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

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ABSTRACT
Austenitic stainless Steel of 316L evaluation is utilized across numerous applications because of its properties like anti-bacterial, bio compatibility, corrosion resistance and chlorine dormancy. But it doesn't have the key properties like hardness, wear resistance which make it not able to contend in applications of cutting tools to take care of the demand. In the present work the specimens are coated with the Physical Vapor Deposition (PVD) of TiN and AlTiN coating at three different coating thicknesses. The coated surface micro structure is observed by Scanning electron microscope (SEM) and the thickness of coating material is verified using Optical Microscope (OM). The specimens are finally tested for their wear resistance on a Pin on Disc wear testing machine under dry sliding conditions. The values of wear at various loads are tabulated and from this wear resistance is calculated. The results both the type of coatings is compared .The compared results reveal an increase in the properties like wear resistance, hardness which is a sign of increasing the life of the tool.

Keywords
PVD Coating, SEM, TiN, AlTiN

1. INTRODUCTION
The austenitic AISI 316L Stainless Steels grade is a next grade of AISI 316 Stainless Steel with marginally low carbon composition. Among all the austenitic steels, 316L SS have been used in various industrial applications mainly because of its excellent corrosion resistance property. It is widely used in the fields like mechanical, marine, pharmaceuticals, engineering and medicinal applications. There are many surface treatment processes to induce the required properties in metals such as Gas Nitriding, Salt Nitriding, Plasma Nitriding, Ion Implantation Physical Vapor Deposition (PVD) and Chemical Vapor Deposition (CVD).

The main reason behind zeroing on Physical Vapor Deposition or PVD, is because of providing a very strong bond between the coating and the tooling substrate and tailored physical, structural and tribological properties of the film a term used to describe a family of coating processes. The most widely accepted and used Physical Vapor Deposition Process are evaporation (like cathodic arc or electron beam sources), and sputtering (that uses magnetic enhanced sources or "magnetrons", cylindrical or hollow cathode sources). All of these processes occur in vacuum at working pressure (typically 10-2 to 10-4 mbar) and generally involve bombardment of the substrate to be coated with energetic positively charged ions during the coating process to promote high density and the range of coating temperature varies based on the type of coating to be done. Additionally, reactive gases are introduced into the vacuum chamber during metal deposition to create various compound coating compositions. The commonly used reactive gases are nitrogen, acetylene or oxygen.

2. MATERIALS AND EXPERIMENTAL TEST CONDITIONS
2.1 Sample preparation:
The experimental investigation is conducted on 316L Stainless Steel of composition (wt. %). 0.03 C, 2.0 Mn, 1.0 Si, 17 Cr, 12 Ni, 2.5 Mo, 0.045 P, 0.03 S and Fe as remaining balance. A 316L Austenitic Stainless Steel cylindrical rod of diameter 10mm is selected and this rod is cut into equal pieces of length 30mm using a tool cutting machine by continuous reduction of diameter. After cutting the specimen cut edges were grinded against the various grades of ceramic wheels to remove any burs and to obtain a dent free and smooth mirror faced specimen. The specimens were cleaned with acetone to remove all the dirt and grease impurities from the surface to be given for coating.

2.2 Specimen coating:
The specimens were given to the Oerlikon Blazers Coatings India Pvt. Ltd. Bangalore for the purpose of PVD coating. The process followed by them for particular PVD coating process is Enhanced Sputtering:

Enhanced sputtering utilizes a low-voltage circular segment release in the focal point of the chamber to make a plasma force a few times more noteworthy than the fundamental sputtering technique, and hence to deliver a much higher level of molecule ionization in the vaporous stage. The end result is the deposition of a thin, compact coating with the desired structure and composition.

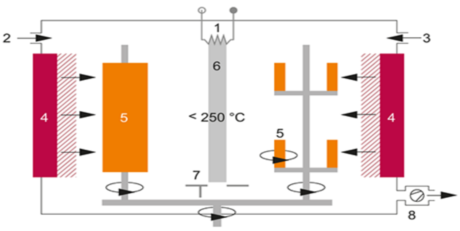

Fig 1: Enhanced Sputtering

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1. Electron beam source
2. Argon
3. Reactive gas
4. Planar magnetron evaporation source (coating material)
5. Components/Tools
6. Low-voltage arc discharge
7. Auxiliary anode
8. Vacuum pump

The coating of the specimen with the TiN was done at a temperature <5000 C and at a vacuum pressure of 2-10 mbar. The coating was done at a varying thickness specimen of 2-3 micrometer, 4-5 micrometer and 9-10 micrometer. The specimens with TiN coated were found to be in gold-yellow color and specimens with AlTiN were found to be in Blue-Black color.

2.3 Experimental test conditions

The PVD coated specimen tested for their wear resistance using the Pin on Disc apparatus. The Pin on Disc apparatus consists of a hard coated stainless steel rotating disc against which the specimen is being held in contact for testing the wear resistance. The Pin on Disc apparatus is used because of its uniqueness and its ability to diagnose different at the same time.

The specimens were placed one by one with coated end facing the surface of the hardened disc. The loads were applied gradually from 10KN to 25KN at a split timing parameters of 2 min for each load. During the whole process the speed of the rotating disc in which the specimen is in contact is made constant at 200RPM. The wear loss is found out based on the material loss of the specimen due to the wear resistance between the TiN coated specimen and the rotating disc. The volume of wear loss of tested specimen is calculated by comparing the initial height of the specimen with that of the final measured height at each and every load applied.

The hardness testing of the specimen is done on Rockwell Harness testing machine with the coated surface in contact. The test is been calculated on all the coated samples along with the uncoated specimen. The values are tabulated to find the rate of increase in hardness with coating thickness.

3. RESULT AND DISCUSSION

3.1 Optical Microscopic Analysis

The Optical Microscopic Analysis was done conducted to check whether the PVD coating thickness was done as per the requirement. For the Analysis purpose the specimen were made as per the requirement.

The specimens were cut into a small piece along the circumference and these cut pieces were fixed into a mold. The process followed to fix the specimens into the mold was cold setting process. In this the specimen were cut and placed into a cold mounting disc. The cold setting compound as quartz sand and phosphoric acid as the cold setting liquid catalyst is added to the mold. This setting is kept undisturbed for 30 minutes, to solidify and form the mold. After solidification the mold is removed from the mounting disc. The dismounted mold is made to rub against the various grades of emery paper to obtain a final smooth and mirror faced specimen without any edge burrs.

The main reason behind following this whole preprocess before OM analysis to remove edge burrs and other surface impurities from interfering in the calculation of the coating thickness. The molded specimen is then placed on the mounting table of the Optical Microscope. The Knobs were adjusted until a clear and magnified image of the specimen is obtained. The vertical and horizontal cross wires were adjusted to find the coating thickness. The measured coating thickness was found by calculating the mean of all values. The similar process is to be followed to measure the coating thickness of remaining samples.

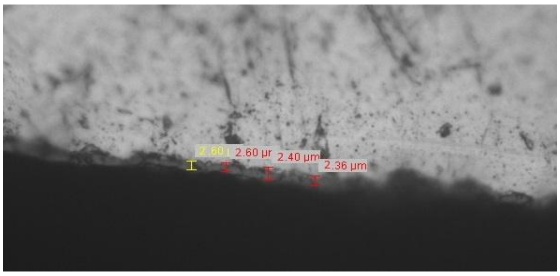

Fig 2: TiN coated specimen with 2-3 Micrometer thickness

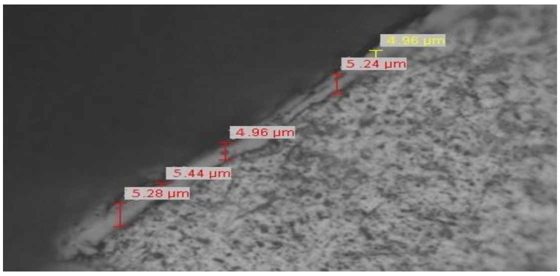

Fig 3: TiN coated specimen with 4-5 Micrometer thickness

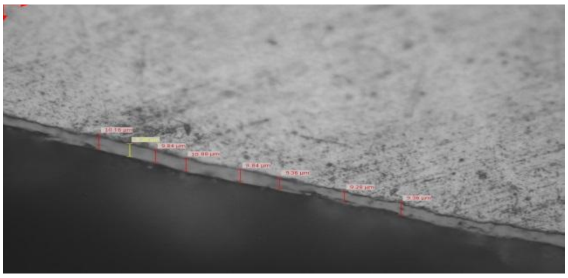

Fig 4: TiN coated specimen with 9-10 Micrometer thickness

3.2 Wear Analysis:

The wear analysis was done on the PVD coated Stainless Steel 316L grade specimen which has been subjected to uniform testing conditions under various loads The Wear analysis of the specimen was done on the Optical microscope to find the nature and the type of wear the specimen has undergone. From the Fig 5: The straight parallel lines indicate the wear on the specimen is found to be uniform along the whole face.

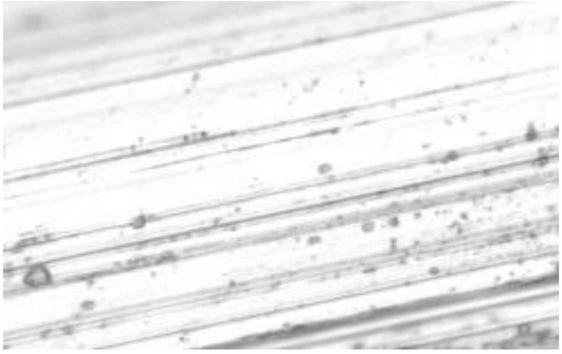

Fig 5: Wear analysis on TiN coated specimen with 9-10 Micrometer thickness

3.3 SEM Analysis:

The SEM analysis of the specimen is done on the samples which been tested on the Pin on Disc wear testing Machine. The specimens were placed on the mounting disc and the focus is adjusted to obtain a clear image of the tested surface. The surface is further magnified to a depth find the nature of wear along the whole surface of specimen. The similar process is carried out on all samples and the SEM images of rate of wear of the specimen were captured.

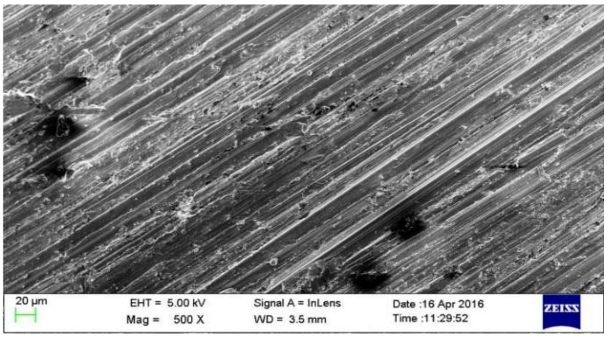

Fig 5: SEM image ofAlTiN coated specimen with 9-10 Micrometer thickness

From the captured images at various places of the specimen at different magnifications, draws that the specimen has undergone a uniform wear along the whole surface.

4. CONCLUSIONS:

The experimental calculated results indicates that the specimen with AlTiN coating has more wear resistance and hardness than the TiN coating with the increase in thickness of coating. So it is clear that with an increase in PVD coating thickness AlTiN coated specimens were more efficient than the TiN coating in the field of cutting tools under dry wear conditions.

5. ACKNOWLEDGEMENT

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6. REFERENCES

[1] Bayan R, IgartuaA ,Fernadez X ,Corrosion wear behavior of PVD Cr/CrN multilayer coatings for gear application, tribology international.,2009,42,591-599

[2] Barshilia HC, Deepthi B, Selvakumar N, Jain A, Rajam KS (2007) Nanolayered multilayer coatings of CrN/CrAlN prepared by reactive DC magnetron sputtering. App. Surf. Sci. 253: 5076–5083

[3] Thamotharan.J* and Sarala.R,Characterization of CrN/TiN PVD Coatings on 316LStainless Steel ,ChemTech research ,2014,pp 3284-3286.

[4] B. Subramanian, G. Umamaheswari and M. Jayachandran, Properties and corrosion behaviour of reactivemagnetron sputtered TiAlN coatings on AISI316L SS in simulated bodily fluid,Corrosion Engineering Science and Technology,2007,Vol 42,.

[5] M. C. Kang, I. W. Park and K. H. Kim: Surf. Coat. Technol., 2003,163–164, 734.

[6] M.A.M. Ibrahim, S.F. Korablov, M.Yoshimura, Corrosion of stainless steel coated with TiN,TiAlN and CrN in aqueous environments,2001,815-828, 44.

[7] E. Martin, A.Lanzutti, M.Lekka, L. Guzman, W.Ensinger, L.Fedrizzi, Chemical and mechanical characterization of TiO2 /Al2O3 atomic layer deposition on AISI 316L stainless steel,2012, 84-88.

[8] Bin Tain, Wen Yue, Zhiqiang Fu. Microstructure and tribological properties of W-implanted PVD TiN coatings on 316l SS.Vacuum, 2014, 99, 68-75