DESIGN AND DEVELOPMENT OF AN ELECTROLYTIC CHLORINE GENERATION SYSTEM FOR PREVENTION OF FOULING IN SEA-WATER COOLING SYSTEMS

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(*Received* 13 *January* 1975; *revised* 15 *November* 1976)

Two designs of electrolytic chlorine generation system developed at this laboratory have been described in detail. The design of *in situ* electrolytic chlorine generation system was found successful in controlling the fouling settlement in the sea-water system on a war ship at the end of nine months intensive service trials. Another design is for universal application in sea-water system both on shipping and industrial establishments.

The fouling in Indian waters is very heavy and varied and is normally represented by species of barnacles, tubeworms, bryozoans, hydroids, sponges, tunicates and mussels. Among the barnacles, *Balanus amphitrite, B. Variegatus, B. tintinabulum tintinabulum and B. amaryllus euamaryllus* are normally encountered as common fouling on submerged structures including sea-water conduits[1—7]. Among the several known species of tube worms, *Hydroides norvegica* and *Sabellaria* sp are commonly found on structures less subjected to turbulence, hence their role is limited in fouling of sea-water conduits. The fouling by hydroids, tunicates and sponges being seasonal is less extensive in the sea-water circuits. Bryozoans, being colonial forms and showing a greater degree of resistance to the toxicity of copper are frequently encountered in the systems. In one known instance, the fouling of sea-water system by this group was so extensive that the water box condensers of a refinery were totally blocked off leading to the refinery going off-streams.[8]

The mussels have been commonly found settling in the sea-water systems in many of the harbours both in India and elsewhere. According to Redfield & Deevy,[9] within its natural range the mussel fouling forms the characteristic fouling of fixed installations such as buoys, mines, nets and sea-water conduits. At Visakhapatnam, particularly, the fouling by an immigrant species viz. *Mytilopsis Sallei*, of this group has of late become very serious due to the prolific rate of propagation of this species[10]. The inlets of a ship stationed at Visakhapatnam were completely blocked off to such an extent (Fig. 1) that even the grating of the inlet was not visible unless the surface growth was removed (Fig. 2). The fouling of the interior of conduit was however, represented both by barnacles and the mussel *M. Sallei* (Fig. 3).

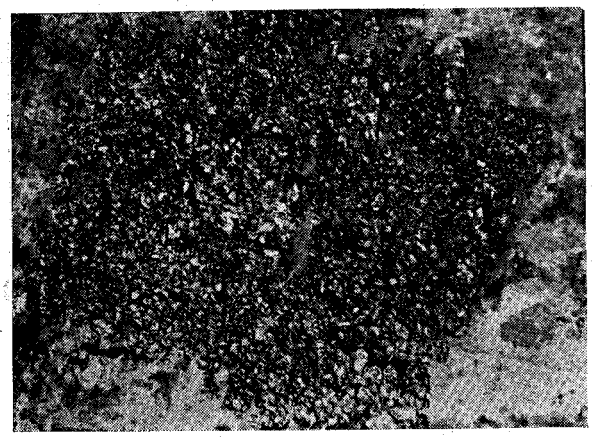

Fig. 1.—Inlet of a ship blocked completely by fouling animals.

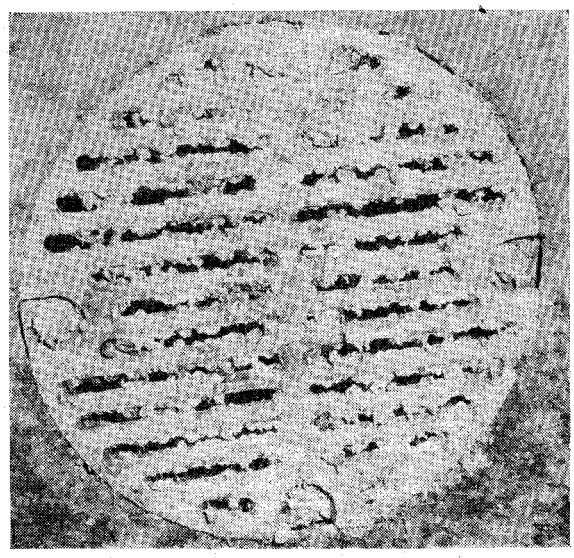

Fig. 2.—The grating of inlet in Figure 1, as seen after removal of surface fouling.

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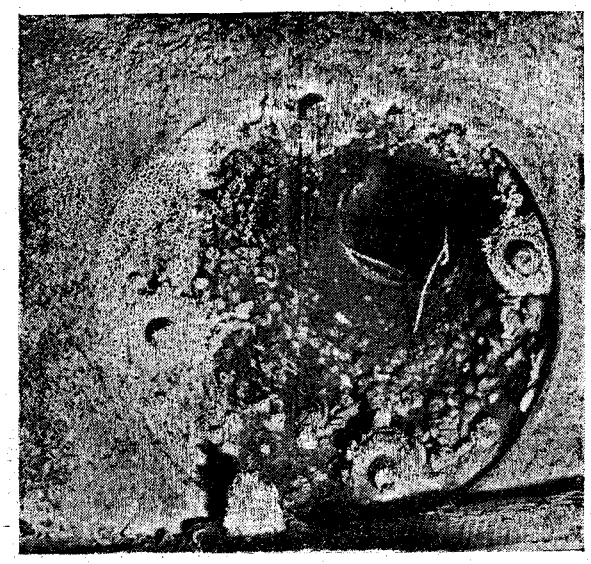

Fig. 3—The interior of the sea-water system showing fouling.

The growth of marine organisms at the inlets and conduits of sea-water circulating systems causes reduction in the diameter of water transport system thereby restricting water carrying capacity of the conduit due to reduction in Hazen and Williams coefficient[8]. The fouling of the sea-water systems particularly in tropical conditions is so high as to necessitate cleaning of condenser tubes once every 18 days[9]. At Visakhapatnam one ship in particular had to be recalled immediately after refit due to heavy choking of the sea-water system.

The laboratory undertook an investigation to suggest suitable measures for preventing fouling settlement in such systems. After examining all the methods of control, both chemical and physical, it was found that chlorination of sea-water alone was the most effective one. The experiments carried out in the laboratory and the field trials revealed that *in situ* electrolytic chlorine generation offered complete protection against fouling settlement[11]. This was then further investigated for its application on board ships. The present paper describes two systems developed at this laboratory in order to control fouling settlement in the sea-water cooling systems. Both the systems have the simplicity of installation and versatility of application to meet the requirements of ship, shore and off-shore establishments.

DESIGN AND DEVELOPMENT

In Situ Chlorine Generation System :

The unit of the above system primarily consists of an anode material composed of platinum and a cathode of stainless steel mounted at the inlet itself to produce chlorine *in situ*. A prototype of the system was designed for fitting at an inlet of a sea water circulating system on a war ship. The anode was in the form of platinum wire wound around a perspex rod in the shape of a coil to allow maximum area of exposure. The cathode was a 3·2 cm ($1\frac{1}{4}''$) diameter stainless steel rod. Both the anode and cathode were mounted on two non conductive rods, separated from each other by 10 cm. The connections of the two electrodes to the power supply was made through a junction box which was also mounted on the frame to preserve space (Fig. 4). All the connections to the junction box and the electrodes were firmly sealed with non conductive jointing compound in order to prevent any seepage of sea-water.

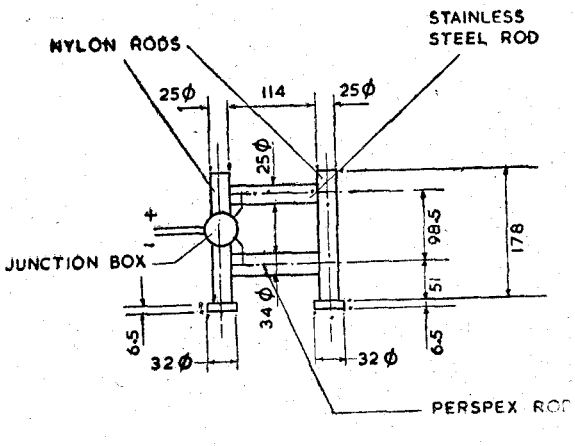

Fig. 4—Design of 'in situ' electrolytic chlorine generation equipment. (Scale 1 : 10 mm).

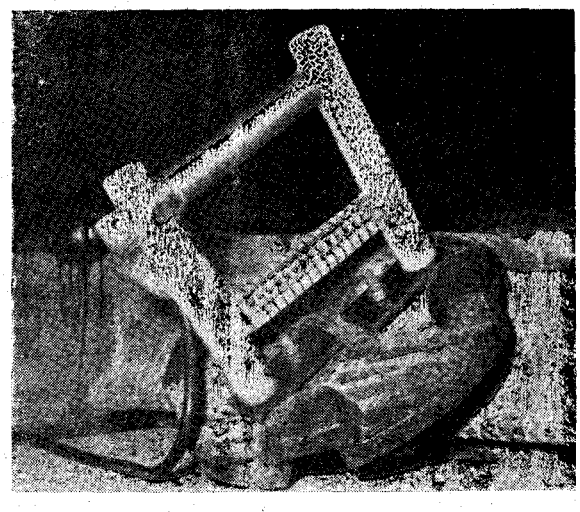

Fig. 5 The unit fabricated for service trials mounted on a grating before installation.

The unit as designed above was mounted on the grating of the inlet of a sea-water cooling system of an air conditioning plant (Fig. 5). The power supply unit was kept in the control room and a D.C. current of the intensity 500 mA was fed to the electrodes. Periodically sea-water was sampled at outlet and the chlorine concentration was determined. The chlorine concentration was found to vary between 3 to 4 ppm which has been earlier determined as adequate for protection without causing any adverse effects on the material[11].

The *in situ* electrolytic chlorine generation system was subjected to an extensive trial for a period of nine months. At the end of the trial period when the ship came back to dry dock, the performance and efficacy of the system was evaluated. Both the inlet and the grating were found to be free from fouling organisms (Fig. 6). The grating was then removed and the interior of the system was examined. This was also found to be free from any fouling settlement (Fig. 7). Neither the anode nor the cathode was adversely affected by the continuous trial and both being in perfect conditions, the system was again fitted for continuation of further trials.

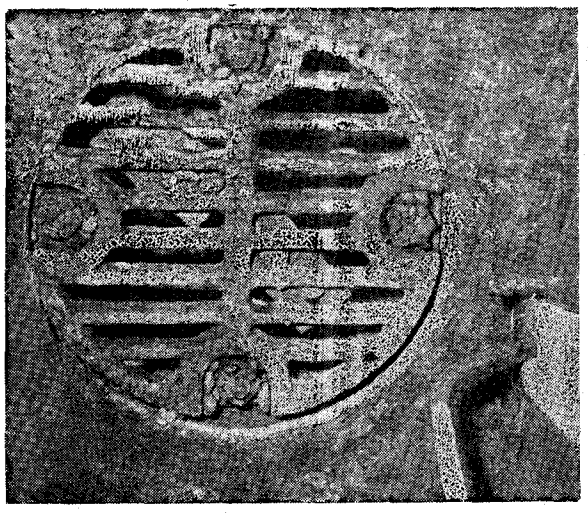

Fig. 6—Sea-water inlet and grating, protected from marine. fouling effectively, at the end of nine months' trial.

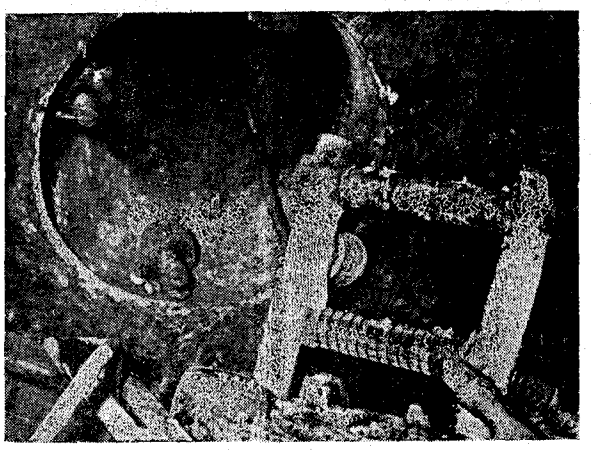

Fig. 7—Fouling-free surface of the interior of sea-water inlet with the electrolytic chlorine generation unit, also free from any deterioration after service trials.

Chlorine Generation-Cum-Injection System

The design described above is ideally suited for sea-water system, the inlets of which can be accessible when desired. However, such a condition is not available in many of the shore and off shore establishments. Therefore a different type of system which can be installed to meet such special requirements was designed. This is based on the chlorine injection method described by Bartha[12].

The details of the system designed are given in Fig. 8. In this the injection of chlorine is effected by electrolytic decomposition of sea-water in an electrolytic cell (EC). The electrolysis of sea-water is brought about in the cell by means of a platinum or platinized anode and a cathode of baser metal. This chlorinated sea-water is then pumped at a suitable point nearest to the inlet by means of a $\frac{1}{4}$ H.p. pump. This pump is also used for drawing in fresh water to the cell.

The system described above was subjected to laboratory trials by employing larvae and adults of the common fouling species. It was possible by this method to maintain a chlorine concentration of 3 p.p.m. The 3 p.p.m. of chlorine concentration has been found to be lethal to the larval and adult species both under laboratory and field conditions[11].

The chlorine generation-cum-injection system has universal application especially on installations where the sea-water system is not accessible. The entire unit can be kept in a place accessible for periodical check-up and maintenance while a spare system can be kept as a stand by. The system can thus be profitably employed in sea-water cooling systems of petroleum refineries, fertilizer plants and other similar establishments.

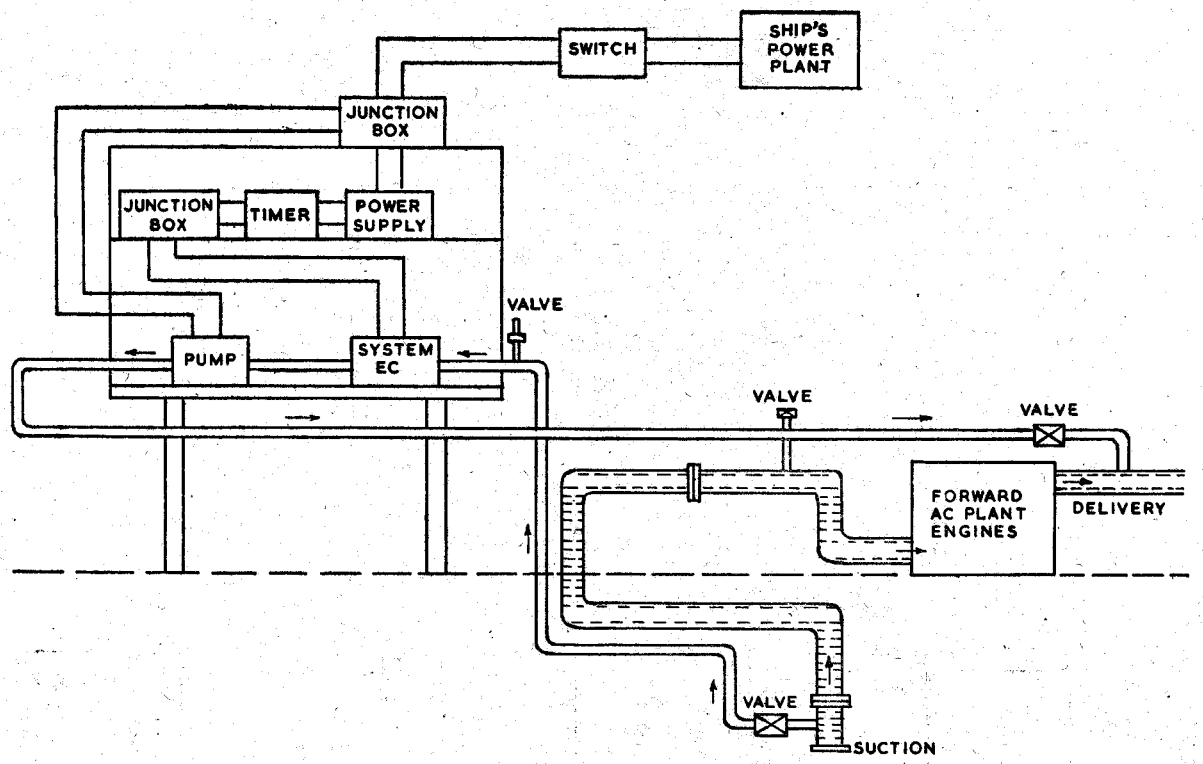

Fig. 8—Schematic representation of the chlorine generation-cum-injection system.

CONCLUSION

The two designs described in the paper meet the essential requirements of easy installation low initial expenditure and minimum operating cost. The system in addition, would be able to permit the plant to operate at full capacity by preventing fouling growth, leading to its increased efficiency. The designs described have the additional quality of being flexible to meet any requirement of the user.

Both the designs of the electrolytic chlorine generation system have now been filed for patenting.

ACKNOWLEDGEMENT

The authors are thankful to Shri M. Madhusudana Rao of this laboratory for his assistance in the fabrication of the prototypes. Thanks are also due to Capt. P. R. Sen, IN, Director for the encouragement given to this work. The authors are particularly grateful to Shri S. V. S. Rao, Deputy Director, for his guidance and co-operation in the development of designs.

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