"STUDIES ON THE DEVELOPMENT OF ORGANIC COATINGS AND ELECTROCHEMICAL ASPECTS OF CORROSION PROTECTION"

SYNOPSIS

Every country spends large sum of money on corrosion control measures. The total investment for the protective measures comes around 2 - 3% of the Gross National Product of India. Several methods are available for protecting steel structures and the choice of the method depends on the environmental conditions and economic factors. Corrosion inhibition by organic coating is the cheapest and easiest for application purposes. Metallic powder pigmented coatings offer resistance to the permeation of aggressive ions and provide cathodic protection to metal surfaces in corrosive environments.

The present investigation includes the following aspects :

(i) Preparation of various types of binders such as Butyl titanate, Cashew Nut Shell Liquid (CNSL) and epoxy-polyamide resins. The structure of the resins are elucidated by Infra Red spectral analysis method.

(ii) Preparation of various pigment weight percentage of primers by incorporating Zinc (Zn), Manganese

(Mn), Nickel (Ni) and Stainless Steel (S.S) metallic powders as pigments with extenders and the above resins as binders.

(iii) The critical pigment weight percentage (CPWP) in each binders are optimised in chloride electrolyte by potentiodynamic polarisation studies.

(iv) The physical properties of the selected primers are evaluated by conventional paint testing methods and the corrosion resistant properties by electrochemical methods.

(v) The surface morphology of the primers before and after exposure in the chloride electrolyte are analysed by Scanning Electron Micrography (SEM).

(vi) The electrochemical behaviour of chlorinated rubber based Micaceous Iron Oxide (MIO) and Titanium dioxide (TiO_2) pigmented finish coat on mild steel substrate are studied in chloride medium.

(vii) The electrochemical Alternative and Direct Current (AC and DC) parameters of the primers with top coated systems are also evaluated in this medium.

Chapter I commences with the introduction to corrosion protection by organic coatings, chemistry of organic coatings, mechanism of corrosion inhibition by pigments, principles of paint formulation and the mechanism of protection by organic coating. The electrochemical (A.C and D.C) techniques that are used to evaluate the performance of coatings in different corrosive environments are briefed.

Chapter II deals with the survey of literature on metallic powders as inhibitive pigments in coatings and the scope of the present studies.

Chapter III gives the experimental procedures regarding the preparation of butyl titanate, CNSL and epoxy-polyamide resins. It includes the preparation of primers with various pigment weight percentages by incorporating Zn, Mn, Ni and S.S. as pigments in the above resins and the chlorinated rubber based MIO and TiO_2 pigmented top coats. Mild steel panels of different sizes have been sand blasted and coated with the primers by brush to the dry film thickness of 80 ± 5 μm. These panels are used for the characterisation of the primers. The top coat is also done by brush to the same thickness and used for electrochemical studies. The physical properties such as adhesion, flexibility, abrasion, impact and water uptake of the selected primers are determined as per ASTM specifications. The electrochemical methods of evaluating protective coatings by potential and galvanic current measurements, Tafel extrapolation and A.C. impedance methods are presented. The surface morphological study of the primers by SEM method are explained.

Chapter IV discusses the electrochemical behaviour of butyl titanate based metal powder pigmented primers, the chlorinated rubber based finish coat and the top coated primer systems on mild steel in chloride medium. The optimisation of the pigment weight percentage by Tafel extrapolation method indicates that 80% Zn, 70% Mn, 30% Ni and 30% S.S. rich primers show low corrosion current than the other primers at different intervals of time. Thus these percentages are selected as critical pigment weight percentage in this medium.

It is shown from the study that the zinc and manganese rich primers offer more protection and maintain higher range of galvanic current for long duration than the other primers. The better performance of Zn and Mn rich primers are due to the galvanic as well as barrier protection offered by Zn and Mn corrosion products on the surface of the coating. SEM analysis also indicates the presence of these corrosion products on the surface.

The electrochemical behaviour of the finish coat shows that the MIO pigmented chlorinated rubber based formulation has more resistance than the TiO_2 pigmented formulation. This is due to a high density and lamellar structure of the MIO pigment.

The electrochemical parameters obtained from the A.C. and D.C. techniques on the top coated primer system indicate that the behaviour of the coating systems are normal diffusion control reaction type. The MIO pigmented top coat is suitable for manganese rich primers because this system has higher order of resistance than the TiO_2 pigmented top coat system. But the TiO_2 pigmented top coat gives longer duration of protection to zinc and stainless steel rich primers. On the other hand, both the top coats are suitable for nickel rich primer in the chloride medium. Both the top coats on nickel primer gives the resistance after 100 days in the order of 10^8 ohms Cm^2 and the corrosion current in the order of

0.01 μ.A for the same period. This order shows that the coating remains intact on the surface.

Chapter V presents the electrochemical behaviour of CNSL based metal powder pigmented primers and top coated systems in chloride medium. The optimisation of the pigment weight percentage by Tafel extrapolation method shows that 90% Zn, 70% Mn, 60% Ni and 60% S.S. rich primers have low corrosion current than the other primers at different intervals of time. Hence these percentages are chosen as CPWP of the pigments in CNSL medium. The electrochemical character of Zn and Mn pigment in CNSL medium is similar to that of butyl titanate binder. But the galvanic current offered by these pigments in CNSL medium is of low and short duration than the butyl titanate medium. The nickel rich primer gives longer duration of protection and this is due to the passivation characteristics of the nickel particles in the formulation. The SEM analysis indicate that there is no change in the surface morphology of nickel primer during the exposure in the electrolyte.

The electrochemical parameters obtained by the A.C. and D.C. techniques for the top coated systems show that the behaviour of all the coating systems are diffusion control reaction type. The MIO pigmented top coat protects the surface for longer duration than the TiO_2 pigmented top coat in all the primers except for the manganese rich primer. The manganese rich primer with TiO_2 pigmented top coat system provides high order of resistance and low corrosion current than the MIO pigmented coating.

Chapter VI deals with the electrochemical behaviour of epoxy-polyamide based metal powder pigmented primers and the top coated primer system in chloride medium. The optimisation of the pigment weight percentage by potentiodynamic polarisation method suggests that 90% Zn, 60% Mn, 40% Ni and 40% S.S. rich primers have low corrosion current than the other primers at different time durations. Thus these percentages are selected as CPWP in the epoxy-polyamide medium. The electrochemical studies of the primers in chloride medium indicate that the nickel and stainless steel pigmented primers give higher resistance than the Zn and Mn rich primers. This is due to the passivation character of nickel and good chemical resistance of stainless steel flakes. The surface morphological study show the following aspects, (i) presence of corrosion products of Zn and Mn on the surface of these primers. (ii) A passive layer formation is observed on the nickel rich primer. (iii) With longer duration of immersion, stainless steel flakes are exposed on the surface.

The electrochemical studies of protection by the top coated system indicate that the TiO_2 pigmented finish coat protect the surface for longer durations than the MIO pigmented finish coats. It is observed that the MIO pigmented top coats are also suitable for stainless steel and zinc rich primers in the chloride medium. The better performance of the TiO_2 pigmented top coat on epoxy based primers are due to the good hiding power of the titanium dioxide pigment and better compatibility of the binders in the system.

Chapter VII summarises the results obtained in the present investigation and the conclusions drawn.