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# CORROSION RESISTANCE OF ELECTRODEPOSITED ZINC ALLOYS: A MARINE EXPOSURE STUDY

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**Considerable efforts are being made to improve the life of galvanised steel substrates. Electrodeposited zinc alloy containing nickel or cobalt play a significant role in this aspect and most of the galvanising industries abroad have switched over to these modified processes. In addition to offering increased service life they are considered as viable alternative to poisonous cadmium deposits also. Notwithstanding the extensive corrosion testing of these coating under simulative conditions in the laboratory, an elaborate programme of a field testing these superiority over conventional zinc deposit both in the passivated and un-passivated conditions was performed for 18 months under severe tropical marine conditions at Mandapam Camp. The results confirm that zinc 15% nickel alloy deposit are superior and zinc 1% cobalt deposit are much better than zinc deposits with respect to their corrosion resistance.**

**Keywords: Corrosion resistance, zinc alloy, electrodeposition**

## INTRODUCTION

Whilst pure zinc coatings continue to be used for the protection of steel from corrosion, considerable efforts are being made to improve them for use in harsher environments, longer service life or reduced coating thickness for a given service life. Electrodeposited zinc-12 % Ni and Zn-1% Co play a major role in this aspect. Though these alloys were initially developed essentially for improving the corrosion resistance of the automobile components, they are considered to be the viable substitute to cadmium and have considerable potential applications in other industries also.

Extensive research has been carried out at CECRI, in developing the process as well as establishing the corrosion resistance of these coatings [1-5]. Notwithstanding the laboratory corrosion testing under simulated conditions [6], an elaborate programme of testing their corrosion behaviour in severe tropical marine conditions at the Marine Corrosion Testing centre, Mandapam Camp, was undertaken and the exposure studies with periodical inspection was carried out for a duration of 18 months and the results are reported in this paper.

## EXPERIMENTAL

Cold rolled steel panels of 15 x 10 x 0.2 cm size were mechanically polished to a high lustre, degreased, masked suitably, so as to expose an area of 15 x 10 cm on one side, electrocleaned in a suitable electrolyte, first cathodically and then anodically, dipped in 5% sulphuric acid, washed rinsed well and then introduced into the plating electrolyte of the following composition:

| | |
|---|---|
| Nickel sulphate | 90 g/l |
| Nickel chloride | 10 g/l |
| Zinc sulphate | 30-100 g/l |
| Boric acid | 30 g/l |
| Sodium citrate | 30 g/l |

operated at 3.0 A/sq.dm, *p*H 3.0 and at room temperature.

| | |
|---|---|
| Zinc sulphate | 145 g/l |
| Sodium citrate | 6 g/l |
| Boric acid | 30 g/l |
| Cobalt sulphate | 20 g/l |

operated at 3.0 A/sq.dm, *p*H 3.0 and at room temperature.

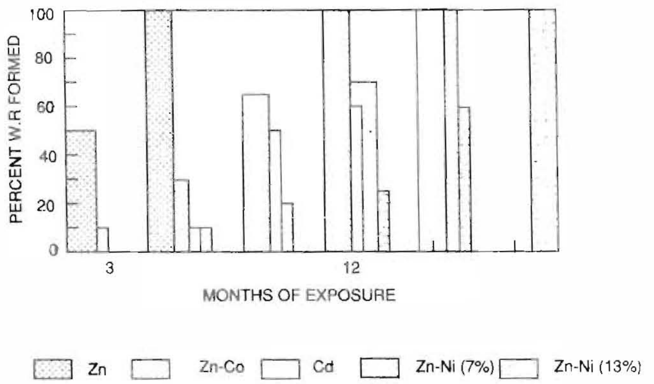


*Fig. 1: Marine exposure studies W R on zinc alloys*

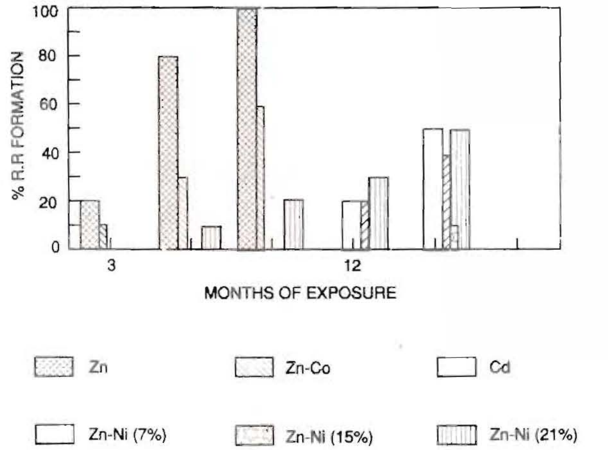


*Fig. 3: Marine exposure studies R R formation of zinc alloys*

Zinc and cadmium deposites were prepared from the conventional sulphate and fluoborate electrolytes respectively [7]. Deposites of 7.5 μm thickness were prepared in each case giving allowance for the loss due to the post treatment and then chromate passivated in suitable solutions. The specimens were then dried in air for a day. The unwanted portions were again masked with araldite and then they were kept exposed to the marine atmosphere at the testing centre. Periodical examinations were made to assess the corrosion behaviour of the deposites.

## RESULTS

On exposure to the marine atmosphere, the alloys exhibited corrosion depending on their nickel content, though generally the alloys outperformed the zinc deposites.

The white rust formation (Fig. 1) started in zinc deposites within a month of exposure and extended upto 50% of the total area in 3 months and almost 100% in 6 months. The deposites were covered with thick white corrosion products with uniform distribution of red rust.

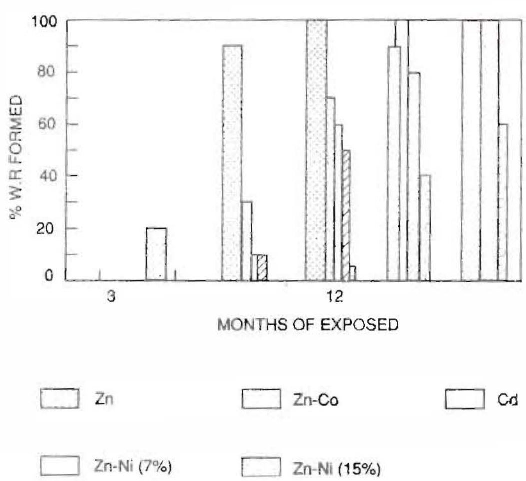


*Fig. 2: Marine exposure studies W R on passivated zinc alloys*

Though white corrosion got initiated in cobalt alloy in a month similar to zinc, it was less voluminous but, compact. White corrosion in cadmium and Zn-7% nickel was observed only after 6 months. Over a period of 9 months, Zn-Co showed around 65% white rusting whereas it was only 50% and 20% in the case of cadmium and Zn-7% Ni alloy respectively. In the case of Zn-15% Ni alloy white corrosion was perceivable only after one year and it was almost 100% only at the close of the exposure ie., after 18 months. Zinc-21% Ni alloy did not exhibit the tendency to form white corrosion product.

The green passivation considerably improved the life of the deposites in general (Fig. 2). Zinc deposites started showing white corrosion products only after 6 months, though gradual decoloration of the green colour was observed after 3 months. However, after 9 months, around 90% of the total exposed area was covered with the white product, whereas it was only 30% and 10% in the case of cadmium and Zn-7% Ni. In 15 months, cadmium exhibited complete coverage with the white products, whereas Zn-Co and Zn-Ni showed a better performance. At the close of the exposure, the 15% Ni alloy exhibited only 40% coverage, when the Zn-Co and Zn-7% Ni alloy showed 100% coverage by the white rust. Zn -21% Ni alloy did not show any symptoms of white rust formation. Within 3 months, zinc and Zn-Co started exhibiting isolated red rust spots (Fig. 3), though the extent of attack was considerably less in the latter.Zinc-21% Ni alloy started exhibiting rusting in 6 months directly without any white corrosion product formation.

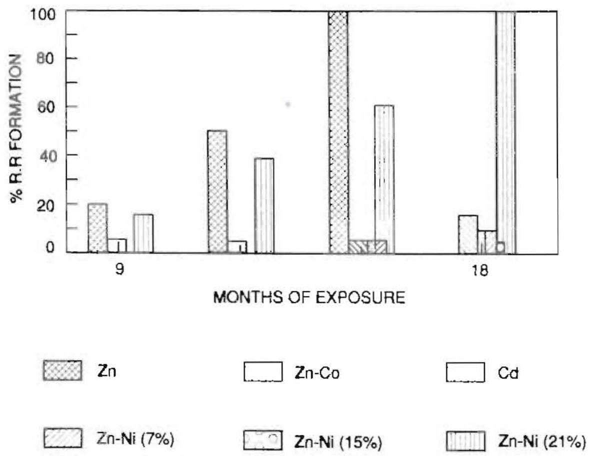


*Fig. 4: Marine exposure studies R R formation on passivated alloys*

Cadmium and Zn-7% Ni behaved almost similarly upto 12 months and thereafter showed marked difference. Cadmium started rapid deterioration such that after 15 months its performance was equal to that of the 21% nickel alloy. Zn-15% alloy showed only 10% coverage by rust after 15 months of exposure.

All passivated deposites under investigation remained good upto 9 months (Fig. 4). Zinc deposit reached 50% rusting in 12 months and Zn-21% Ni in 15 months. While Zn-Co showed around 20% rusting, cadmium and Zn-7% Ni behaved similarly, Zn-15% being the least affected at the close of the study.

## CONCLUSION

Exposure studies under severe tropical marine conditions for 18 months indicate that Zn-7% Ni alloy with green chromate passivation resembles similarly passivated cadmium deposites in its corrosion performance. More improved performance that of the above two can be offered by Zn-15% Ni alloy deposites.

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