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Study of Coated TiN and TiC on Cutting Tools for the PVD and CVD Coated Tungsten Carbide by Sand Blasting Pretreatment of Nickel and Carbon

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Abstract

It has been well established that advanced surface coatings on cutting tools improve wear resistance by modifying the contact conditions between the chip and tool interface. As a result of the recent developments in cutting tool industry, coated tools have made a significant contribution to the metal cutting operations in terms of tool life, cutting time and machining quality. The challenge of modern machining industries is focused mainly on the achievement of high quality, in terms of work piece dimensional accuracy, surface finish, high production rate, less wear on the cutting tools, economy of machining in terms of cost saving and increase the performance of the product. In general, the most important point in machining processes is the productivity, achieved by cutting the highest amount of material in the shortest period of time using tools with the longest life time. The present research work describes the development, Mechanical, Tribological performance of Nano material coating of TiN,TIC, on Tungsten Carbide cutting tool. The Mechanical, Tribological properties of TiN,TIC, are to be compared with uncoated Tungsten carbide cutting tool. And also different coating methods like Chemical Vapour Deposition, Physical Vapour Deposition Method, can be used for comparision.The present work will help to find the tool life and wear behaviour of the each coated tool and it will help to find the best tool coating applicable for the cutting tool. The experiments of Mechanical, Tribological properties tests have to be conducted as per ASTM standards. SEM analysis has to be done for investigating the surface morphology of Tungsten Cutting tool. The coated cutting tool have to be modelled using suitable assumption and analyzed by means of finite element method using ANSYS software. Both results of Experimental and ANSYS software are to be compared.

***Key Words**: Nano coatings, Titanium Nitride, Titanium Carbide*

1. Introduction

The cutting tool industries are constantly facing the very common industrial challenge of reducing cost of machined parts and at the same time improving the quality of the machined surface. These issues are generally addressed by improving cutting tool materials, applying advanced coating, improving the geometry and surface characteristics of the cutting tools, optimizing machining parameters [1]. The need for the use of newer cutting tool materials to combat hardness, wear situation has resulted in the emergence surface coatings, which contributes in reducing cost per machined parts through increasing productivity and extending tool life. The benefits of advanced coatings are of higher hardness, low friction at the chip tool contact, higher wear resistance, high hot

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hardness and high thermal and chemical stability. The machined surface quality with the coated cutter can also be improved by avoiding any built-up edge due to the reduced friction between the tool and work piece. Based on the abundant advantages of surface coatings and the requirement of industrial development and requirement, it is necessary to develop TiN, TIC, coatings on Tungsten carbide cutting tool [2]. Based on these driving force, it is necessary to do surface coating of TiN, TIC, on Tungsten Carbide cutting tool to give good mechanical and tribological properties.

2. Experimental Procedure

TiN and TiC are deposited on a tungsten carbide cutting tools by physical vapor deposition by cathodic arc PVD using a system Bias and Cathodic Arc Evaporation (Oerlikon-Balzers). For the deposition of the coating, TiN and TiC (wt%) alloy was used in a controlled nitrogen atmosphere. The deposition time was adjusted to obtain a layer with a predetermined thickness of(2 μm-20 μm) . The deposition of coating was made under a nitrogen atmosphere to ensure the nitriding of the compound and, next, the sample was subjected to a heat treatment at a temperature of 500 ℃ during 4 hours under an inert atmosphere. Heat treatment was made with the aim of modifying the coating microstructure, extending the diffusion of nitrogen, and leading to the formation and growth of TiN precipitates. Additionally, heat treatment is very beneficial to eliminate the amorphous phases formed during coating processes and the phases could become more crystalline and also could improve adhesion between coating and substrate. Besides, heat treatment also helps to obtain an improvement of structural integrity and a reduction of stress and fragility in coatings[3]. The morphological characterization of the cross-section of the coated and uncoated tool was performed by two scanning electron microscopes: The elemental chemical analysis was done using an EDXS with a detection limit of 0.1 wt%. The crystalline structure was characterized by X-ray diffraction (GI-XRD PANalytical X'Pert PRO MRD) with grazing incidence from 20° to 80° and angle of incidence of 0.5°. The figure [1] and [2] shows typical coating area obtained by PVD and CVD.

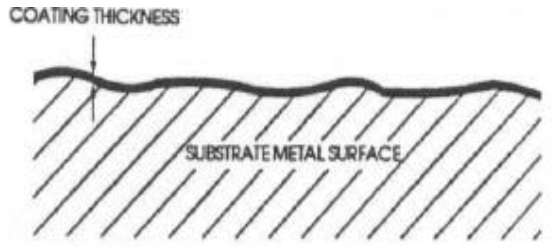


Figure 1. Typical Coating Area Obtained by PVD

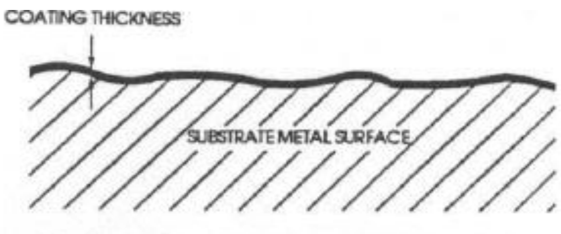


Figure 2. Typical Coating Area Obtained by CVD

2.1. HARDNESS TESTS:-Hardness tests were conducted by means of a MicroVickers Clemex MMT-X7 indenter equipped with a pyramidal diamond tip Berckovich applying 1 kgf during 10 seconds. The readings will be taken for tungsten carbide cutting tool coated with TiN and TiC for various cutting tools of varying wt% (2 μm -20μm).and after studying the readings,the wt% of Tin and TiC will be recommended. The table [1] shows the difference between PVD and CVD.

Table 1. Difference between PVD and CVD

PROCESS	THICKNESS		
	MICRON	INCH	MM
PVD	2 TO 4	0.0000709 TO 0.00012	0.002 TO 0.004
CVD	2 TO 3	0.000079 TO 0.00016	0.002 TO 0.003

2.2. Wear Test Procedure: A pin-on-disc device with round tool inserts was applied to conduct friction and wear tests in which both the friction coefficient and the linear wear of the tribo-pairs were continuously recorded versus sliding distance. The volumetric wear rate was used to compare the wear resistance of the tribo-pairs tested. LOM, SEM and X-ray microanalyses by EDAX were applied for observations of wear scars and wear products. The investigations of coating microstructures by MO and TEM were performed. The examination of fun blades after the exploitation and the analysis of the obtained results were correlated with the performed microstructure observations and micro hardness data of coatings. Though high-speed steel retains its importance for such applications as drilling and broaching, most metal cutting is carried out with carbide tools.Wear test will be carried out on CSM Instruments Tribometer by pin-on-disk test in dry[4].The values of the coefficient of friction (μ) were obtained directly from the installed Tribox 4.1 software. Sapphire ball with a diameter of 6 mm, roughness Ra = 0.02 μm and hardness of 2,300 HV was slid on the WC-Co substrate coated with the TiN. Surface roughness measurements were carried out with a Confocal Microscope Carl Zeis Axio CSM-700 on the coating surface; the average value of AlCrN-T sample was Ra = 0.86 μm. For the pin on disk test, the sapphire ball was fixed on the load arm and the sample was placed on a rotating disc with a rotating radius of 3 mm. The standard contact loads used were 1, 5 and 10 N. The sliding speed was 0.10 m/s with an acquisition rate of2.0 Hz and a distance of 1,500 m for the complete test. The temperature during the test was maintained at 26 ± 1 ℃ with a relative humidity of 30%–40%. The wear test results wil be noted down and the wear which shows less wear for that wt% coating will be recommended for practical application. The Table [2] and [3] Shows detailes of tungsten carbide and Cutting tool detailesa and fig [3] shows tool description.

Table 2. For Tungsten Carbide

Property	**Property value**
Melting point	2870°C
Hardness (Vickers Hardness)	2242 HV
Electrical Resistivity	2×10^{-7} Ohm·m

Table 3. For Cutting Tools Detailes

Detail	**Description**
Standard designation of insert	TCGT 16T304FN-27
Basic shape	Triangle
Cutting edge length	16.5

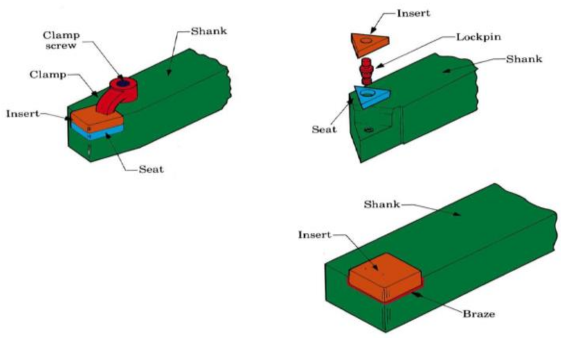


Figure 3. Tool Description

Ceramic and metallic (cermet) powders with microstructures engineered at the nano scale enable producing coatings having enough hardness, wear resistance, and durability to serve as a cost-effective replacement.

3. Coating Technique

3.1. Chemical Vapor Deposition (CVD)

CVD will be used to coat TiN, TiC on tungsten carbide cutting tool. In the CVD process, the tools are heated in a sealed reactor to about 1000℃ (1830℉). Gaseous hydrogen and volatile compounds supply the metallic and nonmetallic constituents of the coating materials, which include titanium carbide TiC, TiN. Thickness of CVD coatings can range from 2µm to 20µm.The high process temperature used in CVD ensures good bonding between the tungsten carbide cutting tool and the coating material. This increases the, toughness results in minimal chipping and improved surface finish. When machining stainless steels and other materials that are prone to causing built-up edge on the cutting tool.

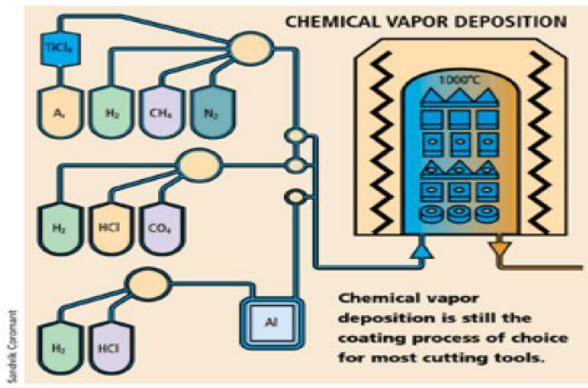


Figure 4. Chemical Vapour Deposition

3.2. Physical Vapor Deposition (PVD)

PVD is the other major process used to produce cutting tool coatings. In PVD, the coating is deposited in a vacuum. The metal species of the coating, obtained via evaporation or sputtering, reacts with a gaseous species (nitrogen or ammonia, for example) in the chamber and is deposited onto the substrate. Because PVD is a low-pressure process, the coating atoms and molecules undergo relatively few collisions on their way to the substrate[4]. PVD is therefore a line-of-sight process that requires moving fixtures to ensure uniform coating thickness .The main difference between PVD and CVD is the former's relatively low processing temperature of PVD which is 500℃ (930℉).This lower processing temperature resulted in multiple benefits for PVD coatings. PVD coatings are essentially free of the thermal cracks that are common in CVD coatings. In PVD, processing temperatures are low enough that eta-phase formation is eliminated, allowing deposition of PVD coatings on sharp edges. Ability to coat sharp edges is also enhanced by PVD coatings' relative thinness versus CVD. Coating microstructures depend on processing conditions. Adjusting process parameters in PVD allows modification from a columnar to an equi-axed structure [5]. PVD coatings also have very high built-in compressive stresses that help them resist crack initiation and propagation. Minimizing crack formation and propagation can help prevent premature tool failure, improving tool edge security. The Figure [5] shows the PVD.

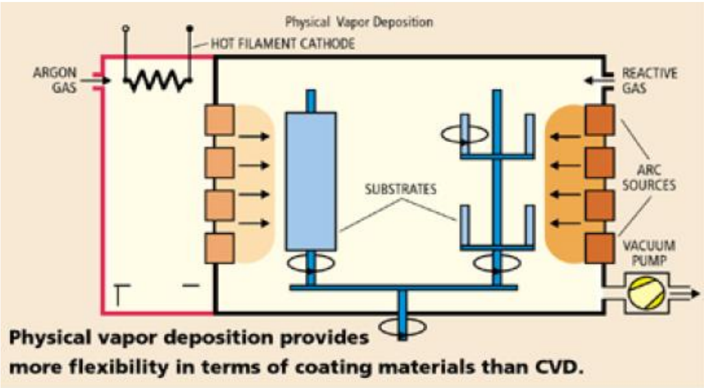


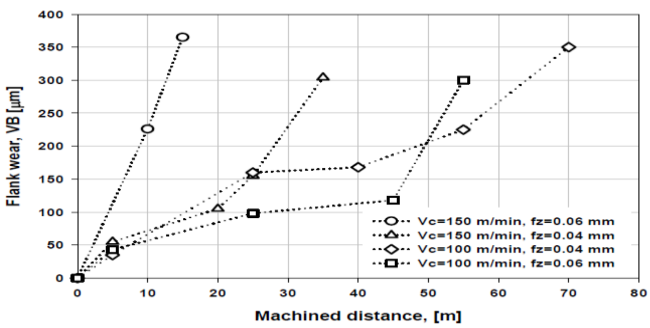
Figure 5. Physical Vapour Deposition

Surface roughness: It is done by using the Profilometer. The profilometer gives the out put with the help of graph.

4. Methodology

4.1. Coating of NANO Powder on Tungsten Cutting Tool

This can be achieved by depositing a thin layer (typically 2-20 µm) of coating of suitable material over the surface of the tool. Coatings act as diffusion barrier between the tooland the sliding chip, they increase wear resistance of the tool, prevent chemical reactions between the tool and work material, reduce built-up edge formation, decreasefriction between the tool and chip, and prevent deformation of the cutting edge due to excessive heating [5]. The below graph[1] shows the cutting tool life.



Graph 1. Shows the Cutting Tool Life

5. Conculsions

The AlCrN-T coating deposited by the PVD process showed physical properties with a wide range of applications for manufacture. The structural analysis shows that the heat treatment of AlCrN coating allows recrystallization and crystal growth, enhancing its wear behavior. These characteristics make the coated tools better for cutting applications. The AlCrN-T coating presented low friction coefficients and wear rates tested by pin-on-disk, in comparison with previous works It was revealed that the AlCrN-T coating has a wide potential tribological application under the condition of sliding wear. It took more than 2000 cycles for the AlCrN layer to reach a value of 0.55. The machinability study with the coated carbide tool and a work piece of titanium alloy, presented improved results according to previous research, and it was fully demonstrated that an AlCrN-T coating can be used with acceptable levels of productivity in the machining of aerospace and biomedical components, with adequate process parameters, lubrication and other conditions. Further experimentation should be made in order to demonstrate the viability of other novel coatings (multi-layer) with similar constitutive and heat-treated materials.

NOMENCLATURE

TIC	Titanium Carbide
TIN	Titanium Nitride
PVD	Physical Vapor Deposition
CVD	Chemical Vapour Deposition
MO	Optical Microscopy
SEM	Scanning Electron microscope
EDXS	Energy Dispersive X-ray detector
LOM	Light microscopy
TEM	Transmission electron microscopy

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