CATHODIC PROTECTION OF THE HULLS OF FISHING TRAWLERS IN INDIA*

K. RAVINDRAN & R. BALASUBRAMANYAN
Central Institute of Fisheries Technology, Cochin-682011

INTRODUCTION

Nearly 10,000 mechanised fishing trawlers mostly built of wood and about 100 trawlers built of steel besides a few fibreglass reinforced plastic and a couple of ferrocement boats constitute the modern fishing fleet of India at present. More and more of bigger vessels are continuously added on to the existing fishing fleet either by indigenous production or by imports.

Though metallic corrosion in sea water is a very well known phenomenon in all ships and various other marine structures, the exact financial loses and the material breakdown have never been fully realized among the trawler owners in India. Except for few commercial anticorrosive surface coatings not much of preventive measures are being undertaken. The Central Institute of Fisheries Technology at Cochin has been studying these problems for some years now and has been able to assess the significance of underwater corrosion particularly of the hull below water line in the trawlers and suitable remedial measures are being suggested from time to time.

CORROSION AT THE STERN AREA

The stern quarter of a ship is the most vulnerable part from the corrosion point of view. As steel continues to be the most versatile material for the construction of large ocean going trawlers its corrosion characteristics should be taken into account while designing any protection system. With the advent of newer materials for marine use, several dissimilar metals come into operation and hence galvanically incompatible ones are in electrical contact at the stern area giving rise to galvanic corrosion. For such areas special designs and protective measures have to be adopted to avoid breakdown and costly replacements and consequently loss of profitable fishing voyages.

Apart from this, the erosive effects of cavitation damage associated either with high velocity turbulent flow and impingement attack or by cavity collapse (Kallis, 1956) by the rotating propeller aggravates the attack at the stern quarter. The problem assumes greater magnitude with the introduction of newer fishing trawlers (FRP and Aluminium) with greater crui-

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sing speed. The cause of extensive damages to marine screw propellers have been studied at this Institute (Balasubramanyan, 1973 a). Figure - I shows intensive damages to a marine manganese bronze propeller which has undergone both dezincification corrosion and erosion damage.

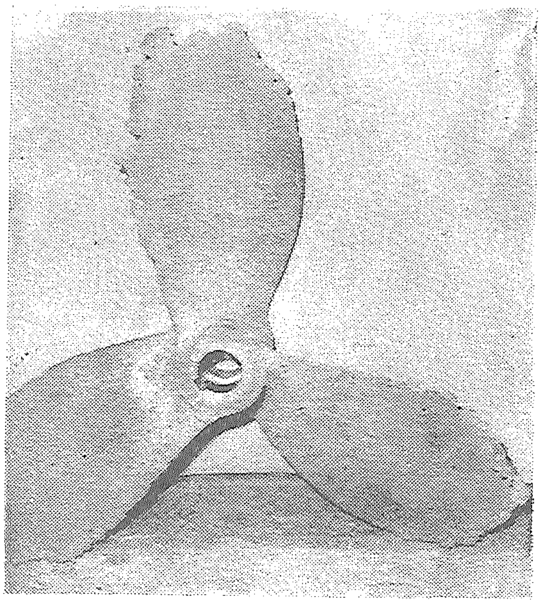

Fig. I Dezincification and erossion attack on marine propeller.

Cathodic protection of fishing trawlers

Cathodic protection is frequently employed to control the corrosion of ships, hull and hull fittings and also for stationary marine structures such as docks, ship berths etc. Though the technique is known for several years before, there has been considerable progress in the selection of newer sacrificial anodes and the exact application of this technique. In India, investigations have been carried out by De *et. al.* 1968 on the cathodic protection of naval ships employing galvanic anodes. The newer version of the impressed current automatic control systems though involves high cost of installation-considering the loss of man-hours due to breakdown, cost of materials and labour involved in replacements in the unprotected vessels - would definitely prove economical and would offset the cost of installation on a long term basis.

Indian fishing fleet mostly consists of various sizes of trawlers from 10 m. to 17 m. OAL built out of wood sheathed with copper or aluminium-magnesium alloy plates. Steel, ferro-cement, aluminium and fibre-glass reinforced plastic hulls also require special protective system to combat corrosion successfully.

Copper sheathing on wooden trawlers

Wooden hulls that deteriorate due to the attack of marine organisms on them are protected with 22/24 SWG cold-rolled copper sheets by virtue of its comparatively high corrosion resistance in sea-water. In stagnant sea-water a corrosion rate of 2.2 mil/year and in fast flowing sea - water a rate of 3.2 mil/year has been reported (Ravindran, 1968) for the commercial quality copper used in the sheathing work. As early as 1824, Sir Humphrey Day demonstrated the protective functioning of Zinc anodes in copper sheathed vessels which system is still being followed to-day though slightly modified. Copper sheathing is protected at a potential of - 600 mV Ag/Ag Cl by means of electrolytic zinc whose iron content does not exceed 15 ppm. Impurities in zinc anodes have detrimental effect by reducing its electrochemical efficiency and also by the formation of calcareous coating on the sacrificial anode. Though the potential and current density requirements for copper are not very critical, over protection does impair the inherent antifouling properties of the metal. It is an accepted criterion that in order to impart antifouling properties a dissolution rate of 10μ gm copper/Cm^2/day is necessary. Over protection leads to a slower dissolution rate below this critical limit making copper virtually non-toxic and hence fouling occurs. Fig. II shows such a phenomenon of inactivation of copper where the copper sheathing has been fouled by tube worms as well as oysters (only impressions seen).

Fig. II. Marine fouling on over-protected copper sheathing.

ALUMINIUM - MAGNESIUM ALLOYS FOR MARINE SERVICE

Detailed investigations at the Central Institute of Fisheries Technology have led to the wide scale adoption of aluminium - magnesium alloys rolled to 22 SWG as an effective substitute for imported copper for the protection of the hulls of wooden fishing boats (Balasubramanyan, 1965). As this alloy is less noble to most of the hull fittings and appendages it requires special measures to protect against marine corrosion especially from the effects of galvanic currents. The schedule for protection against corrosion and fouling by means of selective paints have already been communicated (Balasubramanyan *et al.* 1968) Aluminium being non-toxic unlike copper, the application of antifouling top coat to ward off foulers is imperative. Again, as the antifouling paints in general, excepting a few TBTO based paints are copper based and thus direct contact with aluminium has to be carefully avoided, so also paints containing iron, lead and mercury. Further, the polarization current density for aluminium is very critical as otherwise it will be subjected to cathodic corrosion apart from its action on paints applied to the hull. The following reactions occur at high C.D

$$2H_20 + 0_2 + 4\bar{e} \rightarrow 4\ OH^-$$

and $$2H_20 + 2\bar{e} \rightarrow 2\ OH^- + H_2$$

Under these conditions failure of the coating will occur as a result of alkali attack or hydrogen defoliation. At present we have utilized electrolytic zinc with iron content less than 15 ppm for the cathodic protection of aluminium - magnesium alloys especially at the stern quarter where several galvanically incompatible materials such as bronze propeller, stainless steel shaft, cast iron shoe etc. are present. Protection was achieved by means of well shaped (fish-like) anodes of different sizes and weights distributed at the stern area so that a potential of about -950mV SCE was established at the stern quarter and no undue resistance and drag are created. The anodes were installed on large high density wooden blocks. Though it can be admitted that wooden block cannot act as a perfect dielectric it helped to introduce an extremely high electrical resistance. The painting schedule coupled with the cathodic protection has afforded protection to the aluminium sheets for a period of 3 to 4 years. There has been frequent and quick breakdowns of the protective aluminium - magnesium alloy sheets at the stern quarter in the absence of such anodes. Further studies employing binary and ternary alloys are in progress. The harmful effects of over protection and consequently high current density to the wooden hull itself has been reported by Prasser (1966). The alkalinity caused by the high current density at the through-hull fittings or bolts would lead to the destruction of the wood cells around such fittings, leading to loss of strength.

Ferrocement Boats

Ferrocement (steel and cement) boats are recent introductions to the fishing fleet of India (Balasubramanyan, 1973 b) The special ingredients in the mortar that go into the construction make it comparatively non-permeable to water and hence the steel reinforcement in the structure remains practically corrosion free as long as the passivity offered by a film of iron oxide is not destroyed. But for vessels operating in sea-water continuously for years, the ingress of chloride ion can be anticipated with consequent damage to the passivating film which is being carefully observed. Though investigations on the corrosion and cathodic protection of steel in concrete is well documented (Hansman, 1969; Robinson, 1962) practically no published data is available on the cathodic protection of steel in ferrocement structures exposed to sea-water attack.

Estimation of costs

It has been roughly estimated that about 6 million square feet of copper sheathing has been in use for protecting the wooden hulls of nearly 8000 wodden trawlers. At present as the entire supply of copper for the sheathing work has to come from abroad involving considerable amount of foreign exchange, cheaper substitute of indigenously available marine quality aluminium-magnesium alloys have been advocated by the C. I. F. T. The requirement of zinc for cathodically protecting all these vessels would be about 700 tons for the next six years valued at Rs. 7 million. Hence by substituting copper with aluminum it would result in a saving to the tune of Rs. 50 million. Further, the requirement of zinc for 8 years for the additional 100 steel trawlers works to 50 tons and based on the average market price this involves another Rs. 4 lakhs of investment. Proper use of galvanic grade aluminium anodes of indigenous origin is likely to bring down this cost considerably. In addition to sacrificial anodes good quality zinc chromate paints, aluminium pigmented paints and heavy duty alkali resistatnt anti-corrosive coatings will have added advantage.

The magnitude of material breakdown

due to corrosion below the water line in fishing trawlers can be known only at the time of the annual docking when it will be too late and too costlier to mend. It pays to prevent underwater hull corrosion by carefully planning an effective cathodic protection system with proper choice of anodes, their design an installation. The seriousness of this problem is likely to assume a greater magnitude in the coming years when the fishing fleet would have expanded considerably. Cathodic protection - the timely prevention of underwater corrosion in fishing trawlers - will be the best cure for this ever eluding problem.

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