.02~1.0(m/s), respectively. The wear volume was derived from the section profile of corrosive were track measured by a profilometer. The surfaces of test specimen were observed with SEM and chemically analyzed using ESCA.

3. Results and Discussion

Fig.1 shows the wear rate of the disks and the balls at P=7.3 and 29.4(N), Vs=0.5(m/s), and sliding distance L=4000(m). The wear rates of the ferrous materials indicate much higher than those of the copper materials. SUS630 (precipitated hardening stainless steel) with high hardness and high corrosion resistance reveals the lower corrosive wear resistance rather than corrosive S25C(carbon Steel). As for Al_2O_3 ball, the wear rate is a tendency to be proportional to that of the disk and it is therefore suggested that strong adhesion between Al_2O_3 and the stainless steels occurs. Some aluminum oxides were detected on the wear tracks of all disks by ESCA so that the effect of the corrosion products such

Table 1 Hardness and electrode potential

	Material	Hardness (Hv)	Electrode potential (mV vs. SCE)
Ball	Al2O3	1750	
Disk	S25C	120	- 500
	SUS304	256	- 80
	SUS630 (H1150)	360	-100
	Cu	148	- 120
	BC2	156	- 140
	AlBC3	181	- 170

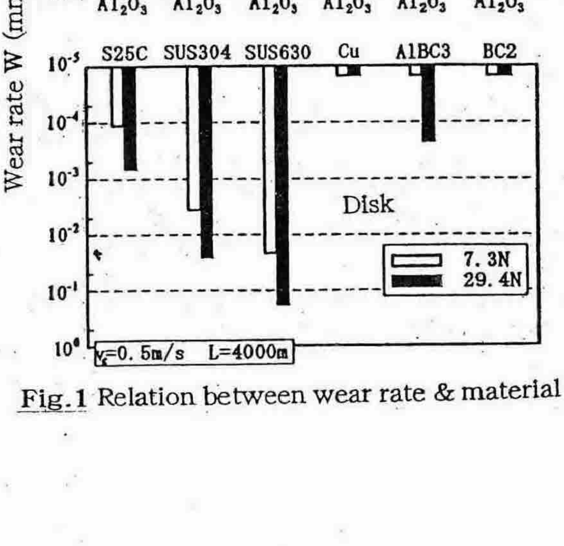

Fig.1 Relation between wear rate & material

Al_2O_3 and$Al(OH)_3$ on the corrosive wear should be considered as R.S.Gates reported [3].

Fig.2 and 3 show the relation between the wear rate of the disks and sliding speed, and the section profiles of the wear tracks at P=7.3(N) and L=1000(m), respectively. The wear rate of SUS630 is lower than that of S25C at the low speed because of the protective film of Cr_2O_3 and low adhesion to Al_2O_3(Fig.3(c)). It however rapidly increases with increasing sliding speed indicating high fiction coefficient of about 0.6 (Fig.3(d)). In this case, the transfer metal of SUS630 was observed on the contact area of Al_2O_3 ball. On the contrary, S25C shows relatively high wear rate at low speed which means long corrosion time indicating deep corrosion pits (Fig.3(a)) but trends to reduce the wear rate with increasing sliding speed. The wear rates of the copper materials are remarkably low. Especially BC2 is lower wear rate with mild wear track (Fig.3(e)) than AlBC3, which demonstrates its practical use for marine bearings. The copper materials also trends to reduce the wear rate with increasing sliding speed. Since the coefficient of friction has the same tendency as the wear rate as shown in Fig.4, it is thought that the copper materials are affected by boundary friction due to seawater and lubricity of the corrosion products.

Fig.5 shows the relation between the wear rate of disks and normal load at Vs=0.5(m/s) and L=1000(m). SUS630, S25C and AlBC3 increases these wear rates with increasing normal load. SUS630 indicates predominant increase over load of 7.3(N), which is in agreement with the experimental results studied by Y. Iwai [4]. Thus SUS630 displays good corrosive wear resistance within the limit of low sliding speed and low normal load, where the protective film of Cr_2O_3. is not destroyed by sliding or the reforming speed of the film is higher than sliding speed even if it is destroyed. Meanwhile the wear rate of BC2 is very low and is not affected by normal load. For reference, all of the disks gradually decrease the electrode potentials with sliding time, which means removal of the protective films due to sliding contact.

4. Conclusions

Wear tests of ferrous and copper materials sliding against Al_2O_3 were conducted in artificial seawater. The following results were obtained.

(1) The copper materials show higher corrosive wear resistance and low coefficient of friction than the ferrous materials. Especially BC2 demonstrates the lowest corrosive wear among the test materials.

(2) SUS630 reveals rapid increase with increasing normal load and siding speed, which relates to its corrosion resistance and adhesion.

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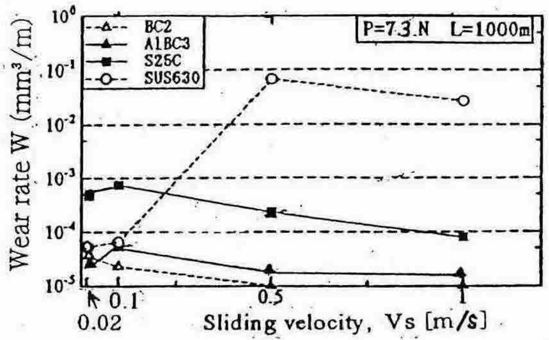
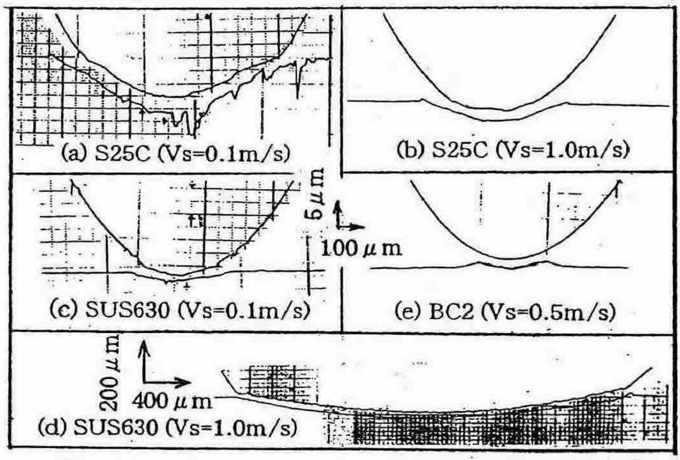


Fig.2 Sliding velocity VS. wear rate



(a) S25C (Vs=0.1m/s)
(b) S25C (Vs=1.0m/s)
(c) SUS630 (Vs=0.1m/s)
(e) BC2 (Vs=0.5m/s)
(d) SUS630 (Vs=1.0m/s)

Fig.3 Section profile of wear track(P=7.3N,L=1000m)

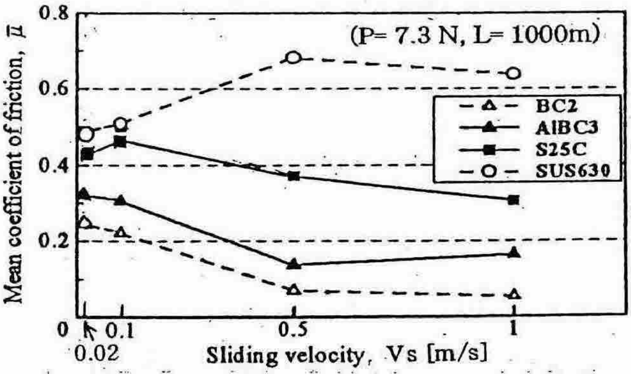


Fig.4 Sliding velocity VS. mean coef. of friction

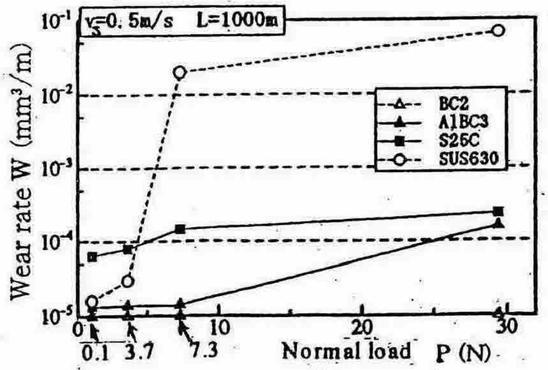


Fig.5 Normal load VS. wear rate