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Insight on the Electrodeposition Technology and Parameter for Corrosion Control of Structural Steel

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Abstract. Corrosion has been and still the world's worst nightmare which costs hundreds and thousands of dollars for companies to maintain their equipment and repairs. Studies are being done all around the world to create the solution toward preventing the corrosion by surface engineering technology. One of the simplest and most cost effective methods to provide thin film coating for advance application is through electrolytic deposition route. However, bath framework has been a major concern for stable coating. Thus this studies look into the insight on the Corrosion, electrodeposition and visible additive for zinc plating technology.

Keywords: Electrodeposition, Corrosion, Technology, Parameter

1. Introduction

The importance of structural steel as metals in the world today cannot be overemphasized because of its high strength [1]. It can withstand high stresses, and for this reason, it is employed in the construction of buildings and structure, manufacture of equipment, production of goods and more. The area of application spans from one sector to sector, covering almost all. Despite the desired strength of structural steel, most are highly prone to corrosion, which results in failure and deterioration of parts [1-3].

With this, it can be said that all metals are prone to corrosion as they are usually in contact with the environment. "Metals corrode because we use them in situations where they are chemically unstable [4]. Thus, the ability of a metal to resist corrosion is essential in the metal selection criteria. However, the corrosion-resistant property of a metal is dependent on its structure and composition. To enhance the corrosive resistance of frequently used metals, corrosion control methods have been put in place which include design, materials selection, protective coatings, inhibitors and other means of environmental alteration, corrosion allowance, cathodic protection [5-7].

The need for the protection of metals is of great importance to engineering since most designs are fabricated with metals because of its high strength and yield properties [8]. Electroplating has proved helpful in controlling the deterioration of metals when exposed to specific environments. In addition to corrosion control, electroplating has other purposes: appearance, unique surface properties and engineering or mechanical properties [9-11]. Some articles are electroplated in order to provide aesthetic value as well as protect the metal from corrosion. In contrast, others are plated to enable joining operations by modification of the metal surface. Sometimes, articles are electroplated to enhance specific properties such as electrical conductivity, etc. or increase the size of the material to enable it to fit into a hole [12]. Electroplating can be the modification of a surface physically to make it suitable for the intended use.



Unlike manufacturing the articles or components from the material with the desired properties, electroplating provides a cheaper and readily available alternative to this choice [13]. Compared to all the different types of electroplating such as nickel plating, silver plating, gold plating, zinc plating is the cheapest and most readily available relative to the others. The significance of this work is in adding to knowledge of the already existing additives used in Zinc Electroplating [13-15]. This would further reduce the cost of acid chloride zinc electroplating baths and waste disposal methods as it also eliminates the use of cyanide, which is harmful to both the environment and human health.

2. Corrosion and the natural processes

Mild steel is an extensively used material that has been involved in all primary forms of constructions on the planet today. Its uses vary from the development of infrastructure, machines, and various material handling situations, such as handling highly corrosive and reactive solutions for chemical and allied industries. Exposure to these environments causes corrosion in varying degrees. This corrosion degrades the material and its properties, thereby making all structures, existing and soon to be built, already subject to a deplorable end [4-6]

The Literature on corrosion and its various techniques of prevention are numerous, displaying multiple experiments and a manifold of observations and useful data. However, the coating process is essential because it factors into the economic section as it prolongs the need to heat the bath and slows production time. On the other hand, electroplating makes up for the cons of the electroless method with being fast and cheap but does not give the same finishing as the latter [7].

Providing coatings that will retain or improve upon the mechanical, chemical, electrical, and morphological structures of structural steel is essential. In addition to offering mild steel with a means to prevent corrosion even further, in the way of “alloying”, to give it better hardness, less brittleness, more luster, and better looks. Absolute corrosion resistance has remained unattained and therefore requires t more work, of any nature, be put into finding out the right combination of elements for optimal, if not perfect, corrosion prevention, based on the situation are critical despite the negative effects posed by corrosion degradation due to material failure thereby reducing the economic, health and safety hazards developed due to electrochemical wear. The graphical corrosion analogy of existence is presented in Figure 1. [2-4].

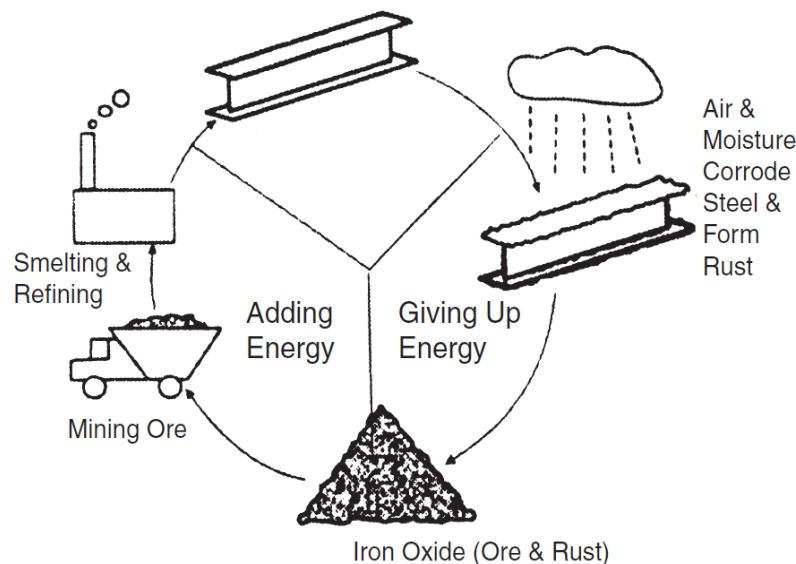


Figure 1. Graphical Representation of Corrosion [14]

Corrosion, therefore, has to do with the combination of materials and the environment. Hence, the corrosion behavior of a material cannot be fully understood without identifying the environment where it is present. The costs employed in treating the waste produced from cyanide-based baths are also of concern [5] as proper discharge and treatment regulations need to be put in place to prevent cyanide's effect on the environment.

3. Additives and bath effect during electrodeposition

Electroplating has also been employed in industries like that of the automobile and Nano and microelectronics because of its aesthetic appearance. This effect is the presence of additives in the electroplating solution, which are called brighteners [5]. For this reason, cyanide has been employed as an additive in electroplating baths because it produces the desired effect. However, cyanide is known to be toxic and poses a hazard to human health. Substantial work has been done in electroplating, also known as electrodeposition, as it is a popular corrosion control method employed in many industries [4]. Over the years, electroplating has evolved from an art to an exact science. Different researchers have investigated the condition at which a well-plated metal is to be obtained.

To reduce the effect cyanide has through electroplating, regulatory laws were put in place to ensure the proper waste treatment to prevent cyanide discharge to the atmosphere and water body. These waste treatment techniques are quite cost-intensive and make the process of plating with cyanide-based baths very expensive. The substitution of cyanide in electroplating baths did not solve all the problems experienced with cyanide-based solutions. Some non-cyanide alternatives pose specific challenges in adaptability with some of the processes and cost and effectiveness [7].

It does not mean that non-cyanide alternatives are of no substantial positive effect but should be a cross-evaluation before they are employed in electroplating solutions. In the use of non-cyanide electroplating baths, additives such as wetters and brighteners are required in answer to produce specific desired properties. Both additives serve as surfactants; however, wetting agents lessen surface topography and lattice tension while brighteners offer necessary appealing worth for the electroplated metal. Organic Compounds have been discovered as brightening agents in electroplating. These also require regulatory measures in terms of waste treatment [8]. The natural organic additives are non-cyanide alternatives in zinc electroplating. It is hypothesized that the addition of plant and fruit extracts as additives would produce a brightening effect on a zinc electroplated mild steel.

With this in mind, alternatives in organic compounds have been discovered to produce the same effect. These alternatives have caused the development of other types of solutions used in electroplating.

The conditions, under which this bath can be used, in area of process issues, have been outlined in the table above. The table makes it easier to analyze both solutions in terms of results and operation comparatively. This allows one to decide on which solution is ideal for the work to be done.

Cetyl trimethyl ammonium bromide (CTAB) and ethylene diamine tetraacetic acid (EDTA) served as brighteners combined to make up a condensation product. The Quantity of the compounds used varies a lot to obtain an optimum value in which the different parameters involved would achieve ideal electroplating. Generally, the common challenge in the bath frame is the control of the zinc metal level, the reason being that there is usually aggressiveness within the zinc anode when concentration rises beyond the expected [13]. This could lead to wastage of the zinc anodes, and to prevent this, specific precautionary measures are being taken. Anode baskets are usually removed at the end of each work shift and before weekends. Previously, the plate's yellowing had been a problem; however, advances in technology have resolved the issue, resulting in excellent brightness and right color in products that have been plated. Another limitation of the alkaline solution is low cathode efficiency, thereby resulting in poor adhesion of deposits. Blistering is also a significant challenge that comes from poor cleaning or intense brightener levels. Surface Cleaning or preparation can be done by either mechanical, chemical means or both. For automatic cleaning, different grades of alumina paper are

used in smoothening surfaces. For the chemical means, alcohols like trichloroethylene or acetone are used to degrease the surface and get rid of any oil or grease on the surface. This is necessary because oil or grease does not dissolve in hydrochloric acid which is used for pickling. Pickling is essential part of surface preparation for electroplating because it removes scales and dust from the metal surface. The rinsing of the specimen is also important to prevent the chemicals on the surface from reacting with the environment. This is done immediately after every stage of cleaning.

Acid solutions used in Zinc electroplating are of two types, namely: chloride and sulphate baths. Each has certain advantages over the other. Acid zinc baths are often needed, especially when a high plating rate and low cost are required in plating or component fabrication [12]. There is an interest in using acid zinc sulphate electroplating solutions because of its relatively low cost, pollution characteristics, and safety features. However, it has weak throwing power and insufficient brightness. Hence, it is not ideal because electroplating is employed not only to provide corrosion control but also to provide aesthetic value to the plated metal.

There has been a considerable amount of work done on the effects of additives on electroplated products. Most of these natural or synthetic additives are Secondary active activities because they impart brightness to deposits [4]. In addition to this, cassava and sugarcane juice are commonly used as natural additives. Sugarcane is a right choice as an additional agent in zinc electroplating. It is an essential species that significantly builds up structural properties that subsequently influence corrosion, wear, and physical characteristics. Pineapple is another natural additive that contains both sucrose and glucose; it makes it an excellent choice for an additive in zinc electroplating its high sugar content Tobacco is a product from agricultural source prepared from the plant's leaves. The inhibitive potential of tobacco has been explored; however, the potential as a brightener in Zinc electroplating has not been looked into [5].

4. Conclusion

The development of various techniques for surface enhancement of materials has increased due to the high demand for an excellent performing and high corrosion-resistant materials. This study has successfully established different additive materials used as alternative additives for electroplating route. With the incorporation of surface-active additives, materials with the Zn composite have the potential for excellent strengthening characteristics that could promote corrosion protection

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