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Development of novel brasses to resist dezincification

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Abstract

The effect of alloying Sn, Pb, As, Sb and P on the dezincification of commercial brass 60Cu–39Zn–1Pb has been investigated in 1% $CuCl_2$ solution by immersion studies and electrochemical measurements. Specimens with a smooth surface finish exhibited more resistance to dezincification. Appreciable inhibitive effect on dezincification was observed for the 55Cu–40Zn–3Pb–2Sn brass composition. The galvanic coupling of lead phase with the matrix accelerated corrosion. To improve the dezincification resistance of the Sn containing brass, As, Sb and P were added at two different levels (0.05% and 0.1%). Brass of composition 48.95Cu–45Zn–5Pb–1Sn–0.05As was more resistant indicating the synergistic effect of Sn and As. The effect of 0.05 and 0.1% of arsenic addition with various concentrations of zinc was also studied. The alloy of composition 57.90Cu–40Zn–2Pb–0.1As showed better corrosion resistance than the alloy containing 1% Sn and 0.05% As (48.95Cu–45Zn–5Pb–1Sn–0.05As). To understand the influence of Sn and As on the dezincification of commercial brass, linear polarization and cyclic voltammetry experiments were conducted for the alloys 60Cu–39Zn–1Pb, 55Cu–40Zn–3Pb–2Sn and 57.90Cu–40Zn–2Pb–0.1As. Linear polarization measurements indicated that the alloys 55Cu–40Zn–3Pb–2Sn and 57.90Cu–40Zn–2Pb–0.1As possessed higher resistance to corrosion than commercial brass. Inspection of cyclic voltammograms revealed that the peak current densities as well as the passive current density were lower for the alloys 55Cu–40Zn–3Pb–2Sn and 57.90Cu–40Zn–2Pb–0.1As than the alloy 60Cu–39Zn–1Pb. The surface layer on the alloys 60Cu–39Zn–1Pb, 55Cu–40Zn–3Pb–2Sn and 57.90Cu–40Zn–2Pb–0.1As after immersion of 72 h in 1% $CuCl_2$ solution were analyzed by X-ray diffraction and scanning electron microscopy. Higher enrichment of Sn and As at the interface of surface layer and metal was indicated for the alloys 55Cu–40Zn–3Pb–2Sn and 57.90Cu–40Zn–2Pb–0.1As, respectively.

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1. Introduction

Dezincification or the preferential dissolution of zinc from brass is known for decades. The two general mechanisms postulated to explain this phenomenon are selective dissolution of zinc [1,2] and simultaneous dissolution of both copper and zinc with the subsequent re-deposition of copper [3,4]. The preferential dissolution of zinc leads to a porous and friable layer of corrosion products of copper at the surface. The addition of small amounts of tin [5,6] and elements like arsenic, antimony and phosphorous [7–9] improves the dezincification resistance of brasses in various aggressive environments.

One of the applications of brasses is for the casting of decorative items. Brasses are widely used for outdoor applications and sanitary fittings, which are exposed to corrosive environments [10]. The present study was directed towards determining the optimum concentration of alloying elements that provide good resistance to dezincification in commercial brasses for decorative castings. Immersion measurements have been carried out to identify the influence of alloying elements and surface finish on the corrosion behaviour of brasses. Electrochemical studies and surface characterization methods were used to identify the nature of corrosion.

2. Experimental procedure

The chemical composition (in wt.%) of the brass alloys studied are provided in Table 1. The 60Cu–39Zn–1Pb brass is a commercial alloy which is industrially used to prepare decorative brass objects. The commercial brass objects as well as the other brass samples were obtained from D.S. Gupta and Sons, Moradabad, India, one of the largest exporters of commercial brass castings in India. The samples were supplied in the form of flat strips

Table 1
Thickness reduction for rough and smooth casted brasses after immersion in 1% $CuCl_2$ solution for 72 h

Sample	Chemical composition (%)	Thickness reduction for rough casted brass (mm)	Thickness reduction for smoothly finished brass (mm)
1	60Cu–39Zn–1Pb	0.212 ± 0.12	0.017 ± 0.009
2	48Cu–45Zn–5Pb–2Sn	0.208 ± 0.11	0.019 ± 0.008
3	55Cu–40Zn–3Pb–2Sn	0.051 ± 0.03	0.009 ± 0.003
4	48.95Cu–45Zn–5Pb–1Sn–0.05As	0.037 ± 0.03	0.008 ± 0.002
5	48.90Cu–45Zn–5Pb–1Sn–0.05As–0.05Sb	0.048 ± 0.02	0.016 ± 0.006
6	48.85Cu–45Zn–5Pb–1Sn–0.05As–0.05Sb–0.05P	0.071 ± 0.05	0.023 ± 0.005
7	48.90Cu–45Zn–5Pb–1Sn–0.1As	0.323 ± 0.13	0.021 ± 0.008
8	48.80Cu–45Zn–5Pb–1Sn–0.1As–0.1Sb	0.23 ± 0.08	0.100 ± 0.01
9	48.70Cu–45Zn–5Pb–1Sn–0.1As–0.1Sb–0.1P	0.22 ± 0.11	0.030 ± 0.004
10	52.95Cu–45Zn–2Pb–0.05As	0.057 ± 0.01	0.026 ± 0.006
11	52.90Cu–45Zn–2Pb–0.1As	0.024 ± 0.01	0.017 ± 0.005
12	57.95Cu–40Zn–2Pb–0.05As	0.028 ± 0.01	0.015 ± 0.006
13	57.90Cu–40Zn–2Pb–0.1As	0.008 ± 0.003	0.004 ± 0.002