BARRIER COATINGS AS A MEANS OF CONTROLLING CORROSION

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ABSTRACT

Corrosion is the gradual physiochemical or alteration of material (usually metals) through the chemical or electrochemical action of its environment. It can be simply defined as the unintentional attack on a metal through the reaction with the environment. This paper shows what corrosion control by barrier coating is, and it highlights the types of barrier coatings namely; metallic and non-metallic coatings. The metallic coating comprises the anodic and the cathodic coating methods of preventing corrosion while the non metallic coating is essentially corrosion control using paints. It also intends to outline the basic characteristics or properties of the different corrosion control methods stated above. The reasons for paint failure and some recommendations for prolonged life and satisfactory performance of the coatings were also reflected.

Keywords: Coating, Anode, Cathode, Paint failure, Barrier coating.

INTRODUCTION

Corrosion is a natural phenomenon and almost all metals corrode, or are expected to deteriorate with time. For example iron rust when exposed to the atmosphere, copper tarnishes and aluminum acquires a whitish hydrated oxide film (Igbafe, 1996). Corrosion occurs in the chemical, petrochemical, food processing industries, air, sea and railroads transportations, in conventional and nuclear power generations, in building and construction industries, in agriculture and in numerous domestic applications.

The driving force that makes metals corrode is the ability of metals to reverse from their metallic state to their ionic state. This is the natural and stable form of metals in which they exist as ores. As a result of this, corrosion constitutes a serious burden to industries and huge financial looses are regularly incurred (Igbafe, 1996).

Due to the huge amount being used in the replacement, overhauling or rebuilding the corroded equipment and component, there arose the need for corrosion control mechanisms. One of the methods of controlling corrosion is by using barrier coatings.

Barrier coatings are protective materials applied to metal surfaces to separate the environment from the metal surface or to control the micro-environment on the metal surface (Trethewey and Chamberlain, 1992). Barrier coatings function by interposing a continuous physical barrier between the protected surface and its environment.

TYPES OF BARRIER COATINGS

Coatings can be classified into the following groups;

(i) Metallic coatings
(ii) Non-metallic coatings

The metallic coatings can be sub-divided into anodic and cathodic coatings. The non-metallic or organic coatings can be referred to as paints. (www.ntu.edu.sg)

METALLIC COATINGS

Many objects around us are finished with metallic coatings to preserve and give luster to the basic substrate metal which provides the strength, rigidity and formability to produce the object. For example, many cans are coated with tin. Metallic coatings interpose a continous barrier between the metal surface and the surrounding environment (Trethewey and Chamberlain, 1992). As earlier mentioned, metallic coatings can be sub-divideed into;

- Anodic or sacrificial coatings, and
- Cathodic or noble coatings

ANODIC OR SACRIFICIAL COATINGS

Anodic coatings are metallic coatings applied to protect a metal by acting as the anode. With respect to ferrous metals, anodic or sacrificial coatings are metals which are anodic to iron or steel e.g. zinc.

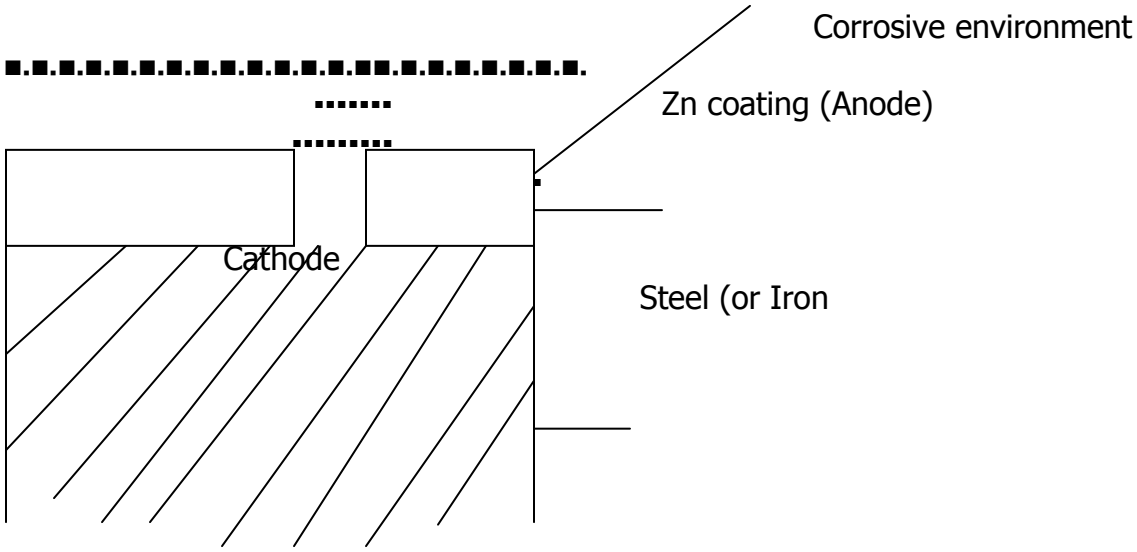

Fig i: Anodic coating

At exposed sites, the zinc (sacrificial metal) corrodes preferentially, protecting the steel. (Etcheverry and Costa, 2005)

In other words, if any discontinuity, pore or other effects exist in the anodic coatings such as galvanized steel or iron, the zinc will corroded since the iron is the cathode. Thus iron is

protected cathodically by sacrificial zinc coatings. Generally, the thicker the coatings the longer the cathodic protection.

CATHODIC OR NOBLE COATINGS

Cathodic coatings are metallic coatings that are applied to protect the base metal. As regards ferrous metals, they are usually cathodic or iron or steel. For example tin, copper and silver. Cathodic coatings are chosen for their resistance to corrosion in particular environment.

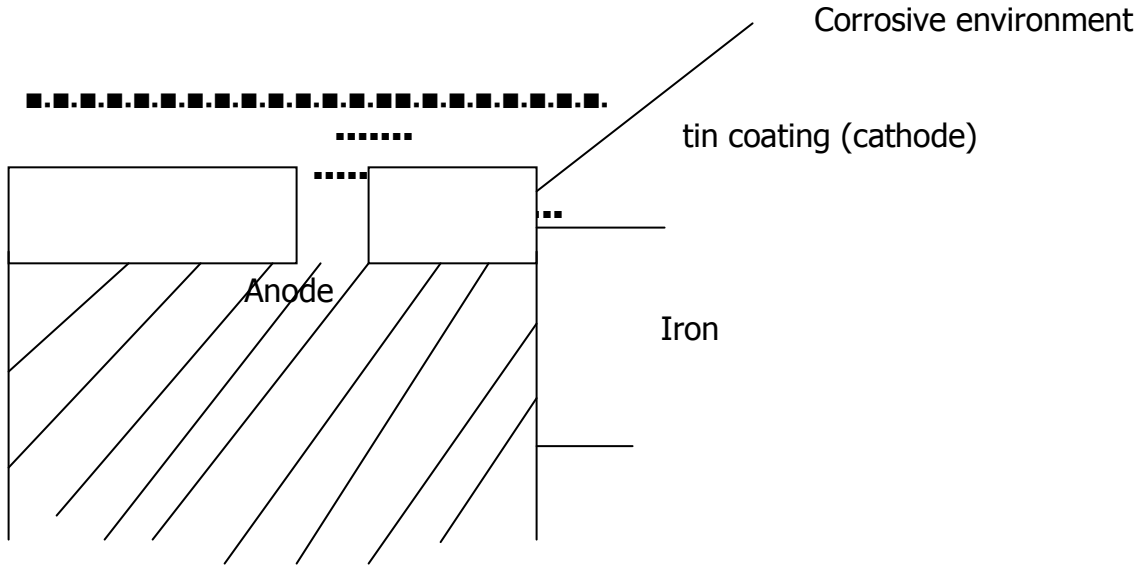

Fig. ii :Cathodic coating.

The quality of the application becomes very important when using cathodic coatings, because small defects and coating damage will cause the substrate metal to corrode faster since it is anodic to the coating as show in fig.ii (Etchverrry and Costa, 2005).

Note that much more damage can be done to a base metal with porous coatings than one without it. This is because the base metal is the anode and so with a porous cathodic coating, what would have been a general (or surface) corrosion will than be piting (i.e. local corrosion) which is more severe and damaging.

PROPERTIES OF METALLIC COATINGS

In summary, metallic coatings have the following ideal properties:-

(i) They should resist attack from the harsh environment.
(ii) They should not accelerate local corrosion at defects or breaks on the coatings
(iii) They should possess good physical properties and mechanical properties such as elasticity, hardness, etc. to withstand the end-use requirement.
(iv) They should be compatible with fabrication of the complete components.
(v) They should have uniform thickness and free of pores and holidays. (www.ntu.edu.sg)

NON-METALLIC COATINGS

Non-metallic coatings or organic coatings are commonly referred to as paints. They consist of:

(1) A vehicle (the liquid) which controls the paints fluidity and drying to form a solid film.
(2) A pigment (suspended in the vehicle) which controls corrosion reaction or rate of diffusion of the reactants through the dry film.
(3) Additives which accelerate the drying process or enable the dry coating to withstand the working environment better.

When the paint has dried, the remaining solid portion of the vehicle forms the binder. The binders;

- Holds the pigment in place
- Keys or anchors the film to the surface, and
- Provides a barrier which resists the passage of water, oxygen and aggressive ions to the metal surface

The pigment fulfills three important roles;

- It gives colour to the dry paint film
- It acts as a printer coating controlling the corrosion process at the metal surface either by inhibiting the reactions or providing sacrificial protection to the substrate metal.
- It increases the length of the diffusion path for oxygen and moisture penetrating the film thereby delaying the onset of corrosion process and slowing its reaction rates.

Notes that a thick layer of paint is achieved by applying the paint in a number of thin coats. (Trethewey and Chamberlain, 1992)

CHARACTERISTICS OF PAINTS

It is desirable for paints to have the following characteristics.

(1)Chemical inertness and corrosion inhibition: - Paints exposed to the atmosphere depend on pigment to prevent corrosion. So, they must be tolerant to a wide variation and rapid changes in the ambient conditions.

- Temperature fluctuations on daily basis which causes thermal expansion of the substrate thereby stressing the paint skin
- Cyclic stress as a result of wet-dry cycles can cause the paint to swell or crack owing to water or moisture uptake.
- Ultra-violet radiation can degrade the paint surface
- Aggressive ions in polluted atmospheres can form acid rain with rain water and this can attack the paint, leading to chemical changes in the pigment or binder which will decompose the coating.
- As the paint ages, the continued oxidation and loss of gloss will increase the permeability of the paint and so, erosion of the coating and more rapid loss of pigments results. (Trethewey and Chamberlain, 1992)

(2)Provision of Good Barrier:- Many paint films permeable to ions such as chloride ions ($C1^-$), sulphate ions (SO_4^{2-}) and carbonate ions (SO_4^{3-}). All paints to some degree are permeable to water and oxygen.

- Some paints are more permeable than others and so their performance as barriers can only achieved when there is a well adhering multiple coats application which effectively covers up pores and other defects. In general, the greater the paint thickness, the greater the protection offered.
- Pigments are usually added to paints to decrease the permeability. Flake shaped pigments are very effective in this regard and they are aligned parallel to the substrate by painting.

(3)Good Surface Adhesion:- The bond between the paint and the substrate must be strong and continuous over the entire substrate's surface. This is achieved by;

- High quality surface preparation
- The paint must wet the whole surface as it is applied

PAINT FAILURE

The main causes of failure in a paint system which has been selected to match the environment conditions are;

(1)Poor or inadequate surface preparation:- Satisfactory surfaces for painting can obtained by;

- Chemical treatment such as picking by immersion in acid solution (i.e. 3wt.% of H_2SO_4)
- Grit blasting to remove grease, dirt, corrosion products, scale and other impurities. If the surface profile produced by grit blasting is too rough micro-peaks or holiday will be poorly covered by the paint and this lead to serious corrosion problems

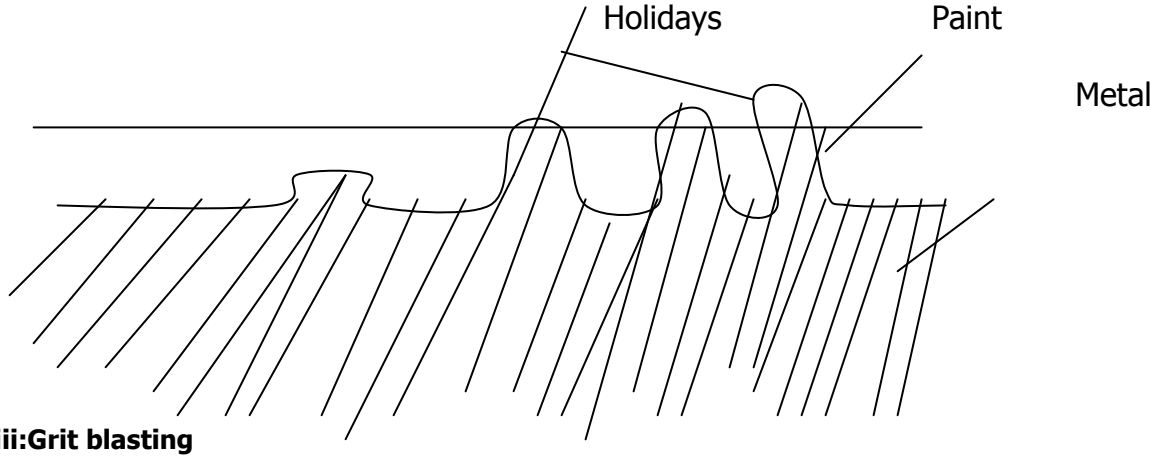

Fig. iii:Grit blasting

(2)Application of paint coating under unsuitable atmospheric conditions: For a satisfactory performance and longevity, the coatings must be applied under suitable atmospheric conditions.

- If the relative humidity is too high a thin invisible film of water will prevent proper anchorage of the coating to the metal surface and this may interfere with the integrity of the dry paint film.
- Solvent evaporation and rate of curing of paints depends on the ambient temperature; evaporation can be slow at very low temperature.
- Temperature changes across a component where the paint is heated to speed or complete the drying process, can cause solvent which has evaporated from one area to condense on adjacent cooler surfaces which are below the dew point of the solvent, and the paint dissolves in a condensed solvent leaving streaks on the surface finish and also reducing the thickness of the coating

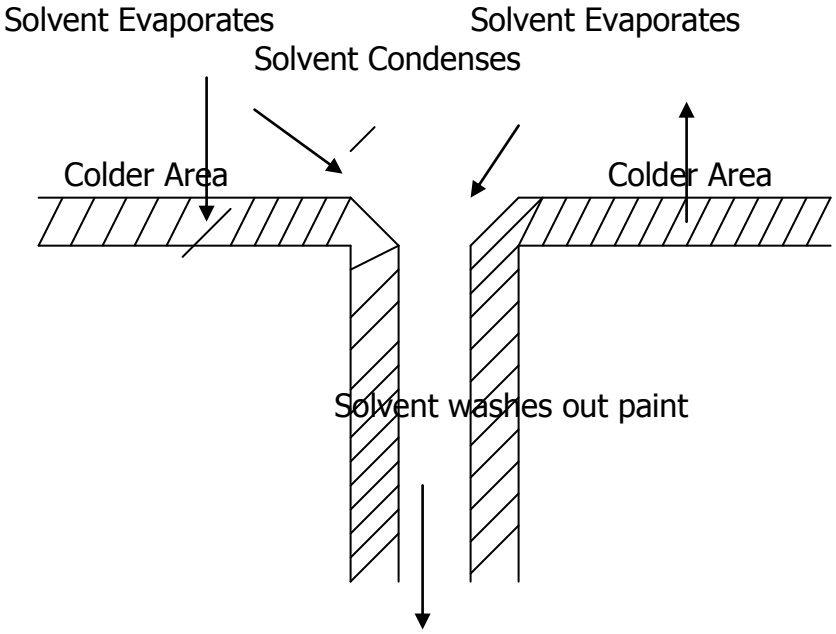

Fig iv: Application of paint under unsuitable temperature condition

(3)Paint application by inappropriate methods:- For better durability of paint coating, it should be applied by the most appropriate method for the best result, paint can be applied by any or combination of the following methods depending on the particular environment.

- Brushing
- Rolling
- Spraying
- Dipping

CONCLUSION

Arising From the foregoing, it is necessary to conclude that the most important single factor influencing the life of paint is;

- Adequate preparation of the metal surface. For a particular application, a medium quality paint applied to a properly prepared surface usually performs better than the best quality applied to a poorly prepared surface.
- In addition to surface preparation, excellent prime coat and thick top coat are required.

For metallic coatings;

- Anodic coatings are desirable
- If cathodic coatings are used, adequate care should be taken so that the coatings are free of pores.

RECOMMENDATION

For longevity and satisfactory performance of coatings;

(1) There should be proper surface preparation of the substrate before coatings of paints are applied.
(2) The coatings should be thick and uniform to cover possible pin holes (or pores) and holidays.
(3) A touch-up programme to cover bad spots should be establish early enough instead of waiting until the coating is so bad that a repair job becomes necessary.
(4) Application of coatings should be carried out under low relative humidity.
(5) Application of coatings should be carried out at optimum ambient temperature.
(6) The temperature of the substrate to be coated or painted should be uniform at every point.
(7) The coating should possess good physical and mechanical properties that can withstand end-use requirement of structure.
(8) The coatings should be compactable with fabrication of the complete components

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