To Study the Mechanical Properties of Aluminium Piston using Zirconium Dioxide

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Abstract **-**The present study deals with improving the material characteristics of Al using plasma coating. Since the melting point temperature of the Al is 660°C, using plasma coating 0.25mm of ZrO_2 is coated on Al and NiCrAlY is used as bonding material between Al and ZrO_2. By scanning electron microscope we can observe difference of microstructure of coated and uncoated material. It is found that porosity on coated material was less and the surface was slightly abrasive. Hardness test is carried out on coated and uncoated material at various points on the surface, it is found that using ZrO_2 the hardness of base material is improved by 26.52%. Corrosion test was carried using Na_2SO_4 and V_2O_5 salts (byproducts of combustion), it is found that ZrO_2 has better resistive capabilities towards corrosion. At thickness of 0.25mm for the coated material it is found that thermal stability of base Al material has increased twice compare to the actual value. It can withstand up to 1000°C without any degradation of coated material. Using zirconium dioxide as coated material on aluminium the mechanical properties of the base material is improved.

Keywords – $ZrO_{2,}$ plasma coating, Hardness, thermal stability, Microstructure.

1. INTRODUCTION

The 6061 grade Aluminum piston is taken since it is a precipitation – hardened aluminium alloy containing magnesium and silicon as it major alloying elements. It is chosen because it has good mechanical properties and it is one of the most Common alloys of aluminium used for general purpose use. A6061 has a Young's modulus (E) of 68.9Gpa. Zirconium Dioxide commonly known as Zirconia is used as a coating material. It is a white crystalline oxide of Ziconium which has a monoclinic crystalline structure in its naturally occurring form. Zirconia is chemically unreactive and is slowly attacked by concentrated hydrofluoric acid and Sulphuric acid. It is one of the most studied ceramic materials, which has high melting point and also possess more hardness.

It is observed that Alluminium with coating shows better mechanical properties. Hence an attempt is made to develop mechanical properties of Aluminium piston material coated with Zirconium dioxide of 250 micrometer thickness with bonding material NiCrAlY.

2. MATERIALS USED AND METHOLOGY

Aluminium 6061 has been used as the base alloy and zirconium dioxide of 0.25mm thickness is coated on it.

2.1 Preparation of worksample: Two aluminium pistons were purchased and those were taken for cutting which is done by milling machine. The piston was cut into 5 pieces, where worksamples are 1×1 inch in dimension.

2.2 Plasma Coating: The Plasma Spray Process is basically the spraying of molten or heat softened material onto a surface to provide a coating. Material in the form of powder is injected into a very high temperature plasma flame, where it is rapidly heated and accelerated to a high velocity. The coating thickness is 250µm. Coating specifications used are Current: 500A, 60-70V, Powder Feed: 40-45 gm/min, Spray Distance: 2-3inches, Coating Thickness: 0.25mm, Bonding Material: NiCrAlY (Nickel chromium Aluminum yttrium), Gun: 3Mb spray gun and after the coating we can also see that there was change in their colour.

2.3 Microstructure: It is well known that the microstructure plays a predominant role in determining material behaviour. Material scientists, therefore, seek to control microstructure through processing. Processing studies have traditionally focused on optimizing microstructural characteristics with the intent of producing a uniform microstructure throughout the material. Increasing microstructure uniformity has been considered a fruitful means of improving properties. Depending on this standpoint, the uniform microstructures have been produced by improving processing technique. Plasma coating is one of them, because the uniform and dense coatings are produced using this method. It shows a typical microstructure of the coating produced by plasma coating. Microstructural observations showed that these coatings usually possess less porosity, oxidized, un-melted and semi-melted particles, and inclusions compared to uncoated worksamples. The coating thickness was 250 µm.

3. EXPERIMENTAL WORK

3.1 Hardness test: It was carried out on both coated and the uncoated worksample in Material Science Lab, Reva University. Based on the Calculations made we can compare the results of both coated and uncoated worksample.
We observe that the coated worksample possess the higher hardness than the uncoated worksample.

3.2 Thermal Stability Test: Thermal stability is the stability of a molecule at higher temperatures. During this test a coated and an uncoated worksample were kept in the Heating furnance which was maintained at 400°C initially. At the end of each interval the state of worksamples were checked, later the temperature was increased by 100°C for every 1hr of time intervals,. It was observed that the uncoated worksample was melted at 600°C whereas the state of coated worksample was unchanged even at 1000°C. By this we can infer that coated worksample withstands higher temperature than the uncoated worksample.

4. RESULTS AND DISCUSSION

4.1 Microstructure of coated and uncoated worksample using SEM

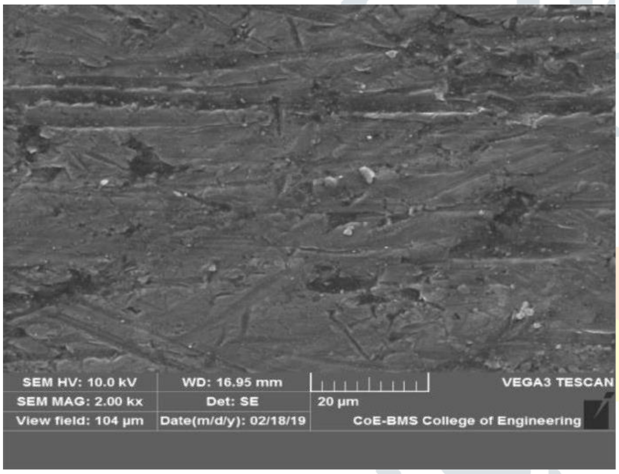

Fig.1: Microstructure of uncoated worksample

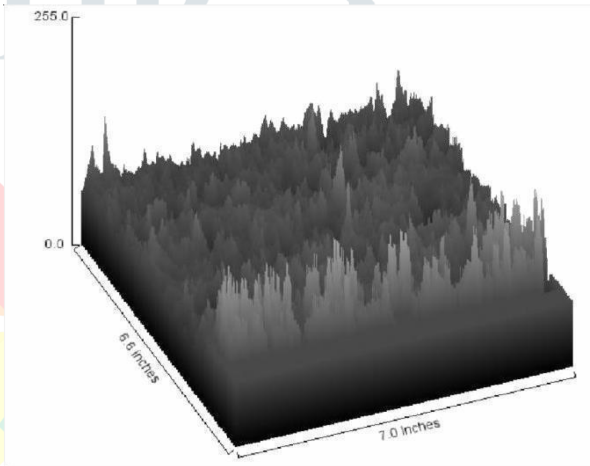

Fig.2: 3D Image of the uncoated worksample

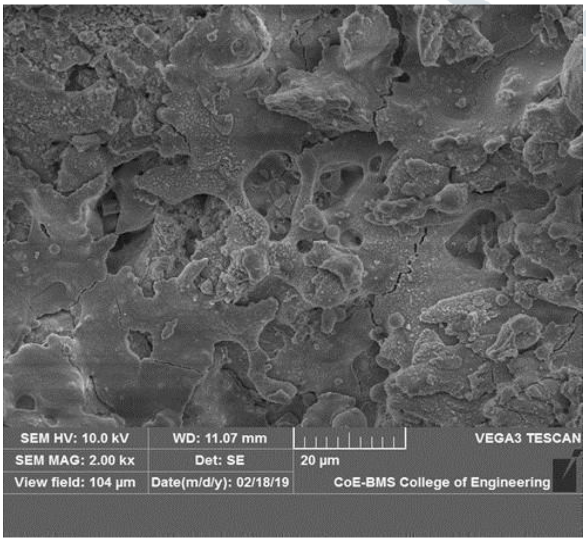

Fig.3: Microstructure of coated worksample

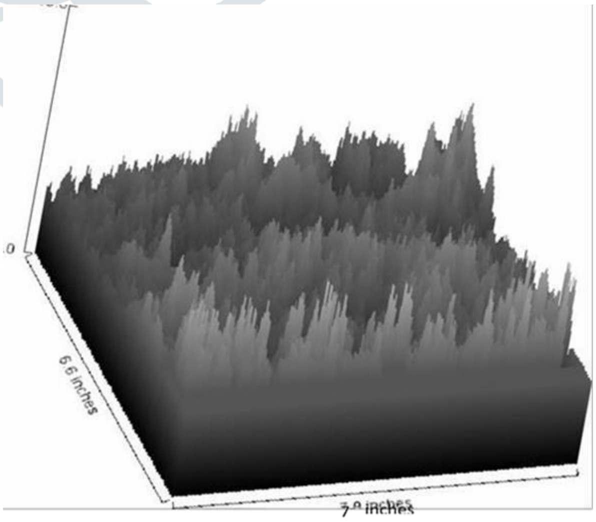

Fig.4: 3D Image of the coated worksample

Microstructure plays a predominant role in determining material behaviour. Metallographic observations showed that these coatings usually possess porosity, oxidized, unmelted and semimelted particles, and inclusions which are shown in the figures 3 and 4 respectively. The coating contains approximately 2.2% porosity, which were determined by image analyzer. The coating thickness was 250µm. the porosity can clearly be seen in SEM picture with =2.00kx magnification. The dark areas indicate the porosities of the coating. SEM observations confirmed that the unmelted or semimelted particles. The main difference we can observe from microstructure analysis is the porosity of the coated worksample which are shown in the figures 3 and 4 is less compared to uncoated worksample which are shown in the figures 1 and 2.

4.2 HARDNESS TEST

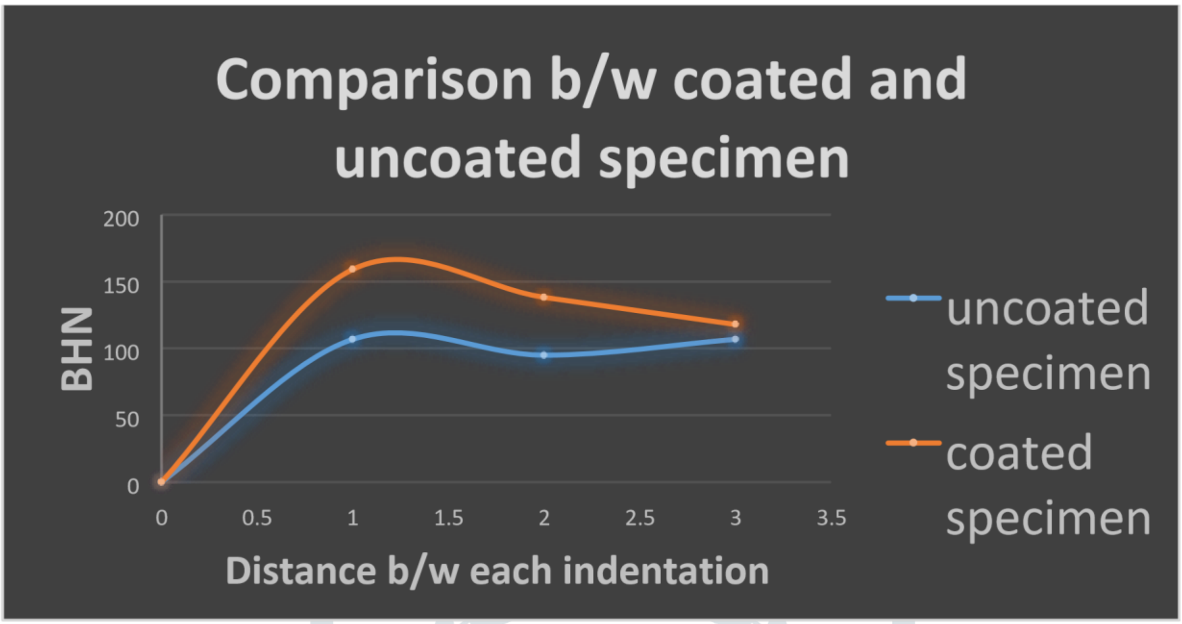

Fig.5: Comparison of Hardness between the coated and uncoated worksample

From the graphical analysis which is shown in the figure 5 we come to the conclusion that the coated worksamples possess the higher hardness than the uncoated work samples and it is observed that the hardness was increased by 26.52%.

4.3 THERMAL STABILITY

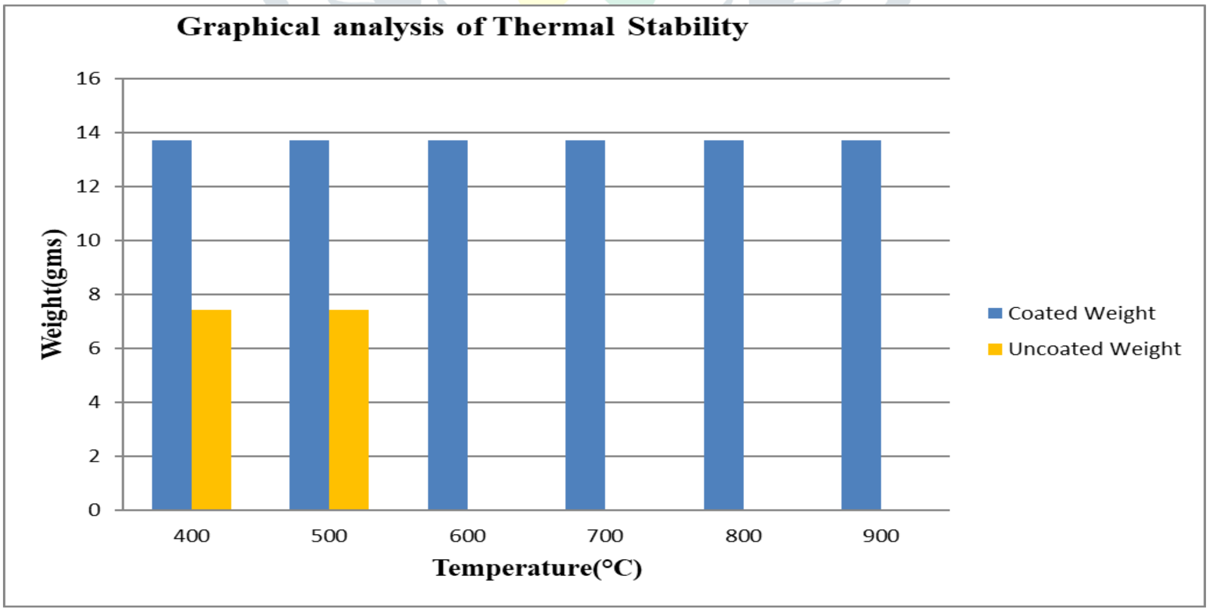

Fig.6: Comparison of Thermal stability between the coated and uncoated worksample

From this graphical analysis which are shown in the figure 6 it was observed that the uncoated worksample was melted at 600°C whereas the state of coated worksample was unchanged even at 1000°C. By this we can infer that coated worksample withstands higher temperature than the uncoated worksample.

5. CONCLUSION

- From the microstructure analysis, the porosity of the coated worksample is less compared to the uncoated worksample.
- Hardness test was conducted on both the coated and uncoated worksamples. From the graphical analysis which is shown in the figure 5, we come to the conclusion that the coated work samples possess higher hardness than the uncoated samples and it was observed that the hardness was increased by 26.52%.
- Thermal stability test was conducted and after repeated trials it was found that the uncoated worksample melted at 600 °C and the coated worksample was unchanged even at 1000 °C which is shown in the figure 6.

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