Performance of CrN/TiN Coated On High Speed Steel

Vikram S. 1 & Prakash R. S. 2
1Assistant Professor, Department of Mechanical Engineering, Kathir College of Engineering, Coimbatore
2Dean, Department of Mechanical Engineering, Kathir College of Engineering, Coimbatore

Abstract: Surface modification by means of thin film deposition is an important industrial process used to protect base materials against wear, fatigue, corrosion and many other surface related damage phenomenon. Thin hard coatings such as TiN, CrN, and TiAlN have been accepted particularly in the cutting and forming tool industries. TiN and TiAlN coating widely used for dry cutting operations due to its high hardness. Especially, CrN coatings have been used to forming tool dies for its hardness and corrosion resistance. Tool steels are supplied with heat treated state, generally hardened and tempered to provide for particular application. Tool dies are precision products whose final shape and dimensions are important in micron level accuracy for production of parts. The tool steels have different machinability which varies with the chemical composition and microstructure of steels.

The objective of this project is to optimize the thickness of coat CrN on 6959 steel die components by using response surface methodology (RSM). It is very essential to substantiate the role of different sputtering conditions for achieve desired microstructural properties. The microstructural characteristics of thin film are effectively governed by sputtering parameters. The characterization of coating is to be examined by using X-rays diffraction method (XRD), scratch tester, pin on disc and microhardness tester.

Key words: CrN, XRD, TiN, TiAlN, 6959 steel

Brief Introduction

1. Surface engineering is an economic method for the production of material, tools and machine parts with required surface properties, such as wear and corrosion resistance when two surface contact, wear occur on both surface. Individuals and industry tend to focus on the wearing surface that has the greatest impact on their own economic situation, and consider the other surface to be abrasive. Plasma assisted coatings have proved themselves excellent for economical, reliable surface modification processes.

2. Literature Review

Hetal N Shah et al., Bull in Mater. [1] Investigate the microstructural characterization of CrN coating on stainless steels as a function of substrate temperature, working pressure and power. At low working pressure residual stress buildup on the thin film. Deposition rate is decreased with increase in working pressure due to decrease in MFP. The stress induced in the film decrease within increase in pressure. Microhardness of thin film decreases with increase of pressure. It is because of presence of crystal imperfection in film growth.

M.A.M.Ibrahim, S.F. Korablov and M.Yoshimura[2] The corrosion behavior of TiN,(TiAl)N and CrN coated on 304 stainless steel by physical vapor deposition was examined in borate solution (pH 0.9) and 0.5 M NaCl solution. The study was performed using open circuit potential, potentiodynamic polarization and cyclic polarization techniques, complemented with XRD and laser microscopy. However they are prone to corrosive attack as consequence of the presence of microstructure defects such as pinholes and pores.

B. Navinsek, P. Panjan, A. Cvelbar [3] The plasma beam sputtering process was used to prepare CrN and TiN hard coatings on steel, sapphire and alumina Superstrate substrates at a temperature of 200 °C. The microstructural characteristics, coating morphology, interfacial properties, microhardness and internal stresses were studied for coatings 3 µm thick. Their oxidation behaviour in an oxygen flow in a tube furnace was studied at temperatures up to 600 °C for TiN and up to 800 °C for CrN coatings. The initial stage of oxidation of TiN and CrN coatings 350 nm thick was also studied by continuous electrical resistivity measurements. This measurement technique offers high reproducibility and accuracy, so can be used to study oxidation for all types of hard coating, and especially for new multilayer and duplex coatings.
J. Walkowicz, J. Smolik, J. Tacikowski [4] The paper concerns the process of the composite: ‘nitrided layer-PAPVD coating’ creation on substrates made of hot working steel. The composite properties are determined by the appropriate selection of coating parameters and nitrided case structure. The results of research concerning the influence of a method of substrate nitriding and the created nitrided case structure on the adhesion and plastic properties of the PAPVD coatings are presented in the paper. Substrates made of hot working steel EN X 35CrMoV5 (0.4% C, 0.4% Mn, 1.0% Si, 5.0% Cr, 1.3% Mo, 0.3% V) underwent different processes of thermo-chemical and finishing surface treatment in order to obtain a nitrided layer of a different structure: Fea(N), Fea(N)+‘white layer’-e,c¾.

S. Ortmann et al [5] In this study, CrN coatings deposited by plasma-activated physical vapor deposition (PAPVD) on hard metal substrates were structured by variation of the deposition parameters that were varied. In this study, the bias voltage was determined to have the greatest influence on the surface structure of the coatings. A wide variety of structures ranging from only somewhat creviced to highly creviced were fabricated, with grain sizes ranging from 5 to 500 nm.

3. Selection of tool steel

The tool steels used for plastic or rubber moulds normally classified or supplied with a) Pre-hardened steels b) annealed steels c) age hardening steels

3.1 Pre-hardened steels

The pre-hardened steel are supplied in hardened and tempered condition. Then straightly goes to production processes with no need of immediate heat treatment processes.

3.2 Age Hardening Steels

They are supplied with solution condition with a hardness value similar to pre-hardened steels that can be further increased by heat treatment. The steels used for plastic moulds are SS420, 2316, 2738, 6959.

4. Deposition Material [CrN]

CrN coating is conventionally used for more hardness and high corrosion resistance industrial applications. The good sliding behaviour of the coating protects against at deficient lubrication. Compared with hard chromium plating, CrN similar corrosion resistance but significantly higher hardness and better coating adhesion. For coating CrN in DC Magnetron sputtering Deposition 99.99% of pure chromium target was selected.

5. Design procedure

In this project application is to make a die with high resistance heat, wear and corrosion resistance. So that my machining tool is having three-coordinates (x, y and z). In that I have concentrating single dimension and also specifically calling as name of specimen. The specimen dimension is 50 x 40 x 3 mm.

6. Calculation of tool steel with coated material

Inner surface temperature, \( T_1 = 360^\circ\text{C} + 273 = 633\text{K} \)
Thermal conductivity, \( K_1 = 19.07 \text{ W/mK} \)
Thickness of coated material (CrN), \( L_1 = 2\times10^{-6} \text{ m} \)
Outer surface temperature, \( T_3 = 50^\circ\text{C} + 273 = 323\text{K} \)
Thermal conductivity, \( K_2 = 24.7 \text{ W/mK} \)
Thickness of base material (P6959 steel), \( L_2 = 3\times10^{-3} \text{ m} \)

7. Specimen preparation

- The specimens are prepared from the AISI 6959 grade steel.
- Parts are cleaned in a multi-stage cleaning process to remove soils, oils, fingerprints and produce an oxide free surface.
- The specimens are cleaned on the stage of ultrasonic effect for removing oil and other...
contamination and liquid honing for surface roughness by using fine adhesive powder.

- The surface of specimens has been coated by using PVD techniques.
- The thickness of coated surface layer is existing between 2 micrometer.
- The CrN have been used for surface coating material on substrate by PVD method.
- The specimens have been prepared for the dimensions of 40 x 50 x 2 mm.
- The surface of specimens has been hard coated CrN by DC Magnetron sputtering deposition process.

8. Coating method deposition

- Hard coating is the process in which a coating is applied to a substrate.
- The main purpose is to reduce wear or loss of material by abrasion, impact, erosion, galling, and cavitations.
- The production of a hard wear- resistant surface layer on metals by coating is known as hard coating.
- The hard face materials are usually more wear, heat & corrosion resistant.
- Here the coating technique used is PVD process- DC magnetron sputtering deposition.

9. DC Magnetron Sputtering Deposition

The equipment required for hard coating is used for DC Magnetron sputtering deposition process (PVD).

- The different parameters are considered, they are N2 pressure, Arc current, Substrate bias, Deposition time and other.
- The surface of hard face is throughly cleaned for the stage of ultrasonic effect for removing oil, other contamination and foreign particles and liquid honing for surface roughness by using fine adhesive powder.
- In chamber, air is pumped out, leaving a high vacuum environment.
- Substrate parts are pre-heated to process temperature.
- Substrates are ion-cleaned to remove the final atomic contaminants from the surface.
- The plasma is formed by magnetic field, argon ions in the Plasma impact on the target (Cr) and causes sputtering of atoms by momentum transfer, unlike other vapor phase techniques there is no melting of materials.
- Argon gas is introduced in the chamber plasma generation.
- Nitrogen gas is used as reactive gas, to form nitrides.
- Pure chromium is used as a target for CrN coatings.

10. Conclusion

- It is concluded that 6959 grade steel has been selected as a substrate material because of its moderate properties of hardness strength and its higher coefficient of thermal expansion when compared with other two types of steels (2316, 2738).
- Its purchasing and machining cost is low. So that selected as a substrate material.
- From the literature review it is concluded that the influencing variables of microstructural characteristics of CrN coating are substrate temperature, working pressure and reactive gas flow rate, thickness of the film and power of sputtering process.
- Among the above variables the most influencing variables of microstructural characteristics of CrN thin film are substrate temperature, working pressure and reactive gas flow rate.

The RSM experiment is planned to conduct, by taking substrate temperature, working pressure and reactive gas flow rate as control variables and keeping all other parameters constant.

References

9. Thomas Bjork a, Richard Westergård