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Microstructure and Corrosion Behaviour of Al-Si Coating on Mild Steel

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Abstract:
This project is done in order to increase the application of mild steel in the industrial application. Mild steel is naturally poor resistance to corrosion. Here a comparative test will be taken on corrosion behavior, residual stresses and the other characteristics. Coating of Al-Si alloy composition on MS substrate increases the corrosion resistance property. Aluminium is light in weight, deoxidizer, higher resistance to resistance. Silicon improves oxidation resistance and strength the low alloy steels. Coating was done on Mild steel substrate in three different mixing proportions and in three different thicknesses by thermal plasma spraying process. Mechanical properties and other characterization will be found out by scanning electron microscopy (SEM). The corrosion behavior was tested in Na-Cl and H_2SO_4 solution. Different types of corrosion test were studied. Finally there was a result obtained in Al-Si (75/25) proportions and 90µm thickness which increases the corrosion behavior of the mild steel.

Keywords: Al-Si, Corrosion, Coating proportions, Coating thickness, Mild Steel, Plasma Spray

1. INTRODUCTION

Recent research has been focused on the study of the coating materials. The need of mild steel is more, but due to its poor corrosion resistance property it could be avoided in some of the applications. Mild steel, also known as carbon steel, will rust over time unless it is treated with some sort of protective coating to prevent the steel from corroding. Elements that are introduced to steel like molybdenum, titanium and chromium can improve the corrosion resistance of steel, but it does not make the steel rust proof. Corrosion has been an important problem for centuries, but with the rapid multiplying uses of metals, the increasing occurrence of corrosive environment, and the depletion of supplies of ores, it has become much more serious in recent years. Corrosion plays a part in the general study of materials and its effect is primarily damaging to materials. Generally, corrosion is a slow process but it is persistent in character. There are no metals which will withstand corrosive attack in all environments. Any metal will corrode under certain conditions and then will either get destroyed or rendered useless. In order to increase the corrosion resistance coatings are carried out. There are already several coatings are there but here Aluminium and Silica are taken as a coating material. Aluminium is light weight and abundant metal. The main important property of Al is higher resistance to corrosion. Silica is a good absorber of moisture. It is also a abundant material. Both are economically low in cost. Plasma spraying process itself a higher corrosion resistance process. Coating would be done on a MS based on two factors, mixing proportions, thicknesses. After the coating process testing will be carried out. Scanning electron microscopy (SEM), salt spray test, Brinell hardness test, field corrosion test, corrosion test in other corroding medias. Finally result obtained on 90µm thickness and Al-Si (75/25) mixing proportions.

2. MATERIALS PROPERTIES

2.1 ALUMINIUM

It is a light metal, with a density about a third that of steel or brass. Aluminium has a higher resistance to corrosion than many other metals, owing to the protection conferred by the thin but tenacious film of oxide which forms on its surface. It is very ductile and non-magnetic. Some of these aluminum alloys are more than 4 times as strong as the same weight of mild steel. Although pure aluminium is not particularly strong, it forms high-strength alloys in conjunction with other metals as: Cu, Cr, Ni, Fe, Zn, Mo, Si and Mg. melting point of pure aluminium is about 650◦C.

Figure.No.1. Aluminium Powder

2.2 SILICA

Silicon dioxide, also known as silica, silicic acid or silicic acid anydride is an oxide of silicon with the chemical formula SiO_2, most commonly found in nature as quartz and in various living organisms. It improves the oxidation resistance. It acts as a deoxidizer. When combined with Aluminium it strengths the low alloy steels.

Figure.No.2. Silica Powder

2.3 MILD STEEL

Mild steel, also known as carbon steel, will rust over time unless it is treated with some sort of protective coating to prevent the steel from corroding. Elements that are introduced to steel like molybdenum, titanium and chromium can improve the corrosion resistance of steel, but it does not make the steel rust proof. Mild steel contains approximately 0.05–0.25% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and easy to form; surface hardness can be increased through carburizing.

Figure.No.3. Mild Steel

3. EXPERIMENTAL INVESTIGATION

This investigation is done with twenty seven specimens. All the specimens were coated in different mixing proportions and coating thicknesses. Coating was done by thermal plasma spray coating. Corrosion test like Salt spray test, Field corrosion test, and tested in other corroding medias.

3.1 SPECIMEN PREPARATION

The Specimens were selected according to three structure, they are Cylindrical rod, MS-plate, MS-L angle plate. The dimensions of cylinder is 4.5 cm diameter and 10 cm length. The dimensions of MS-plate is length 10cm, 5cm breadth and 10cm L angle plate.

3.2 COATINGMACHINE SPECIFICATIONS

Powders mixed in the following ratios: Al-Si (25/75), Al-Si (50/50), and Al-Si (75/25) was used for this research work. It consist of a hoop powder feed unit (9MP) and a robot that controls the position and angle of the spray gun at a speed of 400 mm/s. Before deposition, the substrate was grit-blasted using alumina grits with the aim of cleaning and to roughen the specimen surface. The powder was fed into a hopper and Mild steel bar was clamped/placed and tightened on a stand inside the plasma spray booth. The spray gun, with aid of a flame deposits the powder of interest on the surface of the substrate of approximately from 300 to 3000° at different intervals until the required coating thickness of 90µm is achieved. During the spraying, the gun is stopped frequently to avoid over heating the substrate. Hydrogen (11 L/min) argon (175 L/min) was used as primary and secondary inert gases respectively. The coatings were deposited at a distance of 100 mm and powder feed rate was 32 g/min.

3.3 INSTRUMENTATION

The following figures shows the different specimen structures and the specimen tested machines and also the metals coated with Al-Si in different structures.

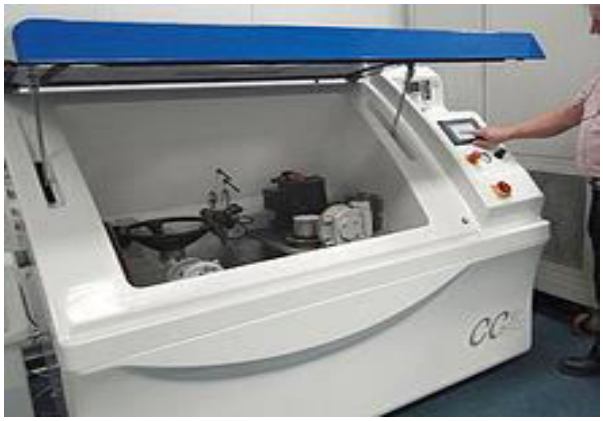

Figure.No.4. Salt Spray Test

Figure.no.5. SEM

Figure.No.6. Cylinder Rod

Figure.No.7. L-Angle Plate

Figure.No.8. Plate

4. RESULT AND DISCUSSION

From the comparative study, the following graph and the SEM analysis shows the the coating surfaces and the coating thicknesses. With the help of this analysis it would be proven that combination of Al-Si is a good corrosion resistance while coated in mild steel. Fig 9 shows the micro hardness of the coated steel and Fig 10 shows the corrosion resistance Vs mixing proportions. Fig 11 and Fig 12 shows the SEM analysis.

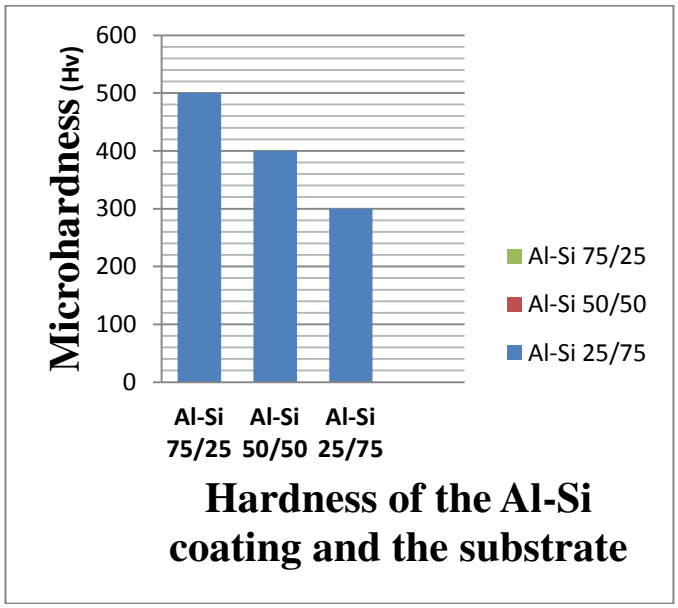

Figure.No.9. Micro hardness of the Coating

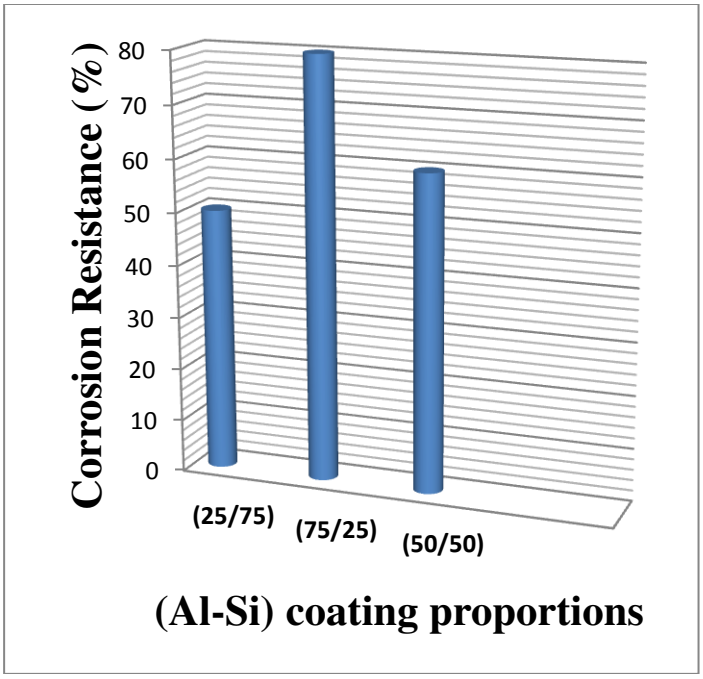

Figure.No.10. Corrosion Test Graph

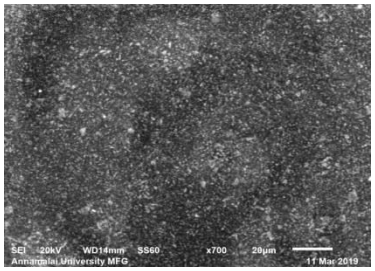

Figure.11. SEM In 700µm Before Salt Spray Test

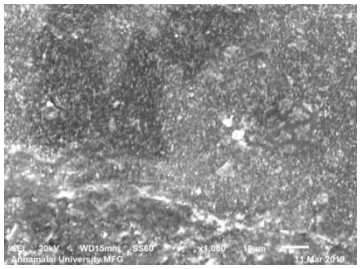

Figure.12. SEM in 1000µm after Salt Spray Test

5. CONCLUSION

Deposition Al-Si alloys was successfully carried out on mild steel surface by plasma spraying technique. The coated Al-Si samples in different ratio were carried out on the surface of mild steel substrate. The substrate exhibited corrosion rate considerably higher that the coatings. A substantial advancement in corrosion resistance was attained in the coated specimens. In 1M H_2SO_4 solution, the best corrosion resistance was exhibited by Al-Si (25/75), Al-Si (75/25) and Al-Si (50/50) respectively. In 350g Na-cl solution the highest corrosion resistance was exhibited by Al-Si (50/50), followed by Al-Si (75/25) and Al-Si (25/75) coating respectively. The micro hardness values show that Al-Si coatings had improved hardness values as compared to the substrate. Al-Si 50/50 had the highest hardness value compared to the other coatings. The residual stresses of the

Al-Si coating were all compressive in nature and of relatively lower valued. Finally the coating substrate of Al-Si (75/25) in 90µm was higher resistance to corrosion.

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