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Experimental Analysis of Plasma Sprayed Multi- Layered Coating for Corrosion Resistance

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ABSTRACT

Corrosion of metals costs the world lots of money per year. On an average, 40% of the total steel production goes to replace the corroded parts and products. Although corrosion problems cannot be solved completely, corrosion- related costs can be reduced with the development and use of better corrosion resistant composite coatings. In this work, a bond coating of NiCoCrAlY is sprayed by plasma spray process. Plasma spray is used to form multi-layer deposits of Yttria Stabilized Zirconia, Aluminium oxide. Normally, single layer coatings are used as thermal barrier coatings for turbine and diesel engines. Here a multi-layer coating is used in this work. Coated samples were subjected to various testing methods. Porosity measurement, salt spray testing, test is carried out in order to check the durability of the coatings.

KEY WORDS: corrosion, Layert Coating, Zirconia

1. INTRODUCTION

Corrosion is the reaction of an engineering material with its environment leading to consequent deterioration in the properties of material. Degradation by hot corrosion and erosion are the main failure modes of components in the hot sections of gas turbines, boilers, metallurgical furnaces, jet nozzles etc. Super alloys have been developed for high temperature applications, but they are not able to meet the requirements of high temperature strength, and corrosion resistance simultaneously.

The protection of metals or alloys against corrosion and wear can be achieved by development and the use of better corrosion and wear resistant thermal spray coatings. These corrosion and wear resistant coatings can add value to products by allowing the mechanical properties of the substrate materials to be maintained while protecting them against wear or corrosion. Thermal barrier coatings (TBCs) have been developed to protect metallic and silica based ceramic components in turbine for high temperatures.

2. EXPERIMENTAL WORK

Super alloys are metallic materials for service at high temperatures, particularly in the hot zones (turbine blades) of gas turbines. Stainless Steel 304L grade is taken as base metal since it resists corrosion. It has less percentage of carbon than Stainless Steel 304 which avoids chrome carbide precipitation. Different samples of varying size were taken for analysis. A bond coating of NiCoCrAlY was used in thermal-barrier coatings. The bond coating was sprayed by plasma spray process. An improvement in oxide coating adhesion can be achieved by the application of bond coatings.

Plasma Spray Coating: Plasma spraying uses metal in powder form. The coating materials in the form of a powder is passed into a plasma jet in which powder particles are melted and accelerated towards the surface to be coated. The powder particles, approximately 50 micrometers in diameter, are accelerated and melted in the flame on their high speed 200 m/sec path to the substrate, where they impact and undergo rapid solidification.

Plasma spray is used to form deposits of 100 µm, 50µm of Yttria Stabilized Zirconia (8% Y_2O_3+ 92% ZrO_2) and Aluminium powder with four various combination of coatings such as SS 304L - Y_2O_3+ZrO_2 (50µm) - Al_2O_3 (100µm), SS 304L - Y_2O_3+ZrO_2 (100µm) - Al_2O_3 (50µm), SS 304L - Al_2O_3 (50µm) - Y_2O_3+ZrO_2 (100µm), SS 304L - Al_2O_3 (100µm) - Y_2O_3+ZrO_2 (50µm).

The coating thickness was chosen as 150 µm since the range of optimum coating thickness for turbine blades is 150 µm to 250 µm.

Figure.1. Three different shapes of specimens after coating process.

Fig 1. shows the Multi layered coatings of Aluminium Oxide [Al_2O_3] and Yttria Stabilised Zirconia [(8% Y_2O_3+ 92% ZrO_2)] with varying thickness and varying coating layer combinations.

Testings of coatings: Four specimens of different coating combinations was taken for each test. After the completion of coatings over the samples, they were subjected to various tests such as Porosity measurement, Salt spray corrosion test. Optical metallography was used to measure the porosity. Experimental value of porosity was measured by image analyzer technique. The samples were scanned in different positions. The total area captured by the objective of the microscope was accurately measured by the software. Hence the total area and the area covered by the pores are separately measured. The porosity value was noted and the mean value of the coatings was calculated. Salt spray corrosion test was performed in Salt fog chamber. The tap water was mixed with 5% NaCl and pumped from a reservoir through the spray nozzles in the form of fog. The mixed solution was passed with humidified compressed air at nozzles. Then compressed air atomized NaCl solution into a fog at the nozzles. The corrosion rate was measured by noting the time period until rusting of the test was conducted for 240 hours. The weight loss was measured for each sample at intermediate period and the mean weight was calculated.

3. RESULTS AND DISCUSSION

Porosity measurement: Porosity was measured by image analysis for each type of coating materials. The level of porosity was lower in multi-layered Aluminium Oxide [Al_2O_3 (50µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (100µm)] as bottom coat than compared with other three type of coating samples. Figure 2 shows the Porosity of the coated specimens.

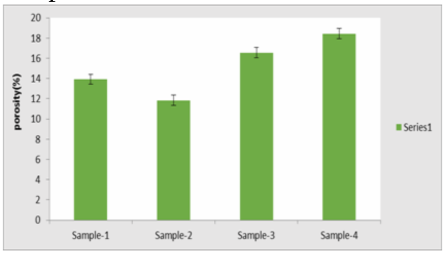

Figure.2.Porosity of the coated specimen

Salt spray corrosion test: Salt spray corrosion test was widely used to evaluate corrosion of the coated specimen 240 hours.

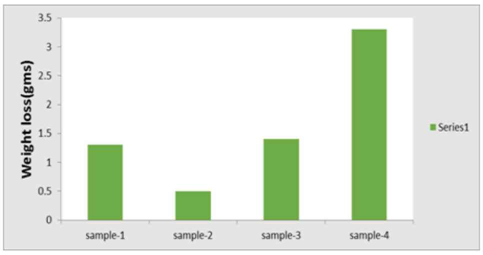

Figure.3.Weight loss of the coated samples during salt spray test

The area occupied by the fully melted zones, a circular and homogeneous morphology of splats, minimum number of pores, voids and minimum space between the splats, represent a morphology resistance to damage by corrosion as shown by the investigation. The random packing of splats and large voids shown in image of multi-layered Aluminium Oxide [Al_2O_3 (100µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (50µm)] as bottom coat, Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (100µm)] as top coat and with Aluminium Oxide [Al_2O_3 (50µm)] as bottom coat and Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (50µm)] as top coat and with Aluminium Oxide [Al_2O_3 (100µm)] as bottom coatrepresents an unfavorable morphology. Whereas the presence of a large melted zone and columnar grain shown in image of Aluminium Oxide [Al_2O_3 (50µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (100µm)] as bottom coat sample represents morphology more resistant to corrosion.The corrosion attack is predominantly in the form of etching.

4. CONCLUSIONS

The image analysis indicated that the porosity of Aluminium Oxide [Al_2O_3 (50µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (100µm)] as bottom coat showed a low porosity of 11.84% whereas samples showed a high porosity of 13.92%, 16.56%, 18.43%.

The Salt spray corrosion test indicates that the onset of red rust on Aluminium Oxide [Al2O3 (50µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y2O3+ 92% ZrO2) (100µm)] as bottom coat coated samples started at 240 hours and the weight loss was found to be 0.5 gm whereas the onset of red rust on other coated Samples started at 216 hours, 210 hours, 204 hours and the weight losses was found to be 1.3 gm, 1.4 gm, 3.3 gm. The Aluminium Oxide [Al2O3 (50µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y2O3+ 92% ZrO2) (100µm)] as bottom coat coated samples showed the improved corrosion resistance than other coated samples.

The Aluminium Oxide [Al_2O_3 (50µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (100µm)] as bottom coat coated specimen showed good performance in the entire test. Hence, we can conclude that the Aluminium Oxide [Al_2O_3 (50µm)] as top coat and with Yttria Stabilized Zirconia [(8% Y_2O_3+ 92% ZrO_2) (100µm)] as bottom coat coatings can be used in order to resist corrosion.

REFERENCES

Anees U Malik, Shahreer Ahmad, Ismaeel Andijani, Corrosion behavior of steels in gulf seawater environment, Desalination, 123, 1999, 205-213.

Fauchais P, Conventional plasma spraying, SPCTS, UMR 6638, Univ, of Limoges.

Kanchana Trakulcoo, Accelarated corrosion testings: Salt spray Test, Asean journal of science and technology, 4(1), 1987, 55-68.

LechPawlowski, The science and engineering of thermal spray coatings, Wiely publications, 2008, 64.

Mitra Akhtari Zavareh, Ahmed Aly Diaa Mohammed Sarhana, Bushroa Binti Abdul Razak, Wan Jeffrey Basirun, Plasma thermal spray of ceramic oxide coating on carbon steel with enhanced wear and corrosion resistance for oil and gas applications.

Moskal G, The porosity assessment of thermal barrier coatings obtained by APS method, Journal of achievements in materials and manufacturing systems, 20(1-2), 2007, 483-486.

Rupa Dasgupta, Aluminium alloy-based metal matrix composites, A potential material for wear resistant applications", International scholarly research network, Article ID 594573, 2012, 1-14.

Vasile Hotea, Irina Smical, Elena Pop, Lozsef Juhasz, Gabriel Badescu , Thermal spray coatings for modern technological applications, Fascicle of management and technological Engineering,Vol.7(17), 2008, 1486-1493.

Vijaysingh B, Suryawanshi, Inamdar K.H, Method of surface roughness evaluation using Ruby Laser Beam", International journal of engineering research and applications, 2(3), 2012, 1512-1515.