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EFFECT OF AlTiN PVD COATING THICKNESS ON 316L AUSTENITIC STAINLESS STEEL WEAR RESISTANCE

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Abstract - *In the current work the specimens were tested at various PVD coating thickness on the 316L Austenitic stainless to find the wear resistance. 316L grade of SS is found in different wet and dry industrial application because of its corrosion resistance property. But still many factors held it back due to the lack of wear resistance, hardness and high temperature resistance which are some of the important properties of an ideal cutting tool. Here in this thesis we are going to PVD coat a 316L SS specimen with AlTiN coating at different coating thickness. The samples were tested for their wear resistance on a pin on disc wear testing machine by varying the loads under dry sliding conditions and these values are compared with that of the other samples along with the uncoated sample to discover variation in wear resistance. These samples are observed under SEM and Optical Microscope to find the nature of wear and case depth .The final calculated results indicates an increase in the rate of wear resistance and an increase in hardness with the increase in coating thickness from sample of 2 micrometer to 10 micrometer*.

Keywords: AlTiN, Pin on Disc, PVD coating, SEM and 316L SS.

1. INTRODUCTION

Since the introduction Stainless steels into the real world applications it has attracted many areas of the science and industry because of its unique properties like corrosion resistance, high strength, heat conductivity and low gas permeability. Most of the recent research and development in stainless steel continues to generate new ideas for improving the mechanical properties. These materials are widely used applications of low temperature technology such as food processing equipment, nuclear reactors, ocean technology, petrochemical processing etc. However, the application of this material on the surface is severely limited by very poor wear behavior. To induce this kind of property and improve the tribological performance of material several surface coating processes are available like Physical Vapor Deposition (PVD), Chemical Vapor deposition (CVD), Chemical Vapor Aluminizing (CVA) and Plasma Assisted Chemical Vapor Deposition (PACVD).

Physical Vapor Deposition (PVD) is a method for producing metal-based hard coatings by means of generation of partially ionized metal vapor, its reaction with certain gases and by forming a thin film with a specified composition on the substrate. PVD coating technology is a thin film coating and an environmentally friendly process with minimum material loss. The PVD coating is used mainly because of its ability to impart new, additional features to the product. PVD coatings can have a vivid color based on the material composition coated.

The AlTiN material is chosen to be coated on to the specimen because of its wear resistance, reliability in dry operations and increase in hardness which makes it an ideal material to be coated to obtain the desired results.

2. MATERIAL PREPARATION AND EXPERIMENTAL PROCEDURE

2.1. Material Preparation

The base material selected for the purpose of coating was Austenitic Stainless Steel 316L grade. A cylindrical rod of diameter 10 mm and length 300mm was taken and is cut into equal specimen of size 30 mm using a tool cutting machine. Care must be taken during the selection of cutting process such a way that it shouldn't result in deposition of any unwanted residual stress on the specimen. During the cutting process the specimen is checked for the perpendicularity of the face with the cutting surface. After cutting the specimens are rubbed against various grades of SiC paper to remove surface burrs, edge burrs and any roughness on the face is be removed to acquire a mirror finish face. The specimens are also cleaned with acetone to remove all the dirt and grease from the surface to be coated.

2.2. PVD Coating

The PVD coating technology used to deposit the AlTiN coating is Sputtering Arc deposition method. In this process the specimen is held in the vacuum chamber and the material to be coated on to the surface of the specimen is being made to bombard with carrier gaseous ions and these get deposited uniformly on to the surface of the specimen. The PVD coating of AlTiN processes is carried out under high vacuum conditions and with a normal temperature range of 250^{0}C to 600^{0}C. These coatings are done in three coating thickness ranges of 2-3 micrometer, 3-5 micrometer and at 9-10 micrometer for the thesis purpose. The final coated specimens are in Blue-Black color.

2.3. Experimental Procedure

The specimen was tested on a pin on disc wear testing machine at normal room temperature and relative humidity of 66% to find rate of wear loss**.** The Pin on Disc equipment consists of a hard coated Stainless steel disc, against which the specimen is to be held in contact. The PVD coated face of the specimen is made to be held against the disc and loads of 10N to 40N were applied at the sliding speed constant at 3m/s. All the loads are added for a varying sliding distance 1000m, 1500m and 2000m of samples for each load applied. All the coated specimens were tested in the similar manner and rate of wear loss is being calculated considering the volume loss of the specimen. From the above values the wear rate and specific wear rate are calculated.

3. RESULTS AND ANALYSIS

3.1. Optical Microscopic Analysis

For the purpose of optical microscope analysis a part of coated specimen is cut and is mounted on to a holder either by cold pressing or hot molding process. Here cold molding process is used in which the specimen is placed in the mold mounting disc and molded using quartz sand as molding solid powder and phosphoric acid as catalyst to form the mold. The process of solidification usually takes around 20-30 minutes, and then the mold is taken out from mold mounting disc.

After dismounting the mold it is made to rub in a uniform direction across various grades of emery paper from 160-2000, until a mirror faced finish is obtained (All this work is carried out to eliminate the face surface impurities and metal edges that interfere during the measurement of coating thickness).

The type of Optical Microscope used is of Olympus GX51 version with a magnification range of 5X - 100X .The mounted specimen is made to observe at various magnifications and at the maximum range of 100X a clear view of coating thickness is obtained. The coating thickness is measured from the measurement table selecting the horizontal/vertical distance between the two selected points, one on the specimen edge and the other on the coating thickness edge. The coating thicknesses of the specimen are found to be in the required range based on observation and calculation of mean thickness from the observed values.

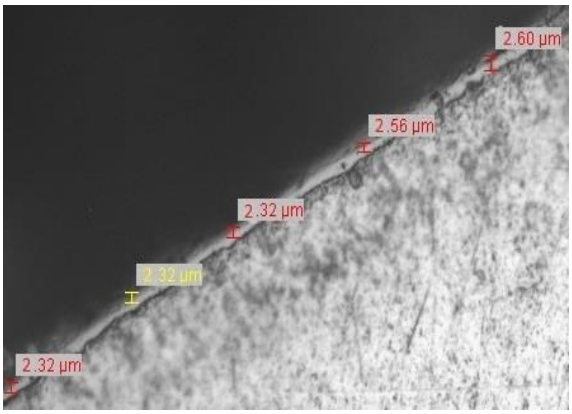

Fig: 1. PVD coated specimen with 2-3 micrometer

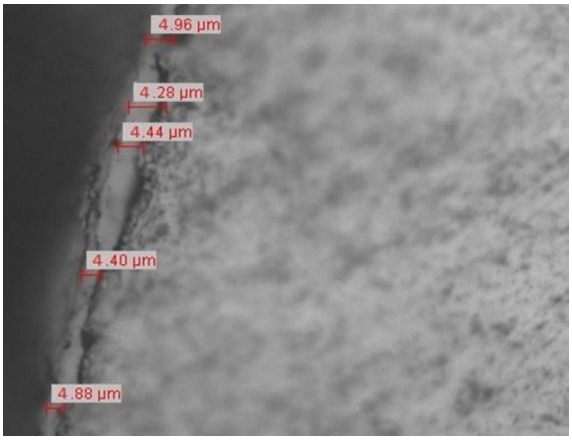

Fig: 2. PVD coated specimen with 4-5 micrometer

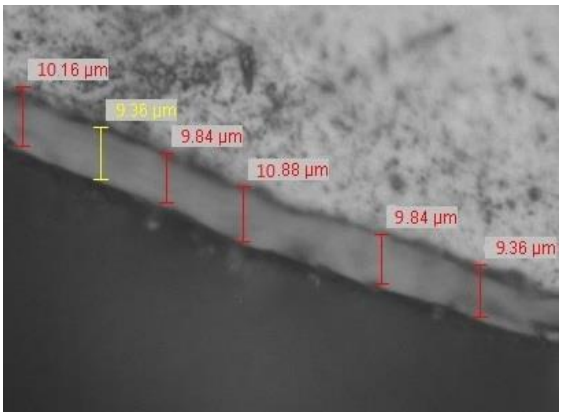

Fig: 3. PVD coated specimen with 9-10 micrometer

3.2. SEM Analysis

The wear analysis is conducted on the specimens that were tested on Pin on Disc wear testing machine. The SEM analysis of the specimen shows that the specimen has undergone uniform wear along the surfaces .From the analysis of fig: 4, the specimen have straight parallel lines uniformly along the entire surface in same direction which an indication that the specimen been uniformly wear along its entire surface. Small pits were found on the specimens that were caused by the material that has wear off earlier.

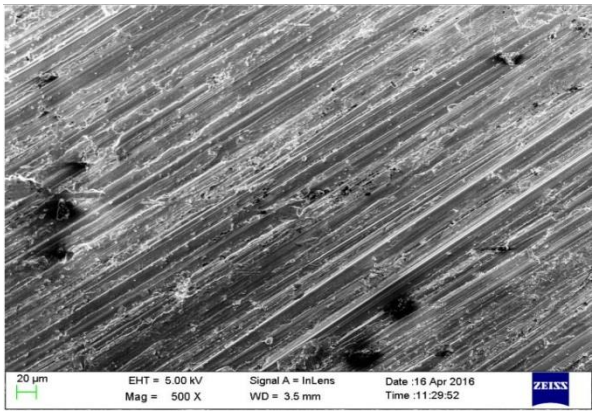

Fig: 4 SEM image of the wear tested specimen magnified to 500X

4. CONCLUSION

The experimental results have shown a decrease in metal wear as the coating thickness increased; this indicates an increase in wear resistance from the calculated values. These outcomes further demonstrated that an increase in PVD coating thickness has alongside increased the hardness of the surface and there resulted in the increase of the life of specimen in dry wear conditions. This thesis concludes stating that the increase in wear resistance and surface hardness finally result in the increased applications of AlTiN coated 316L Stainless steels in the field of cutting tools.

5. ACKNOWLEDGEMENT

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