An Investigation of Tribology Conduct of Alumina Coating on Austenitic Steel

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Abstract--- *The increasing importance of developments in mechanical industry requires a constant evolution of skills particularly in the area of functionalization and protection of metal surfaces. In this work, 500 micron thick Al2O3coating were deposited on substrate made of austenitic steel AISI 316 by thermal spray coating. For the protection against oxidation, Al2O3which has an excellent ability to hinder the inward diffusion of oxygen is desired. Especially above 1000o C Al2O3 become the most effective oxide against environmental attacks. In the experimental testing the Rockwell hardness of AISI 316 coated with Al2O3 is found out to be 27.83 HRC and in the salt spray test we noticed that the red rust formation is not found after 12 hours for the coated specimen and the red rust formation is found after 12 hours for the uncoated specimen.*

Keywords--- *Thermal Spray Coating, Alumina, Austenitic Steel, Corrosion, Salt Spray Test, Rockwell Hardness Test.*

I. INTRODUCTION

Aluminum oxides are being studied extensively in the applications of protective coating due to the excellent ability to hinder the inward diffusion of oxygen. Coatings have historically been developed to provide protection against corrosion and erosion that is to protect the material from chemical and physical interaction with its environment. . Both coating technology can also be divided into two distinct categories:”wet” and ”dry” coating methods, the crucial difference being the medium in which the deposited material is processed. The former group mainly involves electroplating, electroless plating and hot-dip galvanizing while the second includes, among others methods, vapor deposition, thermal spray techniques, brazing, or weld overlays. This journal deals with coatings deposited by thermal spraying It is defined by Hermanek (2001) as follows, “Thermal spraying comprises a group of coating processes in which finely divided metallic or no-metallic materials are deposited in a molten or semi-molten condition to form a coating”. The processes comprise: direct current arcs or radio frequency discharges-generated plasmas, plasma transferred arcs (PTA), wire arcs, flames, high velocity oxy-fuel flames (HVOF), high velocity air-fuel flames (HVAF), detonation guns (D-gun). Another spray technology has emerged recently; it is called cold gas-dynamic spray technology, or Cold Spray (CS).We use thermal plasma spray coating in order to achieve 500 micron alumina coating on AISI316. Thermal spray processes are now widely used to spray coatings against, wear and corrosion but also against heat (thermal barrier coating) and for functional purposes. The choice of the deposition process depends strongly on the expected coating properties for the application and coating deposition cost. Coating properties are determined by the coating material, the form in which it is provided, and by the set of parameters used to operate the deposition process.

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Thermal spray coatings are generally characterized by a lamellar structure and the real contact between the splats and the substrate or the previously deposited layers determine to a large extent the coating properties, such as thermal conductivity, Young's modulus, etc.

II. MATERIALS AND METHODS

2.1 Materials

AISI 316 austenitic steel bars of dimension 1) 20*20mm for sample coated specimens, 2) 20*5*5mm coated specimens for testing

2.2 Pre Treatment Process

Surface adhesion is purely mechanical and as such, a solid key is required, free of grease or other contaminants. Therefore the careful cleaning and pre-treatment of the surface to be coated is extremely important. Surface roughening usually takes place via grit blasting with dry corundum. In addition, other media, such as chilled iron, steel grit or SiC are used for some applications. All items are grit blasted with sharp abrasive grit to achieve a surface roughness of approximately 100-300µin. Besides the type of grit, other important factors include particle size, particle shape, blast angle, pressure and purity

2.3 Coating Technique

Thermal spray is a surface treatment process that the subtle and dispersed metal or non-metallic coating material like wire or powder in a melt or semi-molten state, deposits on the substrate surface to form a sort of deposited layer. Thermal spray material is heated to a plastic or molten state and then accelerated. While these particles hitting the substrate surface, they are deformated due to pressure, form layered sheet, and adhere to the substrate surface. Plasma Spraying service using Sulzer Metco equipment comprising of a number of Sulzer Metco units including a 3MB unit feeding a MBN gun and a 7MB unit feeding a 9MB gun is used in this project for the purpose of coating. A wide range of coatings can be applied including ceramics, zirconium, yttrium, chrome carbides & tungsten carbide and used in a wide range of applications including seal diameters, machines spindles & print rollers.

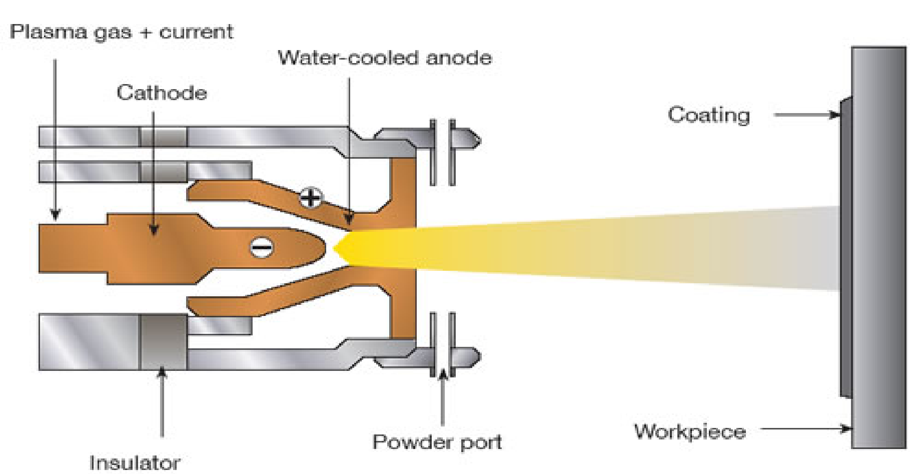

Fig 1: Plasma spray coating technique

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III. EXPERIMENTAL TESTING

3.1 Microstructure

Microstructure is defined as the structure of a prepared surface or thin foil of material as revealed by a microscope above 25×magnification. The microstructure of a material (which can be broadly classified into metallic, polymeric, ceramic and composite) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior, wear resistance, and so on, which in turn govern the application of these materials in industrial practice.

3.2 Salt Spray Test

The salt spray test is a standardized test method used to check corrosion resistance of coated samples. Coatings provide corrosion resistance to metallic parts made of steel, zinc or brass. Since coatings can provide a high corrosion resistance through the intended life of the part in use, it is necessary to check corrosion resistance by other means. Salt spray test is an accelerated corrosion test that produces a corrosive attack to the coated samples in order to predict its suitability in use as a protective finish. The appearance of corrosion products (oxides) is evaluated after a period of time. Test duration depends on the corrosion resistance of the coating; the more corrosion resistant the coating is, the longer the period in testing without showing signs of corrosion.

Salt spray testing is popular because it is cheap, quick, well standardized and reasonably repeatable. There is, however, only a weak correlation between the duration in salt spray test and the expected life of a coating (especially on hot dip galvanized steel where drying cycles are important for durability), since corrosion is a very complicated process and can be influenced by many external factors. Nevertheless, salt spray test is widely used in the industrial sector for the evaluation of corrosion resistance of finished surfaces or parts.

The salt spray test is a standardized and popular corrosion testmethod, used to check corrosion resistance of materials and surface coatings. Usually, the materials to be tested are metallic and finished with a surface coating which is intended to provide a degree of corrosion protection to the underlying metal.

Fig 2: Salt spray cabinet

3.3 Rockwell Hardness Test

In regular Rockwell testing the minor load is always 10 kgf (kilograms of force). The major load can be any of the following loads: 60 kgf, 100 kgf or 150 kgf. No Rockwell hardness value is specified by a number alone.

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It must always be prefixed by a letter signifying the value of the major load and type of penetrator (e.g. HRC 35). A letter has been assigned for every possible combination of load and penetrator, as given in Table 1. Each test yields a Rockwell hardness value on your tester. Testers with dial gauges have two sets of figures: red and black. When the Brale diamond penetrator is used, the readings are taken from the black divisions. When testing with any of the ball penetrators, the readings are taken from the red divisions. Testers with digital displays have a scale selection switch, allowing an automatic display of the Rockwell hardness number on its screen.

3.3.1 Principle of Test

The Rockwell test consists of measuring the additional depth to which a carbide ball or Brale diamond penetrator is forced by a heavy (major) load beyond the depth of a previously applied light (minor) load (SET point). The minor load is applied first and a SET position is established on the dial gauge or displacement sensor of the Rockwell tester. Then the major load is applied. Without moving the piece being tested, the major load is removed and, with the minor load still applied, the Rockwell hardness number is automatically indicated on the dial gauge or digital display. The Brale diamond penetrator is used for testing materials such as hardened steels and cemented carbides. The carbide ball penetrators, available with 1 /16 inch, 1 /8 inch, 1 /4 inch, and 1 /2 inch diameter, are used when testing materials such as steel-copper alloys, aluminum and plastics to name a few.

Fig 3: Rockwell hardness test

IV. RESULTS AND DISCUSSIONS

4.1 Salt spray test

4.1.1Test parameters

Chamber temparature: 34.5-35.5o C

pH value: 6.65-6.85

Volume of the salt solution collected: 1.0-1.5 ml/hr

Concentration of solution: 4.80-5.30% of nacl

Air pressure: 14-18 psi

Components loading in the chamber position: 30 degree

angle

4.1.2 Observation

For uncoated steel specimen:

Red rust formation noticed at 12 hours

For coated steel specimen :

No red rust formation noticed up to 12 hours

4.2 Rockwell hardness test

4.2.1 Test parameters

Scale: C

Indenter used: 120° diamond spheroconical

Load: 150 Kgf

4.2.2 Observations

Observed values in HRC for un coated specimen: 25.8, 25.7, 25.4

Observed values in HRC for coated specimen: 27.4, 27.3, 28.8.

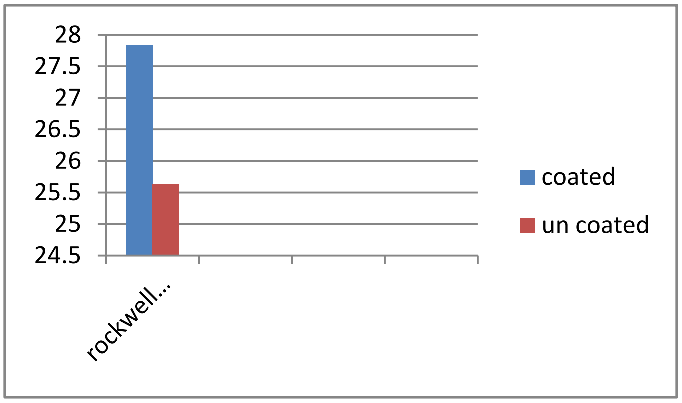

Fig 4: Rockwell hardness number comparison graph

4.3 Microstrucure

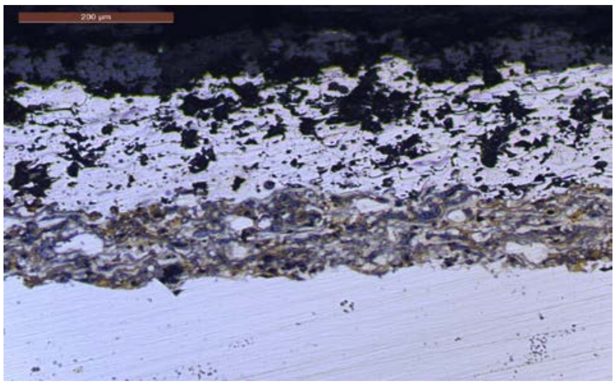

Fig 5: Micrograph of a coated AISI 316 specimen. Mag:200x

The crosssection microstructures of alumina coating on austenitic AISI 316 shown in the fig.4.The improved roughness by grit blasting explicitly visible in the micrographs and the micrograph indicated that the physical bonding between the coating and interface was strong.

V. CONCLUSION

From the obtained experimental work results it was found that, the coating on steel material like steel specimens thermal spray coatings were investigated. The surface morphologies of the major and the minor faces were considerably different from each other. Due the coating on steel materials will improve the mechanical and thermal characterization. This will further improve the hardness, structural grains and thermal properties. Also the Alumina coatings will provide the most dramatic improvements over other coating and uncoated, in steel materials where the applications where failure mechanisms that are driven by high temperatures and chemical diffusion are important for life. In lower temperature applications (lower speeds, discontinuous contact) the coating will still offer improved performance due to the effects of crystallite refinement, which provide a smoother surface and second phase crack arresting or deflection mechanisms that make the coating tougher.

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