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Progressive Atmospheric corrosion study of Metals like mild steel, zinc and aluminium in Tithal Marine Environment

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ABSTRACT

Corrosion rate (Progressive) of mild-steel (MS), zinc and aluminum have been determined under outdoor conditions of exposure at Tithal (South Gujarat) representing a marine environment. Mild steel (MS), zinc and aluminium plates exposed during November-2005 indicates corrosion rate of 122, 55 and 2.1 mg/sq.dm for one month exposure period and 3305, 1227 and 25.9 mg/sq.dm for twelve months exposure period. Mild steel panels exposed vertically suffer less corrosion than those exposed at an angle of 45°. The resistivity towards the environment was in the increasing order of mild steel < zinc < aluminium. Corrosion rate of these three metals was found more in rainy seasons than the rate of winter and summer season.

Keywords: Atmospheric Corrosion, Marine environment, mild-steel, zinc and aluminium.

INTRODUCTION

The corrosiveness of a marine environment depends on the topography of the shore, wave action at the surf line, prevailing winds and relative humidity. Marine atmospheres are usually highly corrosive. The principal culprit in marine atmospheres is the chloride (Cl^-) ion derived from sodium chloride. The main factors which aggravate or catalyze the corrosion process are sea salts and relative humidity. It is known that the corrosion process can occur at relative humidities as low as 35% [1]**.** Hence, the extent metal corrosion is a function of salt and humidity in the air [2]**.**

The present study was carried out in the marine environment under outdoor exposure at Tithal (Dist. Valsad) situated in South Gujarat. This area is three metres above the mean sea level and about 0.25 km away from the Arabian Sea.

MATERIAL AND METHODS

Test plates of mild steel, zinc and aluminium have the following chemical composition:
a) Mild-steel **:** C (0.038%), Mn (0.265%), S (0.015%), P (0.011%), Si (0.012%), Cr (0.021%),Mn (0.006%), Al (0.033%), Cu (0.011%), Sn (0.002%), Ni (0.0115%) and Fe-rest.
b) Zinc **:** 99.39 % purity, Pb (0.03% Max), Cd (0.02% Max.) and Fe (0.01% Max.).
c) Aluminum **:** 99.09 % purity and Si (0.53%).

Test plates are individually mounted on a wooden rack. Special care should be taken that they were electrically insulated from surrounding metallic stand. The frame was placed in parallel outdoor fully exposed condition on the ground level making an angle of 45° towards the horizontal plane. Another set of mild steel (MS) panels were fully exposed vertically.

Twenty four specimens of each metal (mild steel, zinc and aluminium) were exposed at the same time (i.e. during November 2005). After completion of exposed period, the progressive weight loss of metal was determined. So, we get successive corrosion rates for one month, two months, three months upto twelve months. Similarly, another set was exposed during March 2006.

All tests were carried out in duplicate and mean of the two values were taken. After exposure period test plates were wrapped in plastic bags and brought to the laboratory for cleaning. Different cleaning solutions are to clean different metals. Hudson used Clark's solution [3-4] to remove rust from mild-steel made by 2% Sb_2O_3 (antimony Oxide), 5% $SnCl_2$ (stannous chloride) in concentrated HCl (100 ml) at room temperature with constant stirring about 15-20 minutes. Zinc plates are derusted by 10% CrO_3 and about 0.2 gm $BaCO_3$ in distilled water (100 ml) at 25°C for about 2 minutes [5]**.** Corrosion products on aluminium plates were removed by using the solution of concentrated HNO_3 containing CrO_3 (chromic acid, 50 mg/lit) at a room temperature for about 10 minutes [6]**.**

RESULTS AND DISCUSSION

Meteorological and pollution data: Generally, the rain starts in June and continuous up to September. Total annual rainfall was found 1817 mm in 2006 and 2114 mm in 2007. March, April, May and June are the hot months of the year, whereas December, January and February are considered as cold months. Average maximum and minimum temperatures are about 308 K and 290 K respectively. Relative humidity is higher than the critical humidity value (70%) for corrosion of iron [7] for six months in a year 2006 and in 2007 (Fig.1). A sulphation rate was measured at marine station (Tithal) ranging from 9.6 to 19.8 mg SO_3/sq.dm/month (Fig.2). A sulphation rate of 0.03 mg SO_3/sq.dm/day (0.9 mg SO_3/sq.dm/month) is usually accepted as representative of clean-air [8]**.**

The sulphation rate of different locations were observed as follows: 35 mg/m^2/day SO_2 at Cuba (coastal) [9], in Ibero- American region 22-marine atmosphere shows SO_2 pollution about 10 mg/m^2/day [10] and 3.6 to 11.1 mg SO_3/sq.dm/month at Liesegang [11] and 7.2 to 13 mg SO_3/sq.dm/month at Dumas [12]**.**

Mild Steel (MS): MS plates exposed in winter months indicates that the corrosion rate increases slowly up to seven months (i.e. up to may-2006) and then it increased rapidly for another five months (i.e. from June-2006 to October-2006).The corrosion rate of mild steel indicates 122 mg/sq.dm for one month and 3305 mg/sq.dm for Twelve months exposure period.

Similarly, plates exposed in summer months (i.e. from March-2006) shows corrosion rate increases rapidly for seven months (i.e. from March-2006 to September-2006), then it remain almost steady for further two months (i.e. from October-2006 to November-2006) (Fig.-3).

Positional effect: The results indicate that the panels exposed vertically suffer less corrosion than those exposed at an angle of 45° (Table-1).

Zinc: The observation of first set of zinc metals exposed in winter month (November-2005) indicates that the corrosion rate increases slowly up to seven months (i.e. up to May-2006) and then it increased rapidly again for another five months (i.e. from June-2006 to October-2006). The corrosion rate of zinc indicates 55 mg/sq.dm for one month and 1227 mg/sq.dm for Twelve months exposure period. Another set of plates exposed in summer month (March-2006) indicates corrosion rate increases rapidly for seven months (i.e. from March-2006 to september-2006), then it steady for further four months (i.e. from October-2006 to January-2007) (Fig.-4).

Aluminium: Aluminum plates exposed in winter months (i.e. November-2005) indicates that the corrosion rate increases slowly up to seven months (i.e. up to May-2006) then it increased rapidly for another five months (i.e. from June-2006 to October-2006) (Fig.-5). The corrosion rate of aluminium indicates 2.1 mg/sq.dm for one month and 25.9 mg/sq.dm for Twelve months exposure period.

Another set of plates were exposed in summer months (i.e. from March-2006). The corrosion rate increases rapidly for seven months (i.e. from March-2006 to September-2006), then it remain almost steady for further five months (i.e. from October-2006 to Febuary-2007) (Fig.-5).

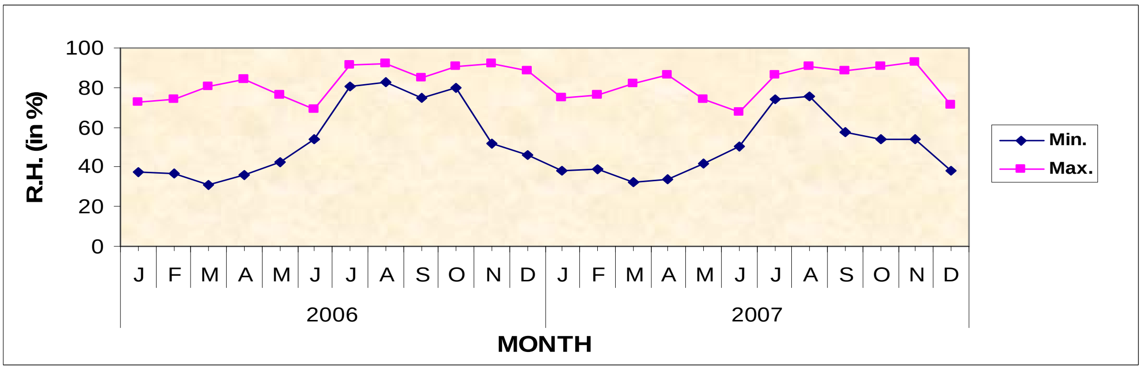

Fig. 1 Average relative humidity (R.H.) in percentage at Marine environment

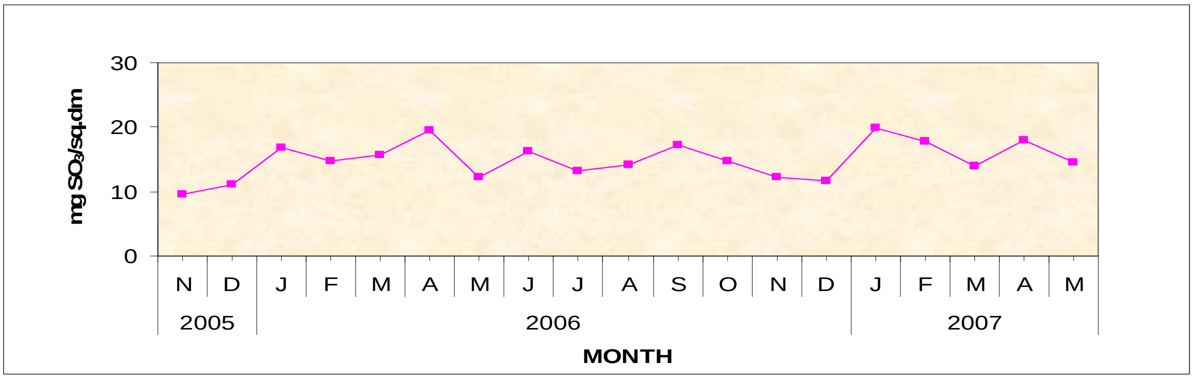

Fig. 2 Sulphation rate at Marine Environment

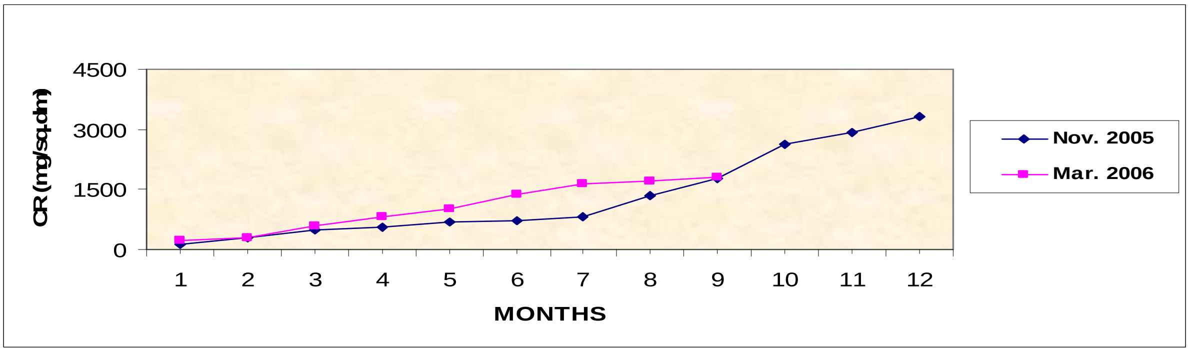

Fig. 3 Progressive corrosion rate (CR) of mild steel under outdoor exposure at Marine environment

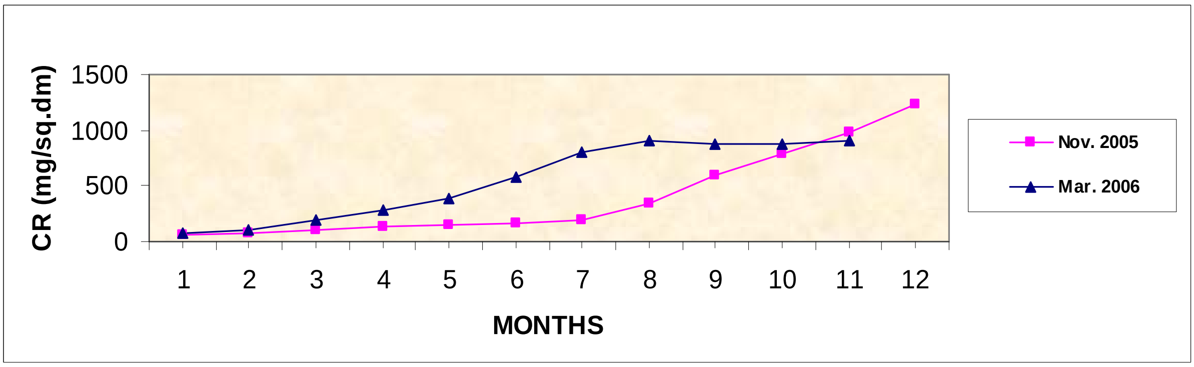

Fig. 4 Progressive corrosion rate (CR) of zinc under outdoor exposure at Marine environment

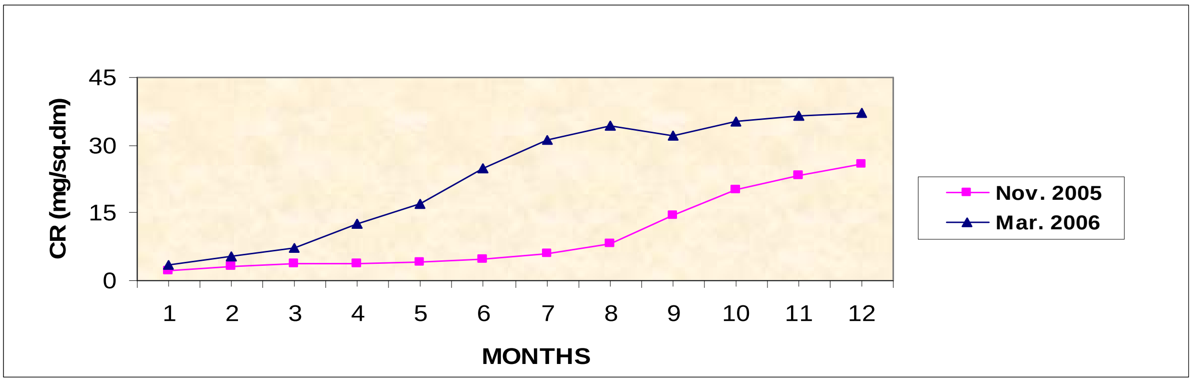

Fig. 5 Progressive corrosion rate (CR) of aluminium under outdoor exposure at Marine environment

CONCLUSION

The resistivity towards the environment was in the increasing order of mild steel < zinc < aluminium. So, we can say that aluminium or aluminium coated sheets would give better performance compared to mild steel or zinc.

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