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Influence on Corrosion Resistance of Additive Element for Environmental-Friendly Brass Alloy

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We have studied environmentally-friendly brass with good corrosion resistance required for water products. The aim of this study is to investigate the mechanical property and corrosion-resistance of the brass alloys, called KBS1 and KBS2. KBS1 and KBS2 can adapt to newly environmental regulation for lead in water supply works in all the countries of the world, and were based on 70%Cu-30%Zn added element such as Al, Ni, Sn and P. The mechanical property and corrosion resistance of KBS1 and KBS2 were compared with JIS copper alloys and were investigated the influence on the corrosion resistance of additive element, in this study. The results showed that the mechanical properties of KBS1 and KBS2 were equal to CAC203 alloy. In addition, the dezincification corrosion test specified by ISO 6509 and Jet-in-slit erosion-corrosion test indicated that both the KBS1 and KBS2 had superior corrosion resistance to CAC203 alloy. Therefore, these additive elements were suggested to be effective for corrosion resistance.

Keywords: *lead-free-brass, low-lead-brass, dezincification-corrosion, erosion-corrosion, corrosion resistance*

1. Introduction

Japan Industrial Standard (JIS) CAC203(CAC203) alloy containing 0.5 to 3 mass% of Pb has been used as water faucet materials for water supply because of its good castability, high mechanical properties and good machinability. However, in late years the application of CAC203 has become difficult because of Pb regulation for drinking water in all over the world. In addition, the use of CAC203 alloy in water service product is limited because it does not have good corrosion resistance.

We developed two kinds of 70%Cu-30%Zn base alloy contained Bi or low Pb as environmental-friendly brass, called KBS1 and KBS2, added Al, Ni, P and Sn. In this study, to evaluate influence on corrosion resistance of additive element, the mechanical properties and corrosion resistance of KBS1 and KBS2 were investigated by tensile test, dezincification corrosion test and erosion-corrosion test, respectively, and were compared with those of three copper alloys.

2. Experimental

2.1 Test Sample

As for the test samples, CAC203, CAC406, CAC804 and the developed brass alloys (KBS1 and KBS2) were casted in φ20mm of metal die and sand mold of JIS type A(JIS H5120). Chemical compositions of test materials are shown in Table1.

Table1 Chemical compositions of test materials

	Cu	Zn	Sn	Pb	Bi	Ni	Al	Si	P
CAC203	Bal.	37.8	0.2	2.1	-	-	0.02	-	-
CAC406	Bal.	5.4	4.4	4.8	-	0.2	-	-	0.020
CAC804	Bal.	20.2	0.1	-	-	-	-	3.25	0.086
KBS1	Bal.	30.6	-	-	0.7	0.4	1.3	-	0.045
KBS2	Bal.	29.1	1.2	0.18	-	-	0.8	-	0.035

2.2 Tensile test

Tensile tests of KBS1 and KBS2 casted in sand mold were performed according to Japanese Industrial Standard JIS Z2241-2011.

2.3 Dezincification corrosion test

Dezincification corrosion tests of CAC203, CAC406, CAC804, KBS1 and KBS2 alloys casted in metal die were conducted according to ISO 6509-1981.

2.4 Erosion-corrosion test (Jet-in-Slit test)

The erosion–corrosion behavior of CAC203, CAC406, CAC804, KBS1 and KBS2 alloys casted in metal die were examined using Jet-in-Slit test. The principle of Jet-in-Slit erosion-corrosion test is shown in Fig.1. As shown in Fig.1, Jet-in-Slit test can be used to evaluate the erosion-corrosion induced by the shear stress and fluid flow turbulence.

The test condition of Jet-in-Slit test is shown in Table 2. After the test, maximum corrosion depth and mass loss were measured.

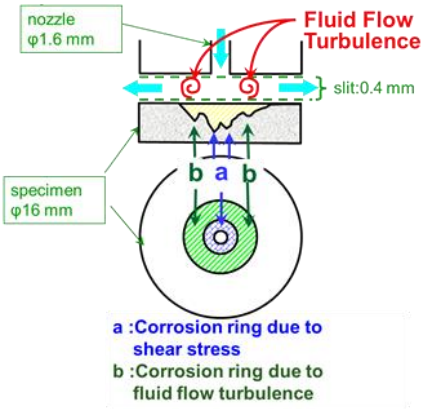


Fig.1 Principle of Jet-in-slit erosion-corrosion test

Table2 The test condition of Jet-in-Slit test

Test condition	
Test solution	1% $CuCl_2 aq$
solution temp., (℃)	40
Flow rate (m/s)	3.3
Slit (μm)	400
time (hour)	2

3. Result

3.1 Tensile test

Tensile test results of KBS1 and KBS2 are sown in Table3, together with the tensile strength and elongation values of CAC203, CAC406 and CAC804 specified by JIS. As shown in Table 3, mechanical properties of KBS1 and KBS2 were inferior to those of CAC804; however, they were superior to those of CAC406. KBS1 and KBS2 meet the standard requirement of CAC203.

Table3 Tensile test results of KBS1 and KBS2 and standard value of JIS materials.

Alloy name	Value	Tensile Strength (MPa)	Elongation (%)
CAC203	Standard Value	more than 245	more than 20
CAC406	Standard Value	more than 195	more than 15
CAC804	Standard Value	more than 300	more than 15
KBS-1	**measured Value**	**301**	**40.5**
KBS-2	**measured Value**	**253**	**25.9**

3.2 Dezincification Corrosion test

The maximum dezincification corrosion depth of specimen is shown in Fig.2. CAC203 only exhibited a very large maximum dezincification depth of 426μm. The other four kinds of copper alloys, included KBS1 and KBS2, had the maximum dezincification depth of less than 30μm, showing good dezincification resistance.

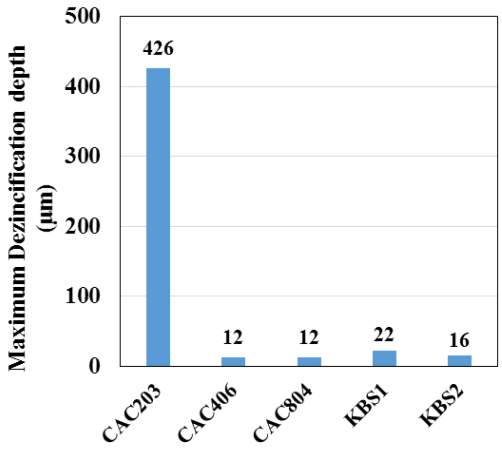
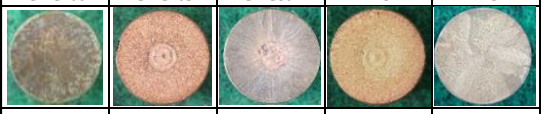


Fig.2 The maximum dezincification corrosion depth of specimen

3.3 Erosion-corrosion test (Jet-in-Slit test)

The results of Jet-in-Slit erosion-corrosion test are shown in Fig.3. In CAC203, CAC804 and KBS1, corrosion ring due to erosion-corrosion were observed. By comparing these three alloys, it could be found that KBS1 had a smaller maximum corrosion depth than the CAC203 and CAC804, suggesting that KBS1 had a better erosion-corrosion resistance than CAC203 and CAC804. In contrast, corrosion ring was not confirmed in CAC406 and KBS2, indicting that CAC406 and KBS2 had excellent erosion-corrosion resistance. Considering the two kinds of the corrosion test results, it could be suggested that KBS2 has the same corrosion resistance with CAC406 bronze castings.

Fig.3 Results of Jet-in-Slit erosion-corrosion test

Alloy	CAC406	CAC203	CAC804	KBS1	KBS2
Appearance					
mass loss (mg)	133	318	317	163	118
maximum corrosion depth (μm)	**25**	**498**	**502**	**287**	**33**

4. Conclusion

1) KBS1 and KBS2 have good mechanical property equal with JIS standard value of CAC203.

2) KBS1 and KBS2 show good corrosion resistance (including dezincification corrosion and erosion-corrosion resistances) as compared with CAC203 and CAC804

3) KBS2 has almost same erosion-corrosion resistance with CAC406 bronze castings.

4) Additive of Al, Ni, P and Sn in brass alloys were effective to corrosion resistance.