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A Review on Corrosion Resistance of Ceramic Coated Materials

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ABSTRACT

The corrosion is the major issue which is effecting the materials properties. To overcome this disadvantage the ceramic coatings are used. The use of coatings on materials is now widespread in global manufacturing for reducing production cost and improving productivity, all of which are essential if industry is to remain economically competitive. As per industrial requirements materials may be get failed due to their mechanical properties like strength, hardness of these materials can be improved by coating. The durability of material depends on its quality. Good quality material is inherently durable. The materials which are coated have high strength than that of the uncoated materials. In this paper, we review the ceramic coating process, types of corrosion on the metals and corrosion resistance of the material.

Keywords : Surface Coatings, Corrosion, Corrosion Resistance, Ceramic Coatings

I. INTRODUCTION

"Coating" means a substance applied to other materials to change the surface properties, such as color, gloss, resistance to wear or chemical attack, or permeability, without changing the bulk properties. This term often refers to paints such as lacquers or enamels, but also refers to films applied to other materials such as varnishes, sealants, adhesives, inks, maskants, and temporary protective coatings. Such materials include, but are not limited to, paints, varnishes, sealants, adhesives, inks, maskants, and temporary protective coatings. Coatings are usually referred to as decorative or protective, depending upon whether the primary reason for their use is to change (or preserve) the appearance or to protect the surface. Often both the purposes are included. The development of coatings over the years is mainly aimed to improve the corrosion resistance coatings and reduce the coating thickness.[5]
There are two facets to metal coatings — coatings on metal substrates, and metals as coatings on any substrates.[13] The latter can be lumped together in a one-word category called "metallizing," which is done in many ways. The former, coatings on metal substrates, generally are thought of as paint-type materials but may include waxes, inks, and other coatings.[1]

The use of plating and surface coatings to finish part surfaces is widespread in manufacturing. Applied as thin films, these coatings provide protection, durability, and/or decoration to part surfaces. The most common plating and surface coating technologies used include [2,3,4]

- ➢ Vapor deposition
- ➢ Chemical and electrochemical deposition
- ➢ Thermal Spraying.

Corrosion is the surface disintegration of metals/alloys within specific environment. Some metals basically exhibit high corrosion resistance than others and this can be attributed to several factors like their chemical constituents, the nature of electrochemical reactions itself and others. [6]The corrosion resistance of metals can be defined in terms of its ability to withstand aggressive conditions. This determines to a large extent the operational lifetime of components in service. However, there are several definitions of corrosion and according to International Union of Pure and Applied Chemistry (IUPAC) "Corrosion is an irreversible interfacial reaction of a material (metal, ceramic, and polymer) with its environment which results in consumption of the material or in dissolution into the material of a component of the envi- ronment. Often, but not necessarily, corrosion results in effects detrimental to the usage of the material considered.[11] Exclusively physical or mechanical processes such as melting or evapo- ration, abrasion or mechanical fracture are not included in the term corrosion" (Heusler et al., 1989). It is realized that this definition virtually include all engineering materials and it is considered as a wide definition. Hence, another definition is given by ISO 8044-1986 which states inter-alia: "Physicochemical interaction between a metal and its environment which results in changes in the properties of the metal and which may often lead to impairment of the function of the metal, the environment, or the technical system of which these form a part".[8]

II. FORMS OF CORROSION

Forms of corrosion According to ASM (2000) there are basically three factors by which corrosion can be classified, viz; nature of the corrodent, mechanism of corrosion, and appearance of the corroded metal. [10]The latter mode of classification is employed and this is due to the fact that it provides adequate information on the mode of failure associated with the corroded materials. The classification is based on the surface morphology and it must be noted that the forms of corrosion are distinct in theory but practically, there are cases wherein the corrosion fits in more than one category. The corroded metals can be grouped into eight forms of wet (or aqueous) corrosion and these are uniform or general corrosion, pitting corrosion, crevice corrosion, including corrosion under tubercles or deposits, filiform corrosion, and poultice corrosion, galvanic corrosion, erosion-corrosion, including cavitation erosion, and fretting corrosion, intergranular corrosion, including sensitization and exfoliation, dealloying, including dezincification, and environmentally assisted cracking, including stress cracking corrosion, corrosion fatigue, and hydrogen damage.[12]Corrosive attack dominated by uniform thinning High rates of metal penetration at specific sites Affected by alloy chemistry and heat treatment Corrosion with a mechanical component Cracking produced by corrosion, in the presence of stress Atmospheric corrosion Crevice corrosion Intergranular corrosion Erosion corrosion Stress – Corrosion Cracking Galvanic corrosion Filiform corrosion Dealloying corrosion Fretting corrosion Hydrogen Damage Stray-current corrosion Pitting corrosion Cavitation and water drop impingement Liquid metal embrittlement General biological corrosion Localized biological corrosion Corrosion fatigue Solid metal induced embrittlement Molten salt corrosion Corrosion in liquid metals High – temperature corrosion [9]

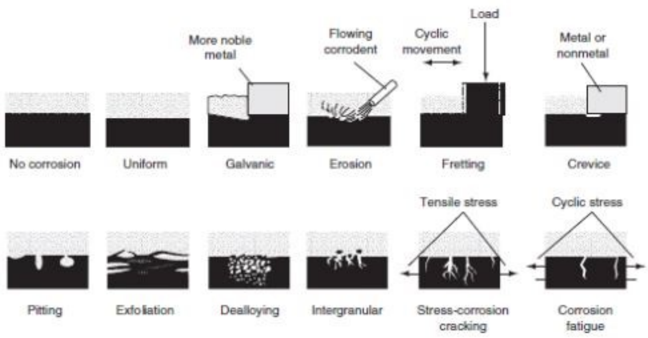

Figure 1. Different Forms of Corrosion

III. CORROSION MECHANISM

Thermodynamic and electrochemistry are of great importance in understanding and control- ling corrosion. Metallurgical factors frequently have a pronounced influence on corrosion resistance. Physical chemistry and its various disciplines are most useful for studying the mechanisms of corrosion reactions, the surface conditions of metals, and other basic properties .As stated earlier, corrosion can be classified into three categories based on the mechanism of their reactions and these are; chemical, physical and electrochemical. Chemical corrosion is purely subjected to the basic laws of chemical kinetics of heterogeneous reactions and refers to cases of corrosion that are not accompanied by generation of electric current for instance, corrosion of metals in non-electrolytes or in dry gases. The attack on metal surfaces during etching is also an example of a corrosion process by chemical attack. The physical mechanism of corrosion is typified in the metallic corrosion of solid metals in contact with liquid metal. In most cases, the solid metal dissolves to form an alloy with the molten metal, while sometimes; attack on solid metal is due to penetration of the liquid metal into the grain boundaries of the solid metal (Umoru, 2001). Electrochemical reactions can be divided into anodic and cathodic reactions.[14] While anodic reaction involves anodic dissolution, Corrosion Resistance Through the Application of Anti-Corrosion Coatings http://dx.doi.org/10.5772/57420 243 at the cathode there is consumption of all the electrons released at the anode.

It also depends on the environment and the cathodic reactions include: metal reduction, metal deposition, oxygen consumption, or hydrogen evolution. In some corrosion reactions the oxidation reaction occurs uniformly on the surface, while in other cases it is localized and occurs at specific areas.

IV. LITERATURE SURVEY

Metals and alloys are most commonly chosen for corrosion resistant concern, especially for metallic or ceramic substrates (Zhang and Tang, 2009). Due to serious environmental issues and health concerns, the use of chromating and phosphating phases (Bibber, 2007; Corell, 1998) are being replaced with molybdate, rare earth, silicate and titanium oxides or zirconium oxides. For example, Huan and Buchheit (2004) studied a vanadate conversion coating and it was demonstrated that the coating formation offers increase corrosion resistance to pitting and suppress oxygen reduction reactions. However the vanadate coating has potentials of producing adverse health effects. While Guosheng et al (2013) concluded that ZnNi coating can serve as low potential cathodic coating for steel substrate and has a long life period and they meet the requirements for cathodic protection. Metallic coated steel can be defined as a steel substrate coated with a layer of zinc, a zinc/ aluminium alloy, a zinc/silicon alloy or pure aluminium. Typical coated steel is as illustrated in Figure 7 below. Fayomi and Popoola (2012) investigated the electrochemical behavior and the corrosion properties of Zn coating on steel substrates by means of Vickers microhardness[9,10]

Several workers have used highly erosion-resistant ceramic coatings such as TiN, CrN in corrosive environments. They however realised that these ceramic materials are brittle and ultimately fail leading to catastrophe. They are very expensive and are used in critical applications; however, the use of novel metallic coatings is still under investigation (Wood and Hutton, 1990; Bousser et al., 2008). Also, numerous patents have been obtained for ceramics materials in the formulation of coatings for anti-corrosion purposes. Some of the ceramics materials are used as corrosion resistant in different application such as: semiconductor industry, fuel cell, and corrosive water containing environments like gas turbine engines, heat exchangers and internal combustion engines among others. Krishnamurthy et al. (2013) demonstrated the application of graphene as a passivating coating materials retards microbially-induced galvanic corrosion (MIC) of metals. The study was conceived on the basis that microbial fuel cell represents a galvanic cell and that the microbes will accelerates the metallic corrosion in the system. The experimental set up of the galvanic cell is shown in Figure 8. The study observed that graphene coating reduces considerably the MIC by preventing dissolution of soluble Ni and its performance is 10 – fold lower compared with uncoated anode. It was concluded that graphene coating have the advantage of possibility of being grown on large-area substrates by chemical vapour deposition. Also that graphene coating prevents MIC by forming passivating layer which thereby restricted the movement of the solution to the Ni surface, disallowed the access of microbes to the Ni surface, and protect the Ni surface from microbes by product. With the aid of morpho- logical study, Zaki and Abdul (2009) revealed that both nanostructured TiO2 and TiO2 demonstrated a little above average resistance to erosion-corrosion. Expectedly the nanostruc- tured TiO2 coating performed relatively better than convectional TiO2 in slurry environment. This was achieved by reducing the gap between the splat boundaries and excluding secondary phase particles. They concluded that by reducing the volume of unmelted particles, number of pores, and provision of optimum surface topography there are possibility for improved performance by the coatings.

IV. CONCLUSION

In this paper, a detailed study of ceramic coatings, the mechanism of corrosion and different forms corrosion is also studied to explain the importance to ceramic coatings in providing the corrosion resistance to the materials. Many works are studied and summarised their results.

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