BIOFOULING STUDIES RELATING TO CATHODIC PROTECTION OF SOME METALS IN SEAWATER

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ABSTRACT

BIOFOULING studies relating to cathodic protection of stainless steel, stainless steel anodes and brass in the presence of microorganisms have been conducted in the seawater of Mandapam coast. The role of microorganisms in the biofouling of cathodically protected materials was evaluated using polished stainless steel, brass and mild steel substrates. It is found that microorganisms cause an increase in the cathodic current requirement for the maintenance of a passive potential and an increase in passive current density. The presence of microorganisms increases the corrosion rate of the protected metal. The corrosion rate is significantly higher in the presence of microorganisms compared to the control. The results obtained are consistent with those obtained in artificial seawater. This study is the first of its kind to evaluate the role of microorganisms in the biofouling of cathodically protected metals in natural seawater. The results have important implications for the design and operation of cathodic protection systems.
of control panels and the cathodically protected panels were assessed. Open circuit potentials were measured after five days when the system attained a steady state using a multimeter against saturated calomel electrode (SCE) and the values are shown in Table II.

Table II: Open circuit potentials of control panels and the cathodically protected panels

<table>
<thead>
<tr>
<th>Metal</th>
<th>OCP of control panel (V)</th>
<th>OCP of polarized panel (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mildsteel</td>
<td>-0.65</td>
<td>-0.98</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>-0.30</td>
<td>-0.55</td>
</tr>
<tr>
<td>Brass</td>
<td>-0.25</td>
<td>-0.90</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

I. General observations on corrosion and fouling

(a) In the absence of cathodic protection, the order of corrosion and fouling for metals were as follows:
- Corrosion: Mild steel > Stainless steel > Brass
- Fouling: Stainless steel > Mild steel > Brass

(b) In the presence of the cathodic protection, the order of corrosion and fouling for metals were as follows:
- Corrosion: Stainless steel > Mild steel > Brass
- Fouling: Mild steel > Brass > Stainless steel

II. The influence of fouling and response to cathodic protection

The first observation made on the in situ tests from the Gulf floor indicated the predominant growth of Enteromorpha on all panels. Barnacles (all balanids), polychaete tube-worms and hydroids were the other chief fouling organisms. In the latter two observations barnacles were found to contribute nearly 75% of the fouling community.

Table III: The number of barnacles settled on panels

<table>
<thead>
<tr>
<th>Metal</th>
<th>Exposure time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>30 days</td>
</tr>
<tr>
<td>Mildsteel</td>
<td>142</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>155</td>
</tr>
<tr>
<td>Brass</td>
<td>None</td>
</tr>
</tbody>
</table>

Brass remained completely free of fouling but cathodic protection resulted in intense settlement of organism. It is obvious that for a toxic metal like brass cathodic protection would result in retarding the release of toxic ions and its antifouling property is thus lost. Our results for brass are in accordance with previous results of similar type in the literature.

III. Selective abundance of barnacles - explanation

We attribute the selective abundance of barnacles on cathodically protected mild steel and brass to the following factors:

- Lower pH values that inhibited larval settlement in the case of brass.
- Barnacles can be attracted in large numbers to surfaces treated with calcium. It seems possible that barnacles are attracted by the calcium deposits formed during cathodic protection. The utilization of these deposits for their shell formation probably results in an increase in shell size. On this basis the results of tests from the Gulf floor (5) can also be explained as due to the influence of calcium deposits since they are a linear function of applied current density. However, the antifouling behaviour of cathodically protected stainless steel may require proof by other methods.

It could be due to release of chromate ions through the porous calcium deposits. The nature of the calcium deposits on stainless steel could also be different from that on mild steel or brass. Experiments are being carried out to study this behaviour of stainless steel in detail.

Table V: A comparison of the amount of calcareous deposits formed and calcium content deposited in biomass on cathodic surfaces (wt. in grams)

<table>
<thead>
<tr>
<th>Metals</th>
<th>Exposure time</th>
<th>10 days</th>
<th>30 days</th>
<th>72 days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>Mildsteel</td>
<td>1.07</td>
<td>0.16</td>
<td>2.43</td>
<td>3.67</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>1.13</td>
<td>0.15</td>
<td>1.35</td>
<td>0.49</td>
</tr>
<tr>
<td>Brass</td>
<td>--</td>
<td>--</td>
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</tr>
</tbody>
</table>

Calcite deposits; b) Calcium content in biomass.

(iV) Calcareous deposits and calcareous shell dwelling organisms: Results presented in Table V indicate that barnacles contribute largely to the calcareous deposits on mild steel and brass, and to some extent on stainless steel. In fact, for mild steel and brass, the calcium content present in biomass exceeds the amount of calcareous deposits by many times. Thus, the gross amount and thickness of deposits are considerably increased. Whether the growth of these organisms affects the quality of the calcareous scale remains to be studied.

The utilization of calcareous deposits by selective groups of organisms and their contribution in turn thus lead to the conclusion that future work should take into account biological factors also. It is thus understood that conventional experiments carried out in the laboratory do not reveal the conditions actually operating in the natural seawater environment. Extensive work has been taken up in Mandapam coast on these lines.

CONCLUSION

i) Cathodic protection results in severity of fouling on mild steel and brass, and in inhibition of fouling on stainless steel.

ii) The calcareous deposits formed during cathodic protection of mild steel and brass seem to offer excellent growth conditions for calcareous shell forming organisms like the barnacles.

iii) Barnacles contribute largely to the calcareous deposits on mild steel and brass, and to a smaller extent on stainless steel, considerably increasing the gross amount and thickness of the calcareous scale in all cases.

REFERENCES
