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Development of Lead Free Bronze with Sulfide Dispersion for Sliding Members

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Cu-alloy has been used for a bearing material for a long time because of the good running in properties for steels as the counter materials. These Cu-alloy were selectable for the applications. For example, high strength brass castings and phosphorus bronze castings were used for high strength domain, lead bronze castings was used for anti-seizure domain. For preventing scoring and seizure, it was often combine with a solid lubricant. In this study, tribological properties of the sulfide dispersed bronze were investigated. As a result, seizure was prevented only sulfide bronze under some test conditions. It was estimated that the dispersed sulfide restricted the transfer of the Cu-alloy elements to the mating steel surface.

Keywords: *Cu-alloy, bronze, Sulfide, Friction, Seizure*

1. Introduction

Lead was well-known solid lubricant and lead bronze was useful material for sliding bearings. However, to protect the environment and human health, various regulations have been enacted. These regulations or trends have an impact on industrial manufacturers. Many industries have developed new materials as substitutes for lead in solid lubricants. For example, lead bronze that has been used for slide bearings, has been replaced by a sulfide dispersed bronze (sulfide bronze). Tribological properties such as friction and wear, were investigated on casting [1] and sintering [2] materials comparing with those properties on lead bronze. As a results, sulfide bronze showed the superior friction properties than lead bronze. However, effects of sulfides on anti-seizure is not clarified.

In this study, tribological properties of the sulfide dispersed bronze were investigated. Especially, effects of sulfides on anti-seizure is focused. For the observation of effects of sulfide, sulfide bronze and phosphorous bronze were prepared.

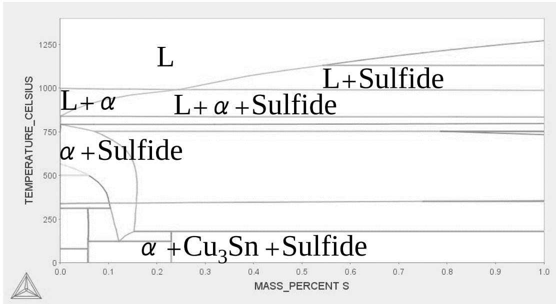


Fig. 1 Calculated phase diagram of sulfide bronze

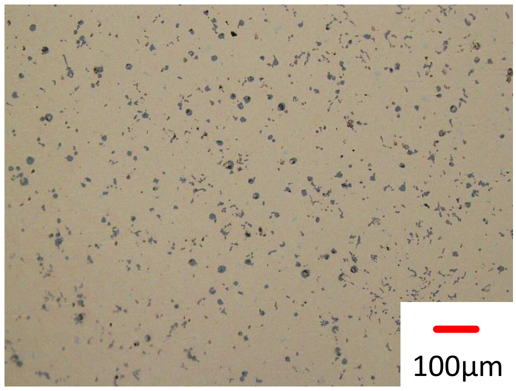
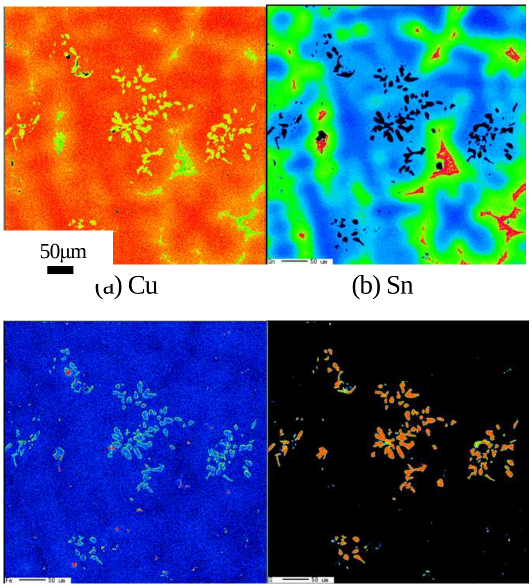


Fig. 2 Microstructure of sulfide dispersed bronze

2. Experiments

2.1 Material

At first, to determine the suitable sulfide contents, phase diagram ware calculated based on CALPHAD (Calculation of Phase Diagram) method on Cu-Sn-Fe-S system as shown in Fig.1. The content of Fe was determined under 1.3 mass% contents because of preventing crystallization of α’-phase of Fe in the Cu-Sn alloy. As a result, it was clarified that sulfide was dispersed in the Cu-alloy because sulfide under 0.25 mass% contents in the alloy was crystalized after crystallization of α-phase Cu. On the other hand, the sulfide remained in the matrix under 0.60 mass % which clarified experimentally. As shown in Fig.2, sulfide was well dispersed in the bronze matrix. Moreover, the sulfides were trapped among the



(a) Cu (b) Sn

(c) Fe (d) S

Fig. 3 Element mapping by EPMA

dendrites of Cu-Sn alloy. These results are observed by optical microscope and EPMA (Electron Probe Micro Analyzer) shown in Fig.3.

2.2 Experimental procedure

Effects of sulfide dispersion in the Cu-Sn alloy were experimentally evaluated using a 3 balls type ring on disc testing apparatus in dry condition. Only the effect of the sulfides was observed, phosphorus bronze so called CAC502C restricted in JIS (Japan Industrial Standard) was prepared for comparison. The matrix of phosphorus bronze was almost as same as the sulfide bronze. Details of compositions are shown in Table 1.

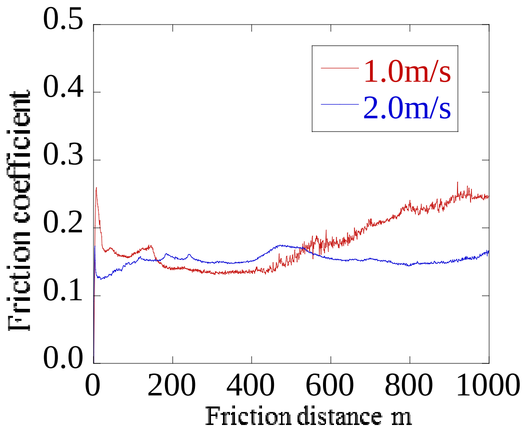
Table 1 Chemical compositions (mass %)

	Cu	Sn	S	Fe	P
Sulfide bronze	Bal.	10.00	0.55	0.15	0.02
Phosphorus bronze	Bal.	10.00	-	-	0.12

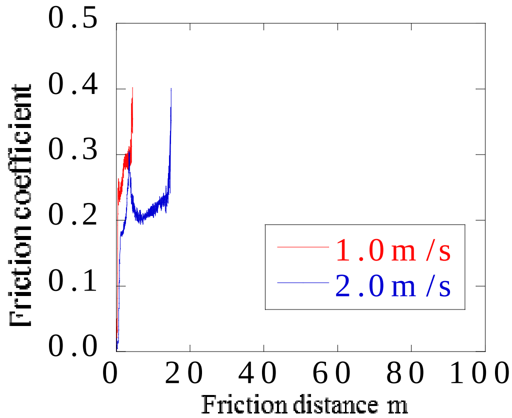
Mating materials were carbon steels so called S45C restricted in JIS. In the test, constant force 10 N was loaded and constant speed 1.0 m/s or 2.0 m/s were selected as the conditions.

3. Results and discussion

Fig. 4 shows results of the friction test. During the test, sulfide bronze did not occur scoring and seizure. On the other hand, Phosphorus bronze had seizure beginning on the test. As a result, seizure was prevented only sulfide bronze. As shown in Fig.5, Sulphur was detected on the friction tracks. It was estimated that the dispersed sulfide restricted the transfer of the Cu-alloy elements to the mating steel surface.



(a) Sulfide bronze



(b) Phosphorus bronze

Fig. 4 Results of friction test

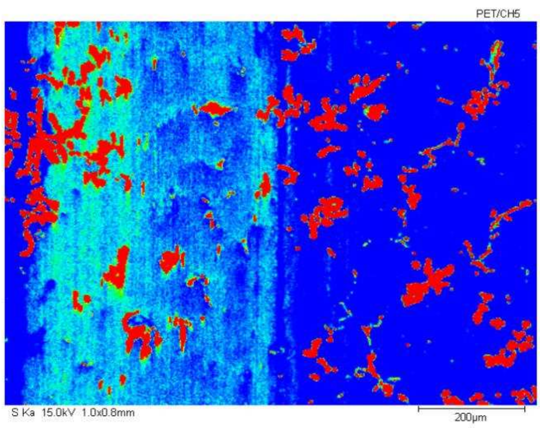


Fig. 5 Mapping of S by EPMA after the test

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