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Corrosive Wear Behaviour of Plasma Sprayed Inconel 718 and Titania coatings on Low Carbon Steel in Marine Environment

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Abstract

Low carbon steel is most widely used in marine and agricultural application due its wide availability and low cost. One of the major limitations of using low carbon steel is its susceptibility to corrosion resulting in loss of material and huge replacement costs. In order to overcome this limitation, one of the methods is applying surface coatings thereby enhancing its corrosion resistance in sea water environment. Plasma spray technology has become very prominent in the field of application of ceramic coatings mainly to protect material surfaces from corrosion and wear. In this direction an attempt has been made to develop coatings composed of TiO_2 and Inconel 718 on low carbon steel substrates and subject them to corrosion test under simulated conditions.

Introduction

Coating is a covering that is applied to the surface of an object, usually referred to as the substrate. In many cases coatings are applied to improve surface properties of the substrate, such as appearance, adhesion, wetability, corrosion resistance, wear resistance, and scratch resistance. Coatings may be applied as liquids, gases or solids. Jegadeeswaran et al [1] discussed damage mechanism for the hot corrosion damage of the samples of Ti-31 alloy with Al_2O_3+CoCrAlTaY HVOF sprayed coating at 800°C in a molten salt environment of Na_2SO_4 + V_2O_5.They concluded after gravimetric analysis that the sample gained weight following a parabolic relationship with time. The corrosion behavior of cast Mg-6Al-1Zn + XCa magnesium alloy, aged at different temperatures of 180^{o}C, 200^{o}C, 220^{o}C and 240^{o}C was investigated in accelerated corrosion test chamber according to ASTM-B117 Standard by Manivannan et al [2]. They inferred that the calcium addition and ageing treatment significantly decreases the corrosion rate of AZ61 alloy due to increase in the amount of intermetallic phases, which resulted in the formation of continuous network of β phase. Soheila Faraji et al [3] developed corrosion resistant Cu–P and Cu–P–SiC composite coatings on carbon steel substrates using electroless plating and subjected them to corrosion test in 3.5% NaCl solution. They concluded that Cu–P–SiC composite coatings were superior to that of the Cu–P coatings and carbon steel substrates. In the present work, TiO_2-30wt% Inconel

718 coatings plasma sprayed on Low Carbon Steel substrates is studied for Corrosion behavior.

Coating Procedure

A mixture of TiO_2-30wt% Inconel 718 powders with the particle size varying from 5µm to 50µm was used as coating material to coat low carbon steel substrates using atmospheric plasma spray (APS) technique. Nickel chromium powder was used for bond coating.

APS technique uses a plasma spraying gun which ionizes the working gas flowing between the electrodes to generate temperatures of about 14000K into the high temperature plasma into which is introduced the coating powder which is melted and carried towards the substrate at a velocity of about 800m/s [4]. The substrate was first cleaned of dust particles and then grit blasted to produce a rough surface for proper bonding between the substrate and coating. A thin bond coat of nickel chromium was applied before plasma spraying TiO_2-30wt% Inconel 718 powders. The coating parameters used were powder flow rate of 120 gm/min, current 500A, voltage 48V, Argon flow rate of 30lpm, Hydrogen flow rate of 0.6 lpm, CPSP of 800 and a standoff distance of 10 cm.

Micro Hardness Test

Vickers's hardness tester was used to measure the micro hardness and a load of 200 g was applied for 10 seconds. The test was conducted at different locations and the average hardness value was calculated.

Corrosion testing Method

The salt spray corrosion test consists of spraying of a salt solution onto the samples being tested. This is done inside a temperature-controlled chamber. The solution is a 5% NaCl solution. The samples under test are inserted into the chamber and then the salt solution is sprayed as a very fine fog mist over the samples. The temperature within the chamber is maintained at a constant level. Since the spray is continuous, the samples are constantly wet, and therefore, constantly subject to corrosion.

The mild steel substrate coated with TiO_2 and Inconel 718 were subjected to salt spray corrosion and the weight of the specimen after cleaning the surface was noted at the intervals of 0,3,6,9 and 12 hours.

Results and Discussions

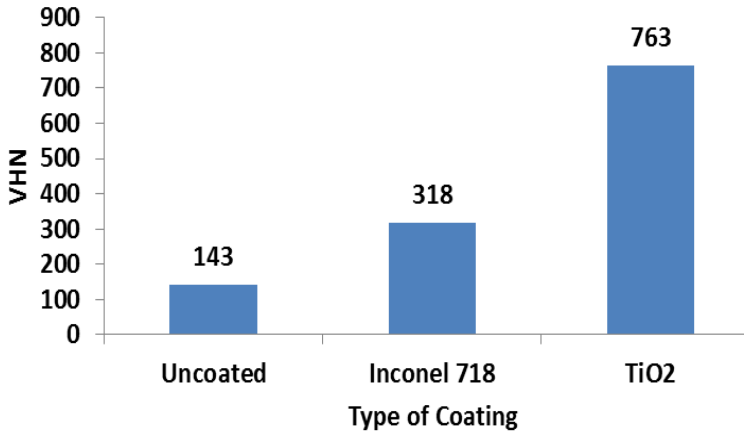

Fig. 1: VHN vs type of coating

Figure 1 shows the Vicker's hardness number for uncoated low carbon steel and Inconel 718 and TiO_2 coatings on Low Carbon Steel.

From the salt spray corrosion test, it is observed that the coating is reacting with salt spray and undergoing corrosion. On cleaning and weighing the specimen, there is decrease in the weight of the specimen. Figures 2 and 3 show that with increase in the time of exposure of the specimen to salt spray fog, mass of the specimen decreases for both Inconel 718 and TiO_2 coatings. The overall decrease in weight for Inconel718 and TiO_2 coating after 12 hours of corrosion is found to be 0.0204 grams and 0.0117 grams respectively. This indicates that corrosion is higher in Inconel 718 coated specimen than TiO_2 coated specimen.

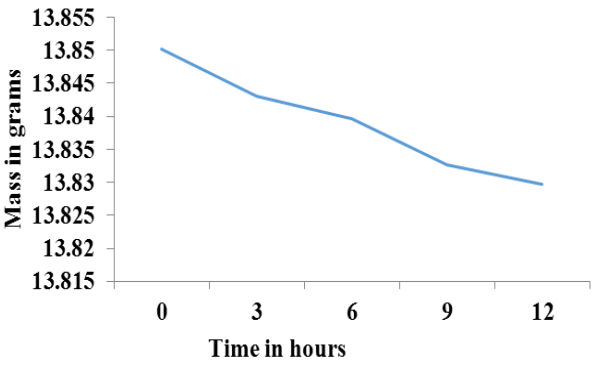

Fig 2: Mass of specimen vs Time for Inconel 718 coated specimen

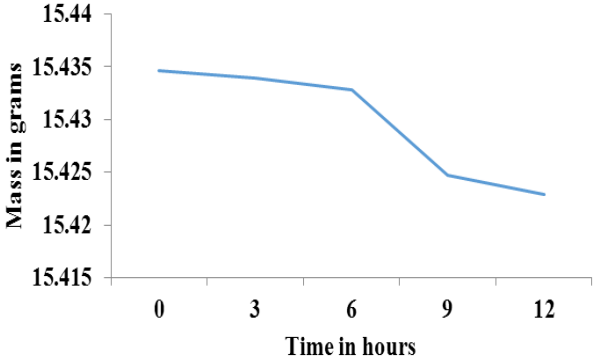

Fig 3: Mass of specimen vs Time for TiO_2 coated specimen

Conclusion

Comparing Inconel 718 and TiO_2 coatings on mild steel, it is observed that corrosion is greater in Inconel 918 coatings compared to TiO_2 coatings.

References

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KEYWORDS: Corrosive Wear, Plasma Spray, Inconel 718, TiO_2