STUDIES OF CORROSION RATE OF METALS IN RURAL ATMOSPHERE

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Received May 02, 2006    Accepted June 14, 2006

ABSTRACT

Progressive corrosion rate from one to twelve months of aluminium, zinc and mild-steel (MS) as well as the atmospheric salinity rate have been determined under outdoor conditions of exposure at Goima-village situated in South Gujarat. Aluminium, zinc and mild-steel plates exposed during July-1995 indicates corrosion rate of 4.2 (1.9 mm/y), 76 (12.9 mm/y) and 1400 (243.3 mm/y) mg/sq.dm for one months exposure period and 109.7 (4.0 mm/y), 244 (3.4 mm/y) and 15,200 (217.0 mm/y) mg/sq.dm for aluminium, zinc and mild-steel respectively for twelve months exposure period. Mild-steel panels exposed vertically suffer less corrosion than those exposed at an angle of 45°. Atmospheric salinity rate ranging from 12.0 to 21.0 mg NaCl/sq.dm/month.

Key Words : Rural atmosphere, Salinity rate, Corrosion rate, Aluminium, Zinc, Mild-steel.

INTRODUCTION

A rural atmosphere does not contain any hazardous contaminants, but does contain organic and inorganic dusts. Its principal corrosive constituent is moisture and of course, gaseous elements such as oxygen and carbon dioxide. The main factors which aggravate or catalyse the corrosion process are relative humidity, rainfall and number of rainy days. At normal temperature, dry air does not have a corroding effect on metals1,2. However, in presence of moisture in the atmosphere, corrosion takes place and it is governed by the principle of critical humidity developed as described in3 and supported by the reference4,5. The time of wetness depends mainly on the meteorological parameters. The most important climatic factors on the corrosion process are the relative humidity, sunshine-hours, temperature of the air and the metal surface, wind velocity, duration and frequency of the rain, dew and fog. The latter is related to the water layer formation, which is influenced by the relative humidity6,8. Rain gives rise to the formation of a thick layer of water and also adds corrosive agents such as H+ and SO4²-, however, it can wash away the contaminates as well as the net effect will...
depend on the quality, intensity and duration of the rainfall, as well as on the corrosion product.

The present study was carried out in the rural atmosphere at Goima Village (Dist. Valsad) in South Gujarat. This area is fifteen meters above the mean sea level and about nineteen kilometers away from the Arabian Sea.

Experimental

The size of metallic panels 12.5x7.5x0.16 cm where cut from sheets of commercial grade. The chemical composition of the metals are given below :

* Aluminium : Commercial, Soft temper.
* Zinc : 98.5% purity, Fe (0.01% max.), Cd (0.02% max.) and Pb (0.03% max.).
* MS : S and P (0.05% max.), C and Mn (0.5% max.), Fe (99.45%).

The specimens were exposed in field under unsheltered condition on a wooden rack at an angle of 45° above 10 feet height from the ground. Another set of MS panels were fully exposed vertically. 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. Clark's solution was used\textsuperscript{11,12} to remove the rust from mild-steel which is prepared by dissolving 2% $\text{Sb}_2\text{O}_3$ (antimony oxide) and 5% $\text{SnCl}_2$ (stannous chloride) in concentrated $\text{HCl}$ (100 ml) at room temperature with constant stirring for about 15 to 20 minutes. Zinc plates were derusted in a solution made by dissolving 10% $\text{CrO}_3$ and about 0.2 gm of $\text{BaCO}_3$ in distilled water at 298 K for about 2 minutes\textsuperscript{13}. Corrosion products on aluminium plates were removed by using a solution of concentrated HNO$_3$ containing CrO$_3$ (chromic acid, 50 g/l) at room temperature for about 10 minutes\textsuperscript{14}.

The atmospheric salinity content (mg NaCl/sq.dm/month) in the air was assessed by adopting the same principle as that of the wet candle method described by Ambler and Bain\textsuperscript{15}.

RESULTS AND DISCUSSION

Meteorological parameters

The most important climatic factors on the corrosion process. Monthly variation in temperature was observed and it was found March to June are hot months, average maximum and minimum are about 312 K and 295 K respectively; whereas December to February are cold months. Total annual rainfall was measured as 6090 and 4901 mm in the year of 1995 and 1996 respectively. The minimum and maximum relative humidity (R.H.) was found to be higher than the critical relative humidity value (70%) in 1995 and 1996.

Atmospheric salinity rate ranging from 12 to 21 mg NaCl/sq.dm/month (Fig. 1). Salinity rate ranging from 5.1 to 32.1 mg NaCl/sq.dm/month at Patan\textsuperscript{16} (rural site). Mendoza and Corvo found 3.9 mg/m$^2$.d chloride (average 6 months) at rural area of Cuba\textsuperscript{17}.

Aluminium

Aluminium plates exposed in rainy months (i.e. July-1995). Figure 2 indicates the corrosion rate increase progressively for the first nine months (i.e. July-1995 to March-1996) and thereafter increased rapidly for another three months. The corrosion rate of aluminium indicates 4.2 mg/sq.dm (1.9 mm/y) for one-month exposure period, whereas the progressive corrosion rate for one month exposed was found 5.0 mg/sq.dm at Surat\textsuperscript{18}. Another set exposed in February-1996 shows steady increase in corrosion rate in the following months.

Zinc

Zinc plates exposed in rainy months (i.e. July-1995) indicates that the corrosion rate increase for the first four months (i.e. July-1995 to October-1995) and after then further increase for another seven months (i.e. from December-1995 to June-1996). The corrosion rate of zinc indicates 76.0 mg/sq.dm (12.9 mm/y) for one month exposure period. Similarly, another set exposed in February-1996 indicates steady increase in corrosion rate (Fig.3).
Mild-steel

The observation of first set of MS plates exposed in July-1995 (i.e. rainy months) indicates that the corrosion rate increased progressively for the first six months (i.e. up to December-1995) and after then there is further increase for another six months (i.e. from January-1996 to June-1996). The corrosion rate of mild-steel indicates 1400 mg/sq.dm (243.3 mm/y) for one months exposure period.

Similarly, another sets of plates exposed in winter months shows increase in progressive corrosion rate for first three months, then it further increase rapidly for three months (Fig. 4).

Various exposure conditions

The corrosion rate for MS subjected to outdoor exposure and under sheltered condition at the same time indicates that the corrosivity is more in fully exposed condition (average 743 mg/sq.dm/month) than the partly sheltered condition (average 638 mg/sq.dm/month) irrespective of season (Table 1). It is due to the reason that in sheltered condition plates are protected from rain, sunlight and dust fall.

Positional effect

The results indicate that the plates exposed vertically suffer less corrosion than those exposed at an angle of 45°. Average value of corrosion rate was 520 mg/sq.dm/month in vertical position and 867 mg/sq.dm/month at an angle of 45° position (Table 2). The reason undoubtedly being the retention of moisture and atmospheric particles for longer periods on a panels exposed at an angle of 45°.

Table 1. Corrosion of mild-steel in fully outdoor and partly shelter condition

<table>
<thead>
<tr>
<th>Month</th>
<th>Rate of corrosion in mg/sq.dm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fully outdoor exposed condition</td>
</tr>
<tr>
<td>1995</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>437</td>
</tr>
<tr>
<td>June</td>
<td>799</td>
</tr>
<tr>
<td>July</td>
<td>1396</td>
</tr>
<tr>
<td>1996</td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>1205</td>
</tr>
<tr>
<td>February</td>
<td>881</td>
</tr>
</tbody>
</table>

Table 2. Positional effect of corrosion rate of mild-steel

<table>
<thead>
<tr>
<th>Month</th>
<th>Rate of corrosion in mg/sq.dm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vertical</td>
</tr>
<tr>
<td>1996</td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>110</td>
</tr>
<tr>
<td>April</td>
<td>233</td>
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<td>May</td>
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<tr>
<td>July</td>
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</tr>
<tr>
<td>August</td>
<td>969</td>
</tr>
<tr>
<td>September</td>
<td>845</td>
</tr>
</tbody>
</table>
ATMOSPHERIC SALANITY RATE

Fig. 1 Atmospheric salinity (in mg NaCl/Sq.dm/month) at rural station.

ALUMINIUM

Fig. 2 Progressive corrosion rate of aluminium under outdoor exposure.
(1) July-1995  (2) February-1996
Fig. 3 Progressive corrosion rate of zinc under outdoor exposure
(1) July-1995  (2) February-1996

Fig. 4 Progressive corrosion rate of mild steel under outdoor exposure
(1) July-1995  (2) February-1996
CONCLUSION

(1) Mild-steel panels exposed vertically suffer less corrosion than those exposed at an angle of 45°.

(2) The corrosion rate of mild-steel plates was found more under fully exposed condition than the plates exposed under sheltered conditions.

(3) The rate of corrosion was found in decreasing order as follows:

   Mild-steel > Zinc > Aluminium

ACKNOWLEDGEMENT

The authors are thankful to the Department of Chemistry, Navyug Science College, Surat for excellent laboratory facilities.

REFERENCES