Investigation on Nano Ceramic Coating over A105 Medium Carbon Steel for Valve Application

Lijin George Jacob V[1*], Bhagyanathan C[2], Vinodh Raj R[3]

[1]PG Scholar, Department of Manufacturing Engineering
Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, Indian

[2]Assistant Professor, Department of Manufacturing Engineering
Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India

[3]PG Scholar, Department of Manufacturing Engineering
Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India

[*]*Corresponding author's email: lijin.october12 [AT] gmail.com*

ABSTRACT —*Medium carbon steels are widely used in environments with high temperature and high pressure with chemically reactive environments due to their good corrosion properties. In applications like valves carrying high temperature and pressure fluids. Wear has been always regarded as costly problem to migrate in these applications. These problem avoids the long run of the components. Hardfacing can be done as a remedial measure but it has got many demerits too.Ceramic coatings are preferred in this research since it provides good wear resistance and high thermal resistance. Nano coating of Titaniais selected to coat over samples.Plasma arc spray coating process is done in this research and results were compared. SEM characterization confirm the uniform coating over the samples and Dry wear test is carried out to check the improved wear resistance*.

Keyword—Plasma Arc Spray, TiO_2

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1. INTRODUCTION

Most common material used in oil production is carbon steel.A105 carbon steel are widely used in petrochemical industries for valve materials, due to their high machinability, corrosion and wear resistance. When these materials are exposed to an aqueous corrosive medium it will be subjected to pitting corrosion or localized corrosions. These materials are used for high pressure application where the operating temperature is minimum 900° Celsius. Under these conditions the material is prone to high wear due to high pressure slurry being transported. During this flow, the velocity of the fluid drops and thus increases the susceptibility to pitting corrosion due to prolonged exposure of the fluid with the material. Nano coatings are more effective than commercial coating process since lower material is required for the process and also it induces hydrophobic properties. Ceramics have high chemical stability and high resistance to corrosion and oxidation. Ceramic coating increases the wear properties as well. Titanium di oxide is also a material having properties similar to zirconia with thermal expansion rate of 9×10^{-6} K^{-1} Titanium coatings are dense, wear and heat resistant, inert to acids, alkali and solvents and also it can improve properties of any surface on which they are applied. Titanium dioxide (TiO_2) is a photosensitive semiconductor valence electrons of tio2 are excited into the conduction band due to high-energy radiation .TiO_2 has been used for different applications in various specifications but mainly as powder and salts. Several techniques are used for coating with titanium, like chemical physical vapour deposition, vapour deposition, electro deposition, spray pyrolysis, plasma spray and sol gel processes. This research paper is mainly focused on improving the wear resistance property of medium carbon steel by coating it with nano coating of titanium by plasma arc spray technique. plasma Are spraying represents a promising method to deposit highly pure, dense and corrosion resistant coatings of ceramic material such as titanium. Plasma-Sprayed coatings are formed by the placement of particles onto a substrate layer-by-layer. For their influencing on the coatings' performance and properties Residual stresses inside the coatings are essential. The tio2ions inside the substrate diffuses when the material is heat treated after the deposition.

2. EXPERIMENTAL DETAILS

A105 steel specimen of dimension 60mm x 20mm x 5mm for plasma spray coating. The composition of the material is given on the table.1. It is necessary to increase the corrosion resistance and the wear resistance of the material. In present industrial scenario these materials are often hard faced with certain alloys. Hard facing technique induces higher

residual stress in the steel substrate and results in decreased corrosion resistance, therefore it is necessary to coat the material with low residual stress developing coating technique. For hard facing, secondary machining is required to get the desired coating thickness, therefore plasma spray technique and sol gel technique is selected to form the coating which induces lower residual stress in the material when compared to hardfacing and desired coating thickness is achieved.

Table 1: Chemical Composition Of A105 Steel

Element	C	Si	Mn	Cu	Ni	Mo	V	Cr	Nb
Wt%	0.35	0.10	0.60	0.40	0.40	0.12	0.08	0.30	0.02

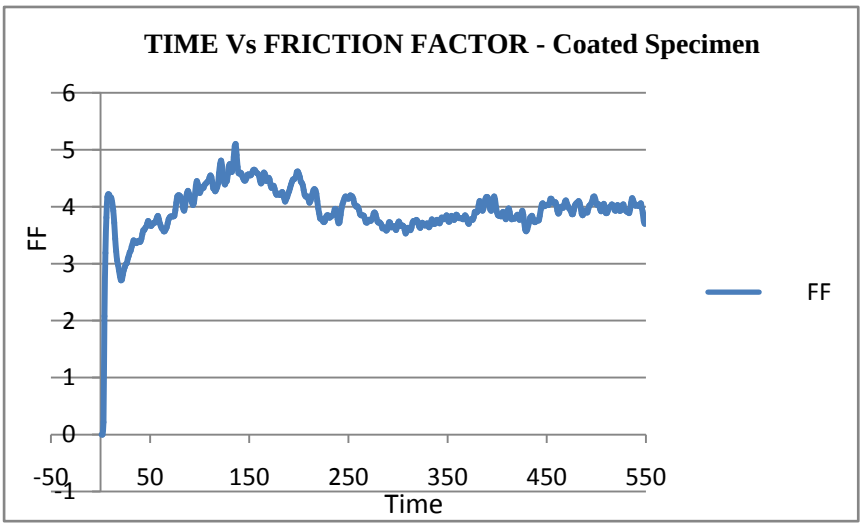
2.1Fabrication of titanium dioxide coating by plasma spray process

Same as like for zirconia, a 60mm x 20mm x 5mm dimensioned specimens is taken for titanium dioxide coating process also. Surface treatment is done with emery sheets. Plasma arc spray coating of titanium is done on the specimen. The nozzle pressure of argon gas for the process was set to 100-120 psi, argon gas flow rate was maintained through 80-90 lpm, nozzle pressure of hydrogen gas was 100 psi,hydrogen gas flow rate was 20-25 lpm, the current was set to 490 amps and 65-70 volts, powder feed of titanium dioxide was 40-50 gms/ min and spray distance was set to 3”-5”. A 100 micron thickness titanium dioxide coating is achieved using above parameters.

3. RESULTS AND DISCUSSION

3.1 Influence of frictional force

Results are made by comparison between coated and uncoated specimens. One specimen was coated with titanium dioxide using plasma arc spray process and the other one was taken uncoated. Coating thickness of plasma spray specimen is 100 microns. Dry wear test was conducted at a sliding distance of 1000 m at a velocity of 2.5 m/ sec at a load of 2kg. The temperature of operation was 200 degree c. The wear test graph was plotted using a pin on disc apparatus. The plots were obtained for both frictional force and wear in microns. The figure shows the influence of frictional force on wear rate of the coated sample and on the uncoated sample. The uncoated specimen showed a slowed start till 5 seconds and then value increases uniformly to a high level till 70 seconds. Titanium coated samples shows negative indication which means the sample shows high resistance to wear. After 15 seconds there is a light increase in the wear values till 70 seconds but the value never exceeded 2.50. When the total wear test result were compared, it was found that the titanium coated samples revealed almost 200 times lesser wear rate than uncoated steel specimen.



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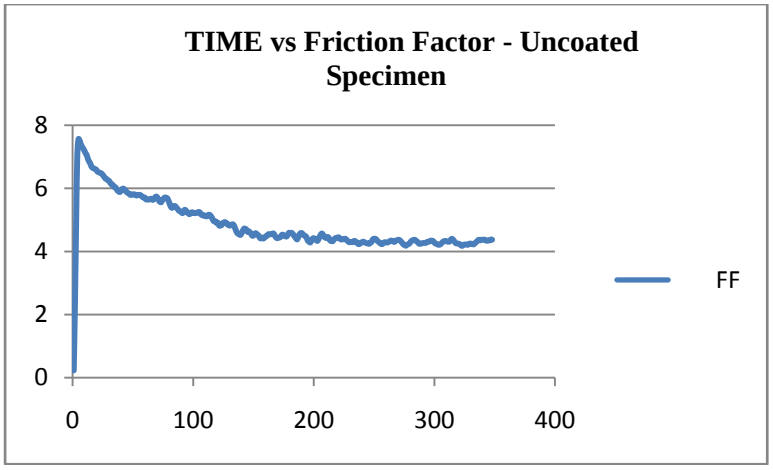


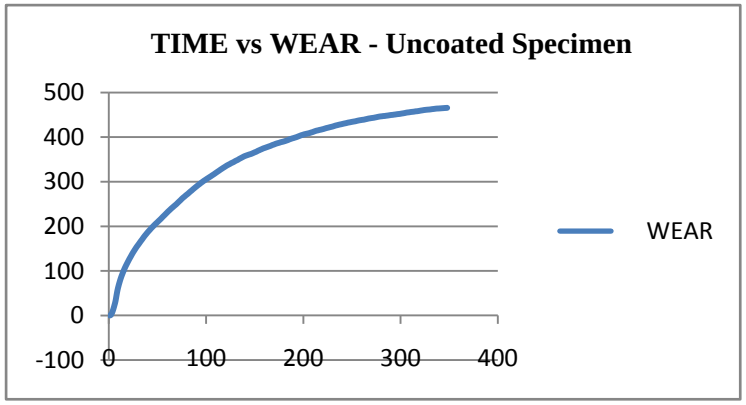
(b)

Figure 1: (a) Time vs Friction Factor – Coated Specimen, (b) Time vs Friction Factor – Uncoated Specimen

3.2 Influence of material removal

According to the graph based on material removal it can be seen that upto 60 seconds of operation the material removed is lower in the plasma spray coated specimen After 60 seconds of operation the frictional force in plasma spray coated specimen is lower, therefore the material removed is lower for the spray coated specimen

Titanium plasma spray coated sample shows a sudden wear increase at the initial stage of testing. After this initial material removal the sample shows a constant friction rate throughout the testing process. the frictional force observed in the whole process remains low comparatively for the titanium coated sample and thus the wear rate is less which shows material removal rate is less.



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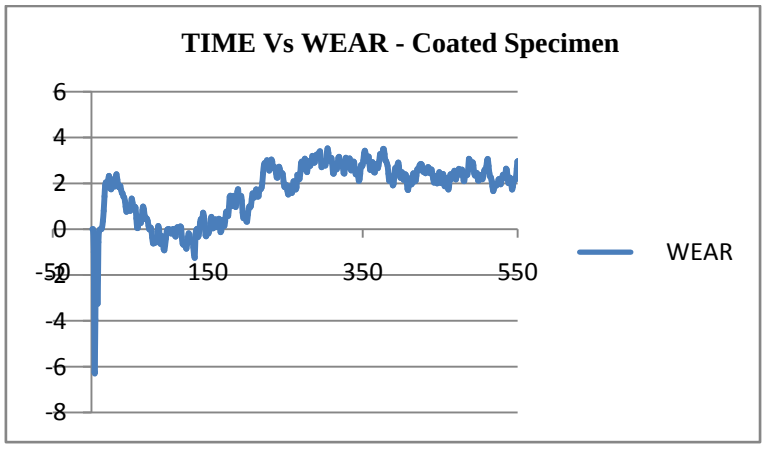
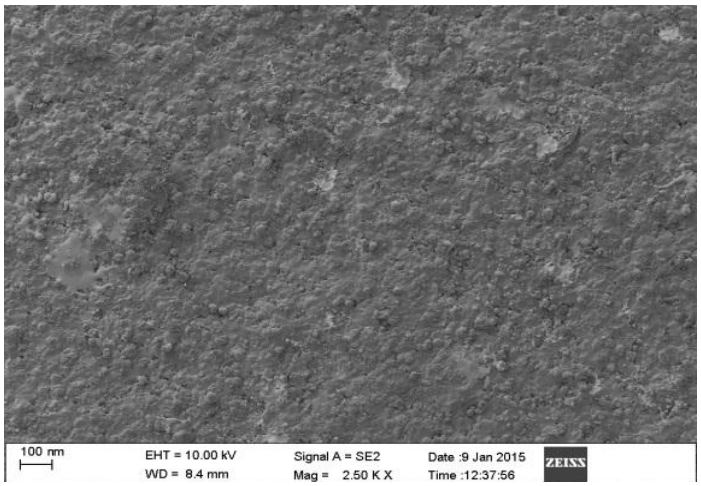


(b)

Figure 2 : (a) Time vs Wear – Uncoated Specimen, (b) Time vs Wear – Coated Specimen

3.3 SEM Characterization

SEM image was taken to study the surface morphology of the coatings on the steel specimen. SEM images revealed the deposits of titania on the specimens coated by plasma spray process, The particle size of the deposited ranges from nano meters to micro meters. The coating is more uniform in plasma spray process and there are very minimal voids or cracks.



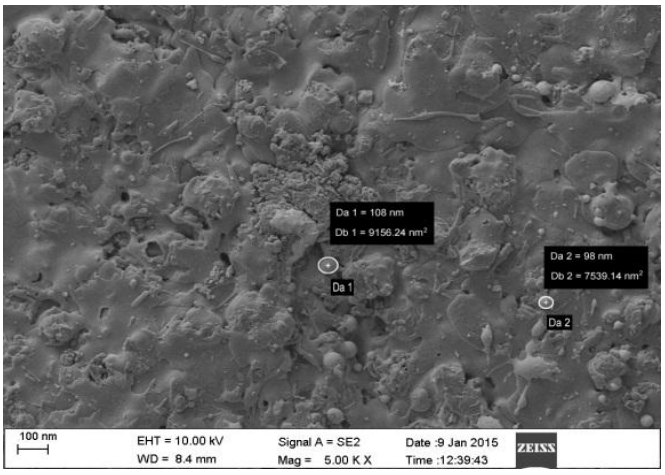


Figure 3 : Ti coated sample using plasma arc spray

4. CONCLUSION

Coating on medium carbon steel improves its properties required for high temperature applications. The ceramic layer coating applied on medium carbon steel even with 80 and 100 micrometer thickness can improve its wear properties. When compared the coated samples, plasma arc spray coated samples were shown to provide more wear resistance. It was achieved by the uniform coating obtained which was proved by the sem characterization of samples. These coatings also provided less frictional force throughout the process. These conclude that material removal rate and wear rate of medium carbon steel can be decreased by obtaining a ceramic coating over it.

5. ACKNOWLEDGMENT

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