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Oxidation of copper at 573K in air

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The kinetics of oxidation of copper and the oxidation resistance of copper with water films of Na_2SiO_3, $MgSO_4$ and $SnCl_2$ were studied at 573K in air.

Key words: Kinetics, oxidation, copper

INTRODUCTION

The kinetics of oxidation of copper were studied by many authors [1-7] and different laws were obeyed. The oxidation resistance of stainless steel was increased by addition of thorium by dipping in thorium nitrate solution [8]. In the present study, the kinetics of oxidation of copper and the oxidation resistance of water film of $MgSO_4$, sodium silicate, and stannous chloride were tested.

EXPERIMENTAL

Polished and degreased copper specimens (1.25 × 2.5 cm) were used for oxidation tests. A rectangular furnace (R.T.-1473K) with a sensitivity of ±10° and Mettler balance with a sensitivity of 0.1 mg were used for oxidizing and weighing the samples.

Kinetics of oxidation

The copper specimens were oxidized for $\frac{1}{2}$ hr to 3 hrs. at intervals of $\frac{1}{2}$ hr. at 573K in air and the gain in weights were found out. A plot of dw^2 vs t was made (Fig.1). The parabolic constant, K_p was obtained from the gradient of the straight line.

Water films

1% aqueous solutions of sodium silicate, magnesium sulphate and stannous chloride were prepared. Water films on copper were obtained by dipping in these solutions for 2 minutes and air dried for 15 minutes. Later the copper specimens with and without water film were oxidised in the furnace for 2 hours at 573K in air and the gain in weight was found out in each case. From the gain in weight of specimens, the oxidation reduction efficiency (X%) was calculated using the following formula:

$$X\% = \frac{W_1 - W_2}{W_1} \times 100$$

where, W_1 = weight gain of specimens without water films (blank)

W_2 = weight gain of specimens with water films.

The $x^2(dw^2)$ values were calculated with computer with a program using the experimental parabolic constant in the equation $x^2 = K_t$. The calculated values of x^2 are given in Fig.1. The photomicrographs (100 ×) were obtained with Neophot metallurgical microscope for the surface and cross-section of the oxidised blank copper specimens.

RESULTS AND DISCUSSION

The plot of dw^2 vs t gave a straight line and this indicates the validity of parabolic law. The parabolic constant was 0.14×10^{-7} g/sq.in/min. The calculated values (Fig. 1) were higher than the experimental values. The results agree with the results of other workers. Weight gain of blank copper specimens = 2.5 mg/sq.in.

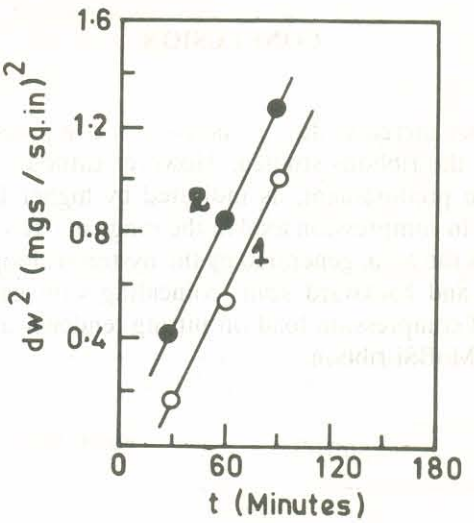

Fig. 1: Oxidation of copper at 573K in air
o Experimental • Calculated

Table I gives the oxidation reduction efficiencies (X%) of copper for various water films. The oxidation reduction efficiency will give the percentage reduction in oxidation and hence the oxidation resistance of these films. Previously, oxidation resistance of S.S. was improved by addition of small amounts of thorium by dipping in the

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solution of thorium nitrate [8]. The effect of addition of alloying elements to copper was given by other authors [9]. In these cases, the oxidation resistance was brought about by the formation of protective oxide films. In the present study also, some protective oxides might have formed due to the presence of water films of silicate, Mg and Sn and these oxides might have acted as barrier for the approach of oxygen to metal surface and no alloying of copper might have occurred at 573K. In earlier work [10], the effect of oxide coatings (slurry) on iron was interpreted on the basis of barrier oxide films.

TABLE–I: The oxidation reduction efficiency of copper

10 K = 0.14 $\times 10^{-7}$ (gms/sq.m)^2/min.
20 For T = 30 to 180 step 30 min.
30 Print T,T × K
40 Next T
50 End

Sl. No.	Water films	X%
1.	$MgSO_4$	8
2.	Na_2SiO_3	32
3.	$SnCl_2$	62

The photomicrographs for the oxidized films are given in Fig.2 for the surface and cross-section. The photomicrograph (1) of surface reveals a matrix structure. The photomicrograph (2) gives the cross section of the oxidized sample (blank) and shows the metal and oxide layer.

Fig. 2: Photomicrographs of oxidized samples of copper at 573K in air
1. Surface
2. Cross –section magnification 100X

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