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Comparative analysis of wear rate (CR-ZN-NI) coated HSS tool and non-Coated HSS tool

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ABSTRACT

In the field of manufacturing High-speed steel plays a major role for cutting, drilling and some other major operations when compared to high carbon steel. Currently only pure HSS is used without any coating on it, in this paper we have coated the HSS with chemical element like chromium, zinc and nickel for end mill cutter. This cutter was used to machine AISI 4340 steel at axial and radial engagement. The machining operations were carried out with proper production conditions and periodically interrupted the wear condition of the cutting tool. Cutting conditions wear carefully chosen, so that a linear wear model for the useful life of the cutting tool could be statistically tested. One phase of a testing used non-coated tools from different suppliers and the non-stationary linear wear models provided a stochastic representation to determine tool quality using reliability and economic measures. Another phase used the coated tools and a stationary linear wear model to relate force, power, specific cutting energy, and mechanistic model parameters to service life measures. This paper also discussed the tool wear and life factor after coating compared with conventional cutting tool (HSS).

Keywords: High Speed Steel, Chromium, Zinc, Nickel

INTRODUCTION

High Speed Steel (HSS) tools have been extensively employed for machining of different kind of materials through the past decades. HSS tools show great toughness in comparison to other tool materials and capable of withstanding against the cyclic or intermittent loading and unloading. For this reason, they are primarily used for cutting operations at which interrupted or intermittent cutting is likely to occur. These include operations such as milling, drilling, broaching, and tapping. High speed steels are also appropriate for producing tools of complex shape such as helical milling, drilling, broaching, reaming, and tapping tools. However, when it comes to machining of hard-to- cut materials such as chromium , zinc and nickel are coated by using physical vapour deposition in (HSS) tools and predict the wear nature and hardness. chromium as a coating for tool steels has been available widely since the last decade and is enjoying increasing attention and application in tool industries.

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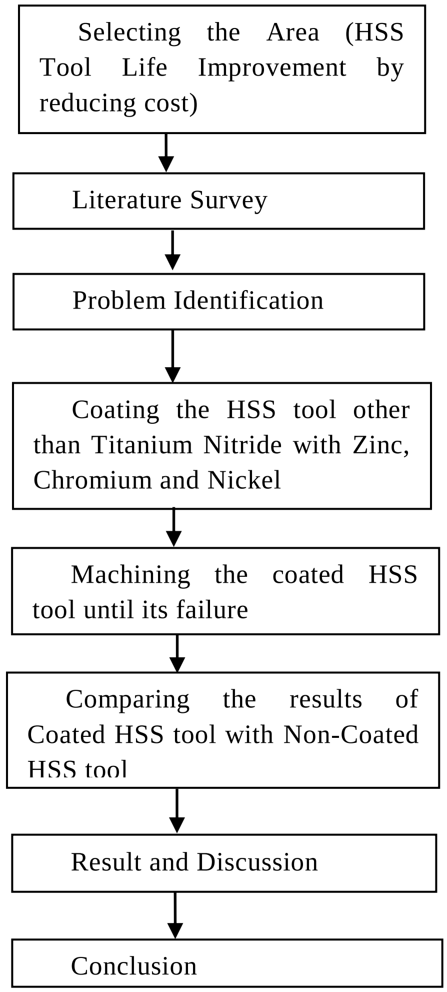
METHODOLOGY



LITERATURE SURVEY

[1] In this paper tools in machining hardening steel under dry conditions. This paper involves of machining hardened steel using titanium nitride (tin), coated carbide tools is studied using full factorial experiments. Many parameters influence the quality of the products in turning process. The objective of this study is on the effect of coating on tool to determine its various parameters such as temperature, cutting velocity, feed and depth of cut in machining hardened steel. Machining of hardened steels has become an important manufacturing process, particularly in the automotive and bearing industries.

[2]in this Machining of Inconel 718 with whisker reinforced ceramic tool gave better performance in terms of tool life under high-pressure coolant supplies up to 15MPa compared to conventional coolant supplies. The use of 15MPa coolant supply pressure tend to suppress notching during machining thus improving tool life, while the use of higher coolant supply pressure of 20.3MPa did not show improvement in tool life due probably to accelerated notch wear caused by water jet impingement erosion. Cutting forces decreased with increasing coolant supply pressure due to improved cooling and lubrication at the cutting interface as well as effective chip segmentation ensured by the momentum of the

coolant jet. Surface roughness generated were well below the rejection criteria.

[3] We investigated mechanical properties of tin as a function of microstructure varying from nanocrystalline to single crystal tin films deposited on (100) silicon substrates. By varying the substrate temperature from 25 to 700 °c during pulsed laser deposition, the microstructure of tin films changed from nanocrystalline (having a uniform grain size of 8 nm) to a single crystal epitaxial film on the silicon (100) substrate. The microstructure and epitaxial nature of these films were investigated using x-ray diffraction and high-resolution transmission electron microscopy. Hardness measurements were made using nanoindentation techniques. The nanocrystalline tin contained numerous triple junctions without any presence of amorphous regions. The width of the grain boundary remained constant at less than 1 nm as a function of boundary angle. Similarly the grain boundary structure did not change with grain size. The hardness of tin films decreased with decreasing grain size. This behavior was modeled recently involving grain boundary sliding, which is particularly relevant in the case of hard materials such as tin.

[4] This paper reports on the tribological properties of commercial Cr–N physical vapor deposition (PVD) processes for enhanced mechanical protection of forming and machining tools. The study is carried out on conventional tooling materials as substrates, i.e. high speed steels (M2) and cemented tungsten carbide. Electron beam (EB), magnetron sputtering (MS) and cathodic arc (CA) commercial Cr–N PVD processes from three different EU coating centers/companies are evaluated in terms of their tribological behaviour by standard characterization techniques for material properties: surface hardness and roughness, film adherence strength and wear resistance under sliding conditions. The results are discussed on the basis of their current applications and their influence on tool performance for manufacturing processes. Moreover, film tribological performance is correlated with their microstructural properties as obtained by electron microscopy and X-ray diffraction. In terms of surface hardness and adherence strength, CA Cr–N seems to outperform EB and MS coatings.

[5] In this Magnesium-based light-metal alloys belong to a class of structural materials with increasing industrial attention. Magnesium alloys show the lowest density among the engineering metallic materials, low cost and large availability. However, the limitations according to mechanical strength and the low corrosion resistance restrict their practical application. To improve the surface hardness and the corrosion resistance, PVD-coating techniques offer possibilities to overcome these drawbacks. The paper presented reveals relevant mechanical and chemical properties of various PVD-coatings on high purity (hp) AZ31 magnesium alloy specimens.

[6] In this study average chip-tool interface temperatures have been experimentally studied using the tool work thermocouple technique. Based on the parametric study, a first-order and second - order empirical models of the chip-tool interface temperatures has been developed for turning of EN-31 steel alloy with tungsten carbide tools by response surface methodology coupled with factorial design. The developed empirical relation agrees well in velocity with the Shaw's non-dimensional model. The first-order and second-order mathematical models are found to be adequately represent the cutting temperatures. The model developed in the research produces smaller errors and has satisfactory results,

[7] In this research work the tool-chip interface temperature is measured experimentally during turning of en-31 steel alloy with tungsten carbide inserts using a tool-work thermocouple technique. First and second order mathematical models are developed in terms of machining parameters by using the response surface methodology on the basis of the experimental results. The results are analyzed statistically and graphically. The metal cutting parameters considered are cutting speed, feed rate, depth of cut and tool nose radius. It can be seen from the first order model that the cutting speed, feed rate and depth of cut are the most significantly influencing parameters for the chip-tool interface temperature followed by tool nose radius. Another quadratic model shows the variation of chip-tool interface with major interaction effect between cutting speed and depth

of cut (v*d) and second order (quadratic) effect of cutting speed (v2) appears to be highly significant. The results show that increase in cutting speed, feed rate and depth of cut increases the cutting temperature while increasing nose radius reduces the cutting temperature. The suggested models of chip-tool interface temperature adequately map within the range of the cutting conditions considered.

[8]This paper presents the performance of ductile cast iron grinding machining using water-based zinc oxide nano particles as a coolant.The experimental data was utilized to develop the mathematical model for first- and second-order models. The second order gives worthy performance of the grinding. The results indicate that the optimum parameters for the grinding model are 20m/min table speed and 42.43 μm depth of cut for single-pass grinding. For multiple-pass grinding, optimization is at a table speed equal to 35.11m/min and a depth of cut equal to 29.78 μm. The model fit was adequate and acceptable for sustainable grinding using a 0.15% volume concentration of zinc oxide nano coolant. This paper quantifies the impact of water-based ZnO nano particle coolant on the achieved surface quality. It is concluded that the surface quality is the most influenced by the depth of cut(s) and table speed.

[9] This paper mainly deals with various chromium coating defects that occur while electro plating of different mechanical components and methodology adopted to prevent it. It also covers suggestions to minimize this problem. This paper contains new suggestions to minimize the problems by using recent technological developments. Since the chemicals used for chromium coating are posing threat to environment it is need of the hour to minimize the use such chemical consumption. The reduction in defective components will increase productivity as well as protect the environment to some extent it also describes the various alternate coating methods for chromium coating through which we can achieve the required surface properties.

In this investigation, the load was varied between 100 and 1300 N, corresponding to a contact pressure between 2 and 5 GPa. The main observation is that the galling and anti-sticking properties of the tool surface dramatically improve by reducing the surface topography. Consequently, reduced substrate roughness or polishing of the contact surface after coating is highly recommended

[10]In this paper the general situation in this field is shown. Already today it is possible to replace efficiently some of the galvanic processes in specific cases (e.g. Cr, Ni, Cd, Zn, Au). It is important to point out that PVD is considered to be a technique which can provide not only metallic, but also alloyed and ceramic coatings with a virtually unlimited range of chemical composition and therefore controlled protective, mechanical and wear-resistant properties. Entering into competition with galvanic coatings the manufacturers of PVD coaters were confronted with new requirements: a huge quantity of substrates of the same size, to be chemically and plasma cleaned and then coated at the highest possible deposition rate. For industrial mass production one can therefore use only large PVD batch systems or in-line coaters. The alternative for today's low price galvanic coatings is therefore dry and clean PVD technologies, fully supported by legislation on environmental protection. The economics depend directly on the substrate type and the quantity.

PROBLEM IDENTIFICATION

- Cost of the tool is high.
- Life of the tool is decreased.
- Production rate is decreased.
- Low profit die to tool less life of tool.

OBJECTIVES

- Wear progression on HSS cutting tools are studied.
- The change of surface finish throughout the tool life of cutting tools are studied
- Analysing the results obtained from coated HSS tool, and evaluates their performance based on the effects of the coating materials used.

STUDY OF COATING AND PROPERTIES OF MATERIALS

Physical vapor deposition (PVD) describes a variety of vacuum deposition methods which can be used to produce thin films and coatings. PVD is characterized by a process in which the material goes from a condensed phase to a vapor phase and then back to a thin film condensed phase. The most common PVD processes are sputtering and evaporation. PVD is used in the manufacture of items which require thin films for mechanical, optical, chemical or electronic functions.

Properties of zinc

- density – 7.13 g/cm³
- color – bluish-white
- zinc is a low-melting metal, with a melting point of 420 °C
- the elasticity and malleability of the metal increases when it is heated to 100 °C
- the boiling point of the simple substance is 906 °C
- when heated to 200 °C, zinc loses its elasticity and turns to a gray powder
- the metal has a high heat capacity and heat conductivity
- zinc is a good conductor

Properties of nickel

- Density -8.90 g/cm³
- Nickel is silvery-white, hard, malleable, and ductile metal.
- It is a good conductor of heat and electricity.
- It is bivalent, that is it has a valency of two.
- The metal dissolves slowly in dilute acids.
- It's melting point is 1453 °C and boiling point is 2913 °c

Properties of chromium

- Density-7.19 g/cm³
- Melting point -1907°C
- Boiling point -2672°C
- Chromium is a silver and gray color.
- Its crystal structure is cubic.

TESTING THE COATED HSS TOOL

Knoop Hardness Test

The Knoop hardness test is a micro hardness test for mechanical hardness used particularly for very brittle materials or thin sheets, where only a small indentation may be made for testing purposes. A pyramidal diamond point is pressed into the polished surface of the test material with a known (often 100g) load, for a specified dwell time, and the resulting indentation is measured using a microscope. The geometry of this indenter is an extended pyramid with the length to width ratio being 7:1 and respective face angles are 172 degrees for the long edge and 130 degrees for the short edge. The depth of the indentation can be approximated as 1/30 of the long dimension

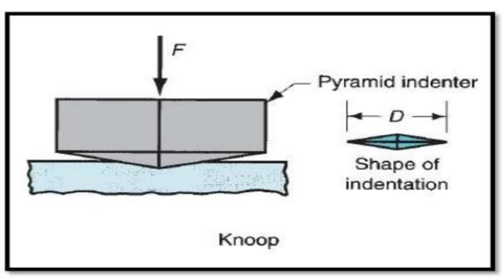


Fig.1 Knoop Hardness Test

The Knoop hardness *HK* or *KHN* is then given by the formula:

HK = Load (Kgf) / (Impression/area) (mm²)

$$HK = P / C_P L^2$$

Where,
L = length of indentation along its long axis
C_p = correction factor related to the shape of the indenter, ideally 0.070279
P = load

Wear testing

Wear is the damaging, gradual removal or deformation of material at solid surfaces. Causes of wear can be mechanical (e.g., erosion) or chemical (e.g., corrosion). Wear in machine elements together with other processes such as fatigue and creep, causes functional surfaces to degrade, eventually leading to material failure or loss of functionality. Wear of metals occurs by plastic displacement of surface and near-surface material and by detachment of particles that form wear debris. The particle size may vary from millimeters to nanometers. This process may occur by contact with other metals, nonmetallic solids, flowing liquids, solid particles or liquid droplets entrained in flowing gasses. The wear rate is affected by factors such as type of loading (e.g., impact, static, dynamic), type of motion (e.g., sliding, rolling), and temperature. Depending on the tribo system, different wear types and wear mechanisms can be observed. Several standard test methods exist for different types of wear to determine the amount of material removal during a specified time period under well-defined conditions. ASTM International Committee G-2 standardizes wear testing for specific applications, which are periodically updated. The Society for Tribology and Lubrication Engineers (STLE) has documented a large number of frictional, wear and lubrication tests.

Standardized wear tests are used to create comparative material rankings for a specific set of test parameter as stipulated in the test description. To obtain more accurate predictions of wear in industrial applications it is necessary to conduct wear testing under conditions simulating the exact wear process. An attrition test is a test that is carried out to measure the resistance of a granular material to wear.

Formula calculate wear rate,

$$V_i = k_i F s$$

Where:

F is the normal load

s is the Sliding distance

V is the wear volume

K is the specific rate coefficient

i is the identifies the surface considered

work piece material- mild steel

plate size =150x100x10 mm

Normal force = 20N

Wear track length = 12 mm

Speed = 200 cycles/min

Revolutions = 6000

Pin geometry spherical = 6mm

Pin materials =A1

The k-value is given in m^3/Nm or m^2/N, sometimes in mm^3/Nm.

CONCLUSION

In the present work the performance of coated HSS tools by using chromium, zinc and nickel conditions is studied. The result shows that the coated tools perform better as compared to uncoated cutting tool. The effect of cutting is reduced, wear and tear of tool tip point as well as more heat dissipation to surroundings, hence increase in tool life and surface finish of the product takes place. With increase in depth of the cut the roughness is increased.

- Here experimental results shows by selecting the proper cutting parameters the coated tools are suitable to produce fine surface finished components.
- Thus the final Outcome the Testing of chromium coated HSS tool have the most less wear rate compare with Non coated HSS Tool
- To improve the hardness
- To improve the life of tool

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