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A New Technology of Anti-corrosive of Metals in Atmospheric Environment

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In this paper, a newest kind of anti-atmospheric corrosion method is introduced. This method does not adopt organic coating, plastic layer or metal plating, instead it adopts a kind of aqueous emulsion containing numerous fine solid compounds that are absorbed onto the component surface, which play the role of anti-electrochemical corrosion.

Keywords *: fine, uniform particle, anti-corrosion atmospheric environment.*

1. Introduction

Atmospheric corrosion is one of the most common steel corrosion. In our living environment, you can see the phenomenon of metal corrosion anytime anywhere. Suddenly those shinning steel products were turned into rusty steel. Various counties across the world have attached great inportance to economic losses caused by metal corrosion.

Therefore, the research on atmospheric corrosion of metal and the prevention of corrosion is one of significance for reducing steel losses and promoting the development of national economy.

Since the twenties of last century, researchers all over the world have conducted a series of studies on atmospheric corrosion and prevention of metal corrosion. But, until now, the introductions about the technologies and formulations on anti-corrosion in textbooks and manuals seem a bit out-of-date, thus they could not meet the demands of any type of corrosion in some environments. For example,[1]. Crevice corrosion of metal has long been a pendent and tricky problem, such as ships, cars, tractors, plate and wupport for electric switches, and so on. On the welding crevice between steel plates and welding crevice between steel angles, good-looking paint is usually applied on them, however, after a not so long period, rust gradually comes out the welding crevices, which not only affects the appearance, but also shortens the service life of the equipment.[2] Every year, thousands upon thousands installations are damaged due to the corrosion of chemical atmospheric (atmosphere containing HCl, SO_2, H_2S, acid fog, alkaline splash and etc.). Many electroplated coatings such as zinc coating, nickel coating, chromium coating which are widely used in common atmosphere environments failed to operate in chemical industrial factories, since some of them are less chemically stable, some of them do not give electrochemical protection(even though nickel and chromium combined coating won't do).

A new anti-corrosion method is introduced here, it is neither the organic nor inorganic protective coating which is currently widely used, but some small parts of uniorm and fine particles being mixed with water or water base organic plastic solutions. It speads and adheres on the surface of metals by spraying, brushing and dipping.

After adhering to metal surface, these uniform and fine particles will significantly improve the anodic polarization of the metal microcell, thus achieve anti-corrosive effects.

It is well known that, under equilibrium potential, there exist two similar but contrary procedure:

The ampere density of reductive procedure:

$$\underset{1}{\longrightarrow} = K_1 C_1 E^{-}\frac{W_1}{RT}$$

$$\underset{1}{\longleftarrow} = K_2 C_2 E^{-}\frac{W_2}{RT}$$

The ampere density of oxidative procedure:

C_1 and C_2 are concentration of reactive materials on the surface of both anode relatively, W_1 and W_2 are active energy of both reductive and oxidative procedures relatively.

Once the surface of anode or cathode adhere some active chemical materials, the active energy W will be changed relatively:

$$\xrightarrow[1]{} = K_1C_1E^{-\frac{\alpha nFQ}{RT}}$$

$$\xleftarrow[1]{} = K_2C_2E^{\frac{\beta nFQ}{RT}}$$

These special particles(represented by the symbol P_k in this paper) usually take effect, as long as over 20% of the surface under protection absorbs them. The relationship between the absorption and the electrode potential can be represented as follows:

$$\beta = \beta_0 \exp\left[\frac{\int_{Q_0}^{Q_0} q_{q=0}\,dQ + C_{Q-1}Q(\Delta Q_o - \frac{q}{2})}{RTP_a}\right]$$

Where β is the adsorption equilibrium constant when $Q = Q_0$, ΔQ_0 is the shift of the zero charge potential caused by the saturate covering layer of adsorption molecules. Q is the adsorption amount. P_a is the limit adsorption amount when the surface is covered by single-layer molecules.

2. Experimental

2.1 The Observed Results by Electronic Scanning Microscope.

Fig. 1. The phosphating film, formed in the phosphating liquid without P_k particles, has many cracks and pores.

Fig. 2. The phosphating film, formed in the phosphating liquid with 1% P_k particles, has significantly less cracks and pores.

2.2 Testing Results of Electrochemical Property:

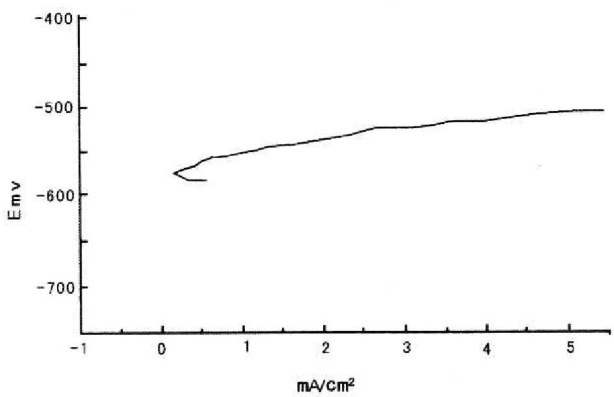

Fig. 3. The anodic polarization cure of the phosphating film, which is formed in the phosphating liquid without P_k particles, is measured in 3% NaCl electrolyte. The anodic polarization is insignificant.

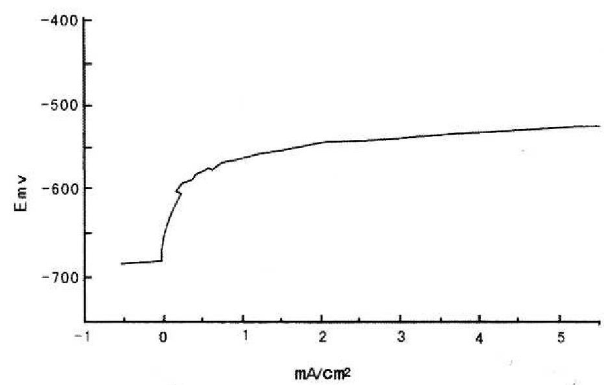

Fig. 4. The anodic polarization curve of the phosphating film, which is formed in the phosphating liquid with 1% P_k particles, is measured in 3% NaCl electrolyte. The anodic polarization is very significant.

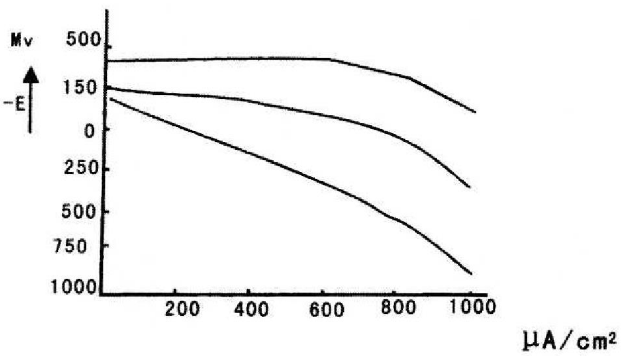

Fig. 5. The anodic polarization curve of the oil soluble inhibitor film in 0.1% HCl electrolyte.
C – Oil film without inhibitor.
A – Oil film contained conventional inhibitor.
B – Oil film contained 3% P_k particles.

2.3 Salt Spray Test Result:

a. Test conditions: Temperature: 40℃; Relative humidity: 100%; NaCl content: 3%
b. Test results: After 48 hours of salt spray test, the results are as follows:

Specimen A: No obvious change
Specimen B: There are 20% of rusty spots.

2.4 Exposure Test in Chemical Industrial Environments

a. Test conditions: Outdoor environment of chemical factory
b. Test results: After 6 months exposure:

Specimen C (covered with oil film without any inhibitors): ruste seriously.
Specimen A (covered with oil film contained conventional inhibitors): slightly rusted.
Specimen B (covered with oil film contained 3% P_k particles): no rust.

3. Results and discussion

From these test results, one can see that some uniform and fine solid particles play inportant role in anti-corrosion for metal in atmospheric environment. These particles can be mixed with water to form latex, or can be mixed with oil to form the oil-soluble inhibitor, it also can be dispersed in the paint···, and then can be coated on the surface of metals by brushing, dipping and spraying.

This is a new anti-corrosive technology for metals.

The anti-corrosive mechanism can be illustrated as follows:

There two kinds of corrosion of steel in atmosphere: one involves those metals with protective layers, like phosphate layer, plated layer and paint layer; another involves those metals without any protective layer. The electrochemical corrosion for former case is: the substrate metal is anode and the protective film is cathode; while the electrochemical corrosion for later case is: the steel itself is anode and the industrial dust and dirt attached on its surface is cathode. The electrode potential for those fine and uniform solid particles(referred to as P_k) is much negative than the steel, they act as countless anodes evenly distributed on the surface of steel.

Therefore, in general situation, the corrosion process is as follows:

Anode process: $Fe \rightarrow Fe^{++} + 2e^-$
Cathode process: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
$2OH^- + Fe^{++} \rightarrow Fe(OH)_2$

As the protective film contains P_k particles:
Anode process: $P_k \rightarrow P_k^{++} + ne^-$
Cathode process: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
$nOH^- + nP_k \rightarrow P_k(OH)_n$

In this case, it is the P_k(other than Fe) that undergoes immediate corrosion and forms the deposit, as a result, Fe is protected.

4. Conclusions

From the above-mentioned testing results, it can be seen that fine particle emulsion has good anti-atmospheric corrosion effects. It is easy to apply with cheap price and wide applications. It can be used for temporary anti-corrosion in storage or transportation, and it can also be used as a primer which can be used together with other primers or finishes. Herein we report the preliminary testing results, and further study will be conducted, so that it will play a bigger role in all sectors of the national economy.

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