Enhancing the property of SS316 steel using polyether ether ketone

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Abstract. Aim of this project is to improve the corrosive property of SS316 steel using polyether ether ketone. SS316 is the standard molybdenum bearing grade having excellent forming and welding characteristic. In this experiment low carbon version of 316 steel was taken as base metal which is used in heavy gauge welding component. Using plasma spray method, the coating process done on SS316 metal and their uniformity of coating was examined by microscope. Salt spray test has been conducted to check the corrosive property of polyether coated steel.

1 Introduction

SS316 steel is composed of 18.5 % chromium, 14% nickel, 3% molybdenum and 2% manganese as a major element. It has a tensile and yield strength of 485 Mpa and 170 Mpa respectively. SS316 steel is mainly used for marine application but the corrosion will be more in warm water. Hence in order to enhance the corrosive property of SS316 steel, it was subjected to polyether coating [1,2,3]. Polyether ether ketone having high chemical resistance even at high temperature. It show good resistant to thermal degradation and also attack by aqueous environments [4,5,6]. It has also having high resistance to biodegradation. It seals and manifolds are commonly used in fluid applications. In this experiment, plasma spray method was used to make a polyether coating over SS316 steel. In plasma spray process, the molten material is used to spray on the surface of material. Material is injected in powder form at very high temperature using plasma flame. Hot material strike the surface to form the coating. Plasma spray consist of both cathode and anode. In this method anode is Copper and cathode material is tungsten. Plasma gas passed around the cathode and through the anode which is shaped as a constricting nozzle. Due to high voltage the plasma occur which produce ionization. Arc produced due to resistance heating make a gas to reach high temperature. Through an external port, powder was fed into plasma flame [7,8].

2. Experimentation

At first, SS316 steel of 100 x 100 mm was taken and polished by grinding machine to carry out the coating process. Plasma spray coating process is used to spray the molten metal on the surface. In this method SS316 was subjected to plasma spray coating of polyether ether ketone in order to increase the corrosive property. Hot molten material which strike the surface create a layer by rapid cooling process. PEEK deposited on SS316 steel was obtained by plasma spray coating process. Due to high temperature of plasma, the polyether ketone form the coating on the surface. An arc is produced in
between the electrodes which consists of argon. During this process PEEK powder is continuously sprayed on the SS316 steel substrate. Table 1 shows the process parameter for salt spray testing.

Table 1. Parameters used in salt spray testing

| Parameter                        | Value          |
|----------------------------------|----------------|
| pH solution                      | 6.7 to 6.84    |
| Pressure                         | 12 psi to 16 psi|
| Sodium Chloride                  | 5.2 - 5.4%     |
| Chamber temperature              | 34.8 - 35.3 C  |
| Collection of solution per hour  | 21.5 ml        |

Figure 1. Salt Spray Testing Apparatus.

3. Testing and result

3.1. SEM analysis

Figure 2 shows the scanning electron microscopic image of polyether ether ketone and figure 3 shows the SEM image of PEEK coated SS316 steel.

Figure 2. SEM image of PEEK

Figure 3. SEM image of PEEK coated SS316 steel
3.2 Atomic Force Microscope testing

Atomic force microscope formed the shape of the work piece surface in three dimensional with high resolution. Image can be obtained by scan the position of probe and measure the height during probe movement over the work piece [11-15]. To maintain constant force during testing electronic loop is used. Scanning will start in x-y plane when the tip contact the sample.

Table 2. Roughness analysis from AFM

| Parameter                        | Range     |
|----------------------------------|-----------|
| Sampling amount                  | 65536     |
| Maximum                          | 144 nm    |
| Minimum                          | 0 nm      |
| $S_y$ value (peak to peak)       | 144 nm    |
| $S_z$ value (ten point height)   | 72 nm     |
| Average value                    | 70 nm     |
| $S_a$ value (Average roughness)  | 14 nm     |
| $S_k$ value (Surface skewness)   | 0.00137283|

Figure 4. AFM image

Figure 5. AFM image in 3D
3.3 Corrosion Test

In order to find the corrosive property of SS316 after coating, salt spray test was made. It is one the standard testing method as compare with other. In this method, corrosive attack was done on the coated sample to find the corrosive property of the metal. Duration of coating depends on the resistance offered by the coating over the surface. Salt spray testing is low cost method to find the corrosive property [9,10]. It consist of testing chamber where salt water is sprayed with the help of nozzle. Pressure of air was maintained in the range of 14 psi in testing apparatus. Corrosive test was conducted upto 300 hrs and from the result it is observed that the coated metal show good resistance to corrosion which is shown in figure 7.

| Table 3. Salt Spray Test parameter |
|-----------------------------------|
| Air pressure (psi)                | 14 -18   |
| Chamber temperature (°C)         | 34.5 - 35.5 |
| Components loading in chamber position | 30 |
| Concentration of solution (%)    | 4.80 - 5.30 % of NaCl |
| pH value                          | 6.65 - 6.85  |
| Volume of solution collected (ml/hr) | 1.00 - 1.50 |

4. Conclusion

In this experiment the Polyether ether Ketone (PEEK) coating was made on the SS316 steel. The coatings of 5 microns thickness was obtained using plasma spray coating process by maintaining the distance between the target and the substrate from 2.5 to 4 inch. The characteristics of coating was
analyzed by Atomic force Microscope and Scanning electron microscope. The salt spray test was conducted for coated SS316 steel at pH ranges from 6.74 to 6.87 for 300 hrs. It is observed that the coated sample remains unchanged beyond 320Hrs. Hence it is concluded that with the help of polyether ether ketone, the corrosive resistance can be improved for SS316 steel material.

5. References

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