Effect of Aluminium Addition in White Cast Iron on Corrosion rate in Aqueous Solutions

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The corrosion rate of white cast iron and 3% W/W aluminium added cast iron samples has been determined in 1 M NaCl and Na_2SO_4 solutions of pH 4.0, neutral pH and pH 10.0. The corrosion rate has been found to decrease with increasing pH. At any pH, the rate of corrosion is found to be higher in NaCl as compared to Na_2SO_4 solutions. Also, the presence of aluminium in the cast iron is found to decrease the rate of corrosion in both the electrolytes and at all pH values.

Due to its comparatively low cost, cast iron is extensively used for industrial and other day to day applications like sewer pipes, pump impellars, bearings etc. [1]. It is resistant to corrosion in both neutral and alkaline solutions but is prone to corrosion by acids [1]. The corrosion rates of different types of cast iron in sea waters have been reported by a number of workers [2-6] and the effect of different inhibitors on corrosion of grey cast iron in sulphuric acid and NaOH solutions has been studied [7].

Cast iron is a hard but brittle material. Due to high wear resistance, it is widely used in cylinder liners, valves and components which are subjected to high velocity or abrasion, where it is simultaneously exposed to wear and corrosive environments [1]. The studies on corrosive wear of grey cast iron in sulphuric acid [8] and oil-sulphuric acid mixture has been reported [9]. The hardness and impact properties of white cast iron have been improved in our laboratory by the addition of aluminium [10]. For a wider utilisation, the material should have not only improved physical and mechanical properties, but also it should possess good corrosion resistance to different corroding environments. It was therefore considered necessary to evaluate the corrosion resistance of the aluminium added cast iron and compare it with parent material. The studies were carried out in 1.0 M NaCl and 1.0 M Na_2SO_4 solution with continuous stirring under quasi steady state conditions at a potential sweep of 1.0 mV/sec. in Tafel region of potentials. The results of these studies are presented in this paper.

EXPERIMENTAL

The chemical composition of the samples - Cast Iron (CI) and Aluminium Added Cast Iron (Al in CI) - are as follows:

(CI):Si as SiO_2-1.79%, C-2.70%, S - 0.06%
(Al in CI) : Si as SiO_2 - 1.61%, C-2.65%, S-0.06%, Al - 3.06%

Flat disc shaped samples of 1.0 cm^2 area were cut from rod shaped castings, polished successively with 1/0 to 4/0 emery papers followed by cloth polishing. Then the electrode surface was washed with distilled water, degreased with acetone and again washed thoroughly with distilled

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water. The specimen was mounted in the electrode holder (EG & G PAR) & immersed in the test solution contained in an all glass cell. The test solution was stirred during experiment using a magnetic stirrer and a Teflon coated magnetic bar. Graphite rods & saturated calomel electrode served as counter & reference electrode respectively.

An EG & G PAR make potentiostat (model 273), monitor, computer and printer were used in the present study for recording Tafel plots - the same set up as used previously [11,12]. The quasi-steady state Tafel experiments were carried out under potentiostatic polarisation in the potential range -200 to +200 mV or -250 to +250 mV *vs* open circuit potential. The potential was scanned at a rate of 1.0 mV/sec. The PARCALC programme, procured from M/S EG & G PAR was used to evaluate the Tafel slopes (b_a and b_c). Rate of corrosion was evaluated in mills per year (MPY).

RESULTS AND DISCUSSION

The Tafel plots for the two samples in 1 M solution of sodium chloride (pH values 4.0, neutral and 10.0) are given in Fig. 1; the corresponding plots in 1 M sodium sulphate solutions are given in Fig. 2. For all the curves, the cathodic slope is observed to be higher than the respective

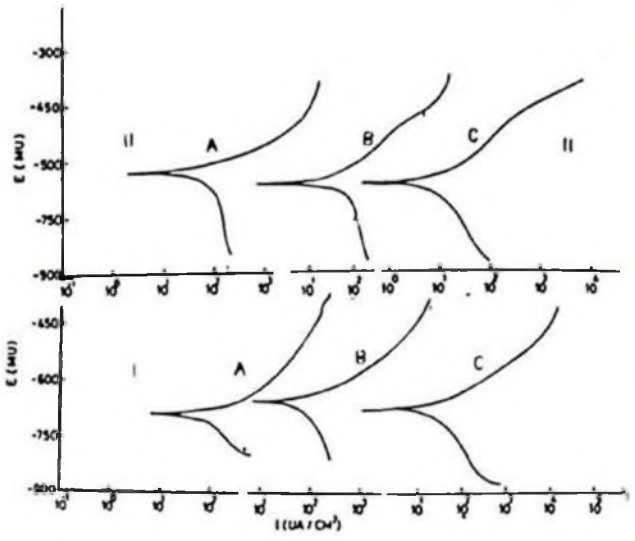


Fig.1. Tafel plot in 1.0 M NaCl solution I Cast Iron: II Al added Cast Iron (a) pH 4.0, (b) neutral pH (c) pH 10 E(mV) i(μA)

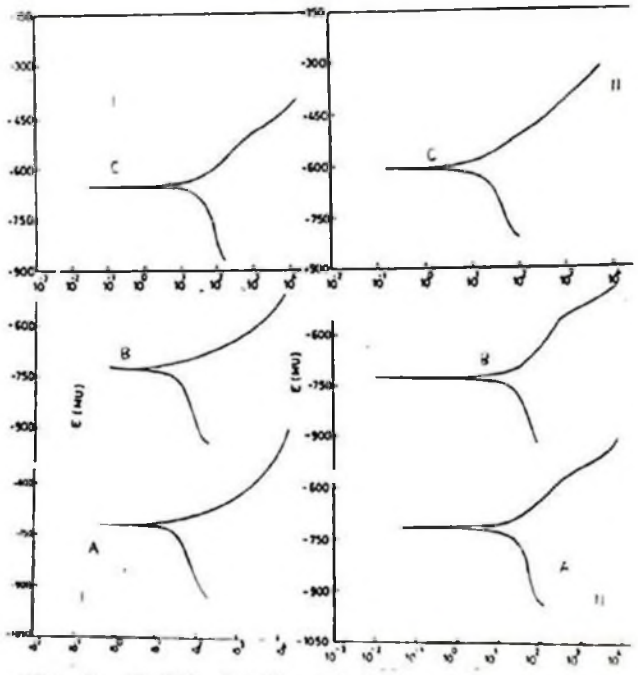


Fig. 2. Tafel plot in 1.0 M Na_2SO_4 solution I Cast Iron: II Al added Cast Iron (a) pH 4.0, (b) neutral pH (c) pH 10 E(mV) i(μA)

Table 1

The corrosion Potential (Ecorr) in 1 M Solutions of NaCl and Na_2SO_4

pH	NaCl 4.0	NaCl Neutral	NaCl 10.0	Na_2SO_4 4.0	Na_2SO_4 Neutral	Na_2SO_4 10.0
Cast Iron	-687.7	-650.0	- 671.4	-714.5	-715.3	-640.0
Al in Cl	-624.8	-658.3	- 659.9	-709.0	-720.7	-604.4

Table 2

Rate of Corrosion by Tafel Method (in MPY)

	NaCl			Na_2SO_4		
pH	4.0	Neutral	10.0	4.0	Neutral	10.0
Cast Iron	61.69	44.69	16.61	22.24	21.54	20.92
Al in Cl	55.03	27.36	5.66	14.26	11.95	8.63

anodic slope. The corrosion potentials (E_{corr}) in the solutions studied are given in Table 1. It is seen that the addition of 3% W/W aluminium has very little effect on Ecorr. In fact, the difference in Ecorr value in a given solution for cast iron and aluminium added cast iron is found to be within ±20 mV except in the case of sodium chloride solutions of pH 4.0; here the difference between the two values is 63 mV.

Tha rate of corrosion in different solutions were calculated from the anodic and cathodic slope values using PARCALC computer programme and are given in Table 2.

The addition of aluminium to white cast iron is found to reduce its rate of corrosion. This is in conformity with the observation reported by Kususe et al. [13]. In acidic solutions, the rate of corrosion is found to be higher as compared to neutral solutions. In NaCl solutions, the rate of corrosion at pH 10 is considerably lower as compared to neutral solutions. This may be due to the presence of a thin oxide/ hydroxide layer at the metal surface. In the case of sodium sulphate solutions, there is only a marginal change in corrosion rate with change in pH. Also, as compared to sulphate solutions, the corrosion rate is higher in chloride solutions. The higher corrosion rate in NaCl solutions is attributable to the instability of the protective layer at the metal/solution interface due to penetration by chloride ions.

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