A Study on AA 6063 Coated With Yttria Stabilized Zirconium

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***Abstract*— In this study aluminium alloys 6063 were selected, and yttria stabilized zirconium coating is given. The plasma-sprayed ceramic coatings technology was used to reduce heat losses to a minimum during coating. The aluminium alloys were subject to many test before and after coating. Initially microstructure analysis and Optical Emission Spectroscopy test were taken to ensure that the sample chosen has similar chemical composition or not. After passing the initial test, the YSZ coating is given to test sample and supportive test was carried out. Surface topography of yttria stabilized zirconium coated substrate was investigated by SEM analysis. The evaluation of adhesion of coating over the substrate is made by using scratch tester and the result obtained was 5B (ISO comparison report). The hardness of the coated substrate was measured by micro vicker's hardness tester and the value increased from 97 to 208VHN. Furthermore abrasion test was carried out to ensure there is a reduction in abrasion loss and the result obtained was 0.07gm loss for uncoated sample and 0.05gm loss for coated sample which results in increasing the life of the component.**

***Keywords*— yttria stabilized zirconium, scratch test, vicker's hardness test, abrasion test**

I. INTRODUCTION

It has always been a wish of mechanical engineers to extend the lifetime of tools, mechanical components or wear parts, by increasing the "surface hardness". Over the last 50 years, many processes have been developed to increase the surface hardness by diffusion and/or coating deposition techniques; each of these techniques were designed to be applied on specific materials and for specific applications . One of the best methods for coating is considered to be a plasma spray coating technique. Plasma Spray is a method of giving a protective coating by the form of plasma spray. The ample range of processing temperatures makes this method for different materials. The application of this technique is escalating every year because of the capability to differ coatings for different materials. The latent for this process is almost boundless for substrate coatings. Material in powder form is injected into a very high warmth plasma flame, where it is quickly heated and accelerated to a high speed. This hot material impinges on the surface of the substrate and cools rapidly to form a coating. [1] O. Knotek, et al says the aim of the coating on ceramic substrates is a further improvement of the material properties, wear resistance. Coatings have been deposited by reactive magnetron sputtering on silicon nitride (Si_3N_4), aluminium oxide (Al_2O_3) and Al_2O_3 + Tic ceramic. As a reference, coated high speed steel and cemented-carbide substrates have been used. Mechanical characterization of the coatings has been made by determination of hardness, critical load and impact load (coating impact test). Scanning electron microscopy investigation of the rupture structure and X-ray diffraction allowed the determination of the coating-substrate microstructure. Model wear tests gave information on the wear resistance of the coated ceramics, and annealing tests verified thermal stability.

[2]Masaki Tanaka, et al describes the Ceramic-metal composite material was developed and spray coated on piston and liners with the help of plasma spray technique. As a result, the wear of plasma coated piston and cylinder liners were small enough to prolong overhauling interval to 4 years. [3]I. Got man, et al described Ceramic surface films have a great potential to improve the tribological performance and longevity of artificial joints as they provide the metallic components with a hard, wear-resistant surface while preserving their toughness and fracture resistance. Although simple in concept, providing a clinically and commercially successful coating–substrate combination has proven challenging. A critical feature for alternative technology is the adhesion of the coating to the substrate. Not only would adhesive failure of the ceramic film negate its potential wear advantages, but also it would liberate hard third-body particles that could increase abrasive wear of the bearing surfaces. From the research survey the Yttria stabilized Zirconia (ZrO_2-8% Y_2O_3) has been used as coating material because of its good wear resistance, frictional behaviour, Non-magnetic, corrosion resistance, Low thermal conductivity.

II. MATERIALS AND METHODS

Optical Emission Spectroscopy (OES) is used to measure the elemental wavelengths by "sparking" the substrate. A testing substrate is positioned on the unit, and the device creates a plasma burn on the substrate surface. The compositional elements are agitated through spark and gives off diverse wavelengths of light. Different element's wavelength is interpreted by the Spectroscopy and reported for alloy compositions. Fig 1b shows the OES tested base metal. Table 1 shows the chemical composition of the AA6063.

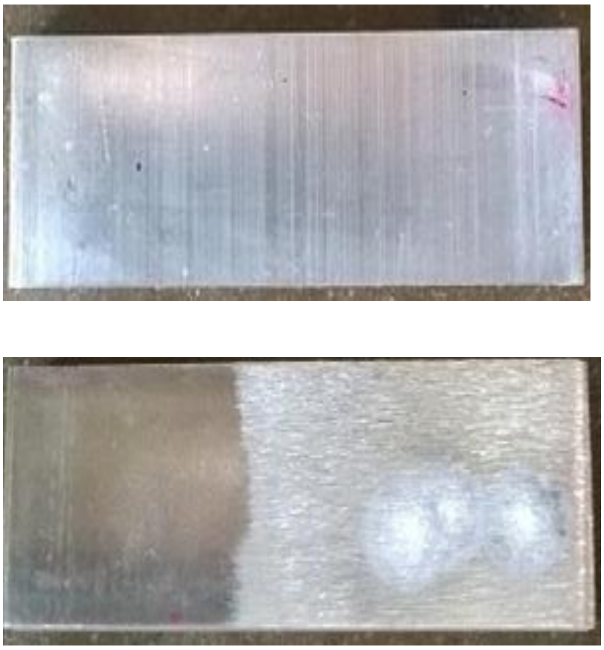


Fig.1a &1b shows OES tested sample.

TABLE I shows the composition of AA6063.

Si	Fe	Cu	Mn	Mg	Ti	Al	Comp
0.4	.260	.010	.014	.443	.008	Bal	%

The samples of aluminium alloy were first polished to the required standard and this polished sample is made for the plasma spray coating with yttria stabilized zirconium as a coating substrate for the studies. Figure 2a &2b shows the optical microstructure of the base metal AA6063 and SEM image of the yttria stabilized zirconium coating which is made on the aluminium substrate. In Fig 2a the microstructure shows Al-Si-eutectic particles in a matrix of aluminium solid solution. The eutectic particles are fine granular structure.

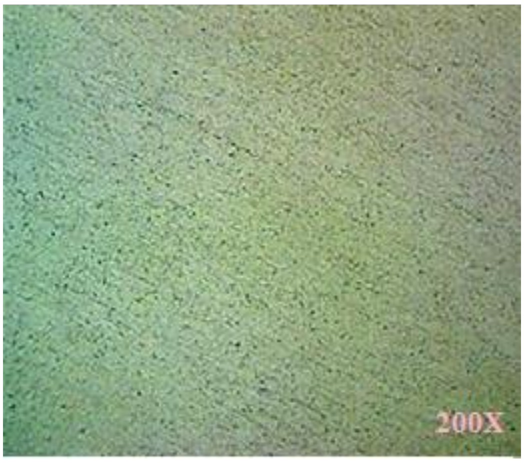


Fig. 2a shows the optical microstructure AA6063.

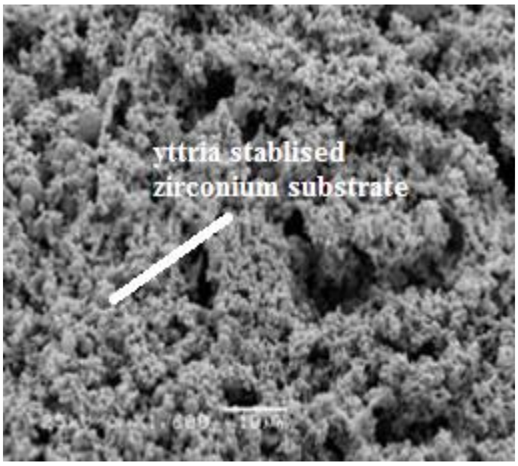


Fig. 2b shows SEM image of the yttria stabilized zirconium coating.

The following investigations are carried out namely: The evaluation of adhesion of coating over the substrate is made using the scratch tester. Hardness is tested by using the micro Vickers hardness tester. Abrasion loss test is carried out by DIN type abrasion tester. Finally the characterization values of the coated and uncoated materials is compared and correlated to find out whether the surface property of the material is improved.

III. RESULTS AND DISCUSSION

Generally the coating thickness relates the cutter size. When the coating is above 60 microns then cutter with 2mm dimension are used for performing the scratch test. The cross hatch cutter is used for an estimation of the adhesion resistance of substrate coatings. The cutter with the right-angled lattice pattern is used to scratch into the coating. Coating is slashed into small squares using the cutter which in turn reduces the lateral bonding, and the adhesion characteristic is determined against ISO/ ASTM.

Fig.3a. Coated scratch test sample.

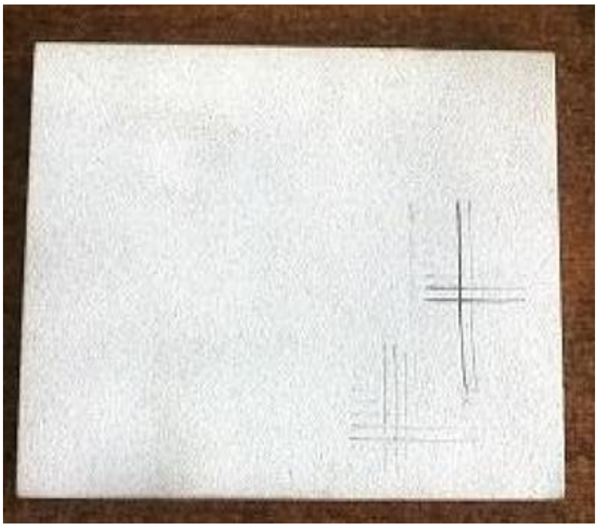


Fig. 3b. Tested scratch test sample.

The test observations in Fig 3b were observed to be under ISO class: 0/ASTM class: 5B which means the edges of the cuts are smooth completely and none of the squares of the lattice is detached. From the above result we conclude that it has good bonding strength and the coating does not detach easily. After performing the scratch test the abrasion loss was performed by using the Din type abrasion tester which is shown in Figure 4. Din type abrasion tester equipment is used to assess the abrasion of elastomers subjected to wear by abrasion action. The abrasion machine basically consists of a laterally movable test piece holder and a rotatable cylinder to which a specified abrasive cloth is fixed. The following parameters are used for making the wear test as shown in Table 2.

TABLE 2.shows parameters used for abrasion loss test.

Load applied	1.2kg
Cylinder size	150 mm dia & 500 mm length
Material of coarser abrasive sheet	60 grade
Travel time for 40 metres path	196 seconds
Abrasion path	40.2 metres
Equivalent revolution	84 times
Rotational frequency	40 rpm

Initially the weight of the uncoated and coated specimens were calculated before testing by using a precision weight gauge. After measuring the weight both of the specimens are abrasion tested with the parameter as given in Table 2 and the figure is shown in 5a &5b. After testing the specimens weight is finally calculated which is shown in Table 3a & 3b.

Fig. 4.Din type abrasion tester.

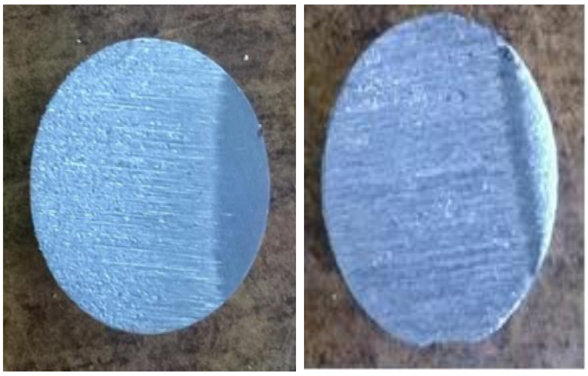


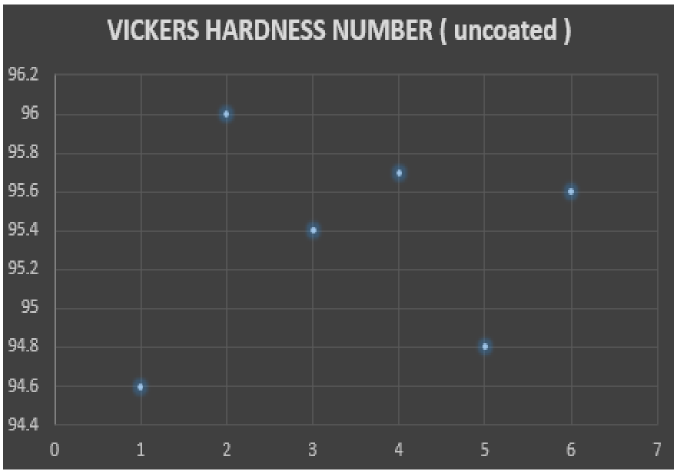
Fig.5a & 5b shows uncoated and coated abrasion tested sample.

TABLE 3a & 3b shows the abrasion loss for uncoated and coated specimens.

Sample no	Initial weight (gram)	Final weight (gram)	Abrasion loss (gram)
1	3.25	3.18	0.07

Sample no	Initial weight (gram)	Final weight (gram)	Abrasion loss (gram)
1	3.75	3.70	0.05

From the above test the percentage loss of coated test sample is lesser than uncoated test sample. This proves that coating has improved the abrasion resistance. The Vickers microhardness test was performed on the uncoated and coated samples. A diamond indenter is used for indenting the samples. A load of 500g and the time of 15s is given on the specimens for indentation. From the hardness test as shown in Fig 6 the hardness have increased from 95 VHN to 207 VHN. From the above test result the coating has improved the hardness of the substrate to a great extent. This result clearly ensure that the coating has improved the characteristic of the substrate and this adds more points to achieve the aim of the project that the yttria stabilized zirconium coating can be suggested for the aluminium alloy.



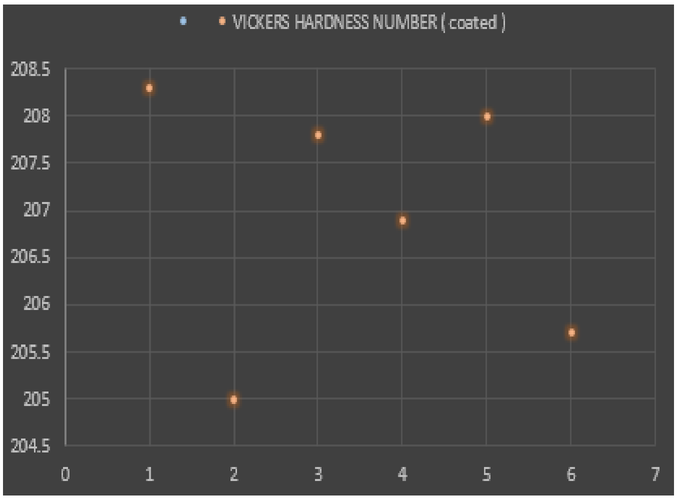


Fig.6 shows Microhardness values for uncoated and coated sample.

IV. Conclusions

From the above discussion it is clearly proved that the yttria stabilized zirconium coating over the surface improved the properties of the substrate. In the scratch test the result is clearly proved that the coating has high bonding strength. So that adhesiveness of the coating over the substrate will also be high, which results the coating does not detach easily. In the hardness test the coating increased almost 2 times the hardness of original value thus life of the component gets increased. To show a clear view about the abrasion resistance of the coating abrasion test was done. From the result it is clear that the value of abrasion rate has been reduced to 30 percentages.

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