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Study on Hardness and Wear Resistance of AlCrN and AlTiN thermal barrier Coatings on Cemented Carbide tool

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ABSTRACT: Cutting is an important process in the manufacturing industry. It is necessary to use good quality cutting tools in order to maintain the quality of a product. The coating on a cutting tool has a great impact in terms of the mechanical and tribological properties as well as the end results of the product. A cutting tool can be made of various types of materials, but the most commonly used material in the industry today is cemented tungsten carbide as its characteristics meet the requirements of manufacturers. To improve the performance of cutting tools, various coatings have been applied to the tools, among them being single coatings, multi-layered coatings, nano composites and super lattices. Hierarchical-structured coatings are the latest discovery in the manufacturing industry. In this investigation, cemented carbide tool is coated with AlCrN and AlTiN to act as thermal barriers and the coating characteristics are studied.

KEYWORDS: Cemented Carbide Tool, PVD, AlCrN, AlTiN, Hardness, Wear

I. INTRODUCTION

The manufacturing industry is constantly striving to decrease its cutting costs and increase the quality of the machined parts as the demand for high tolerance manufactured goods is rapidly increasing. The increasing need to boost productivity, to machine more difficult materials and to improve quality in high volume by the manufacturing industry has been the driving force behind the development of cutting tool materials. Numerous cutting tools have been developed continuously since the first cutting tool material suitable for use in metal cutting, carbon steel, was developed a century ago. Cemented carbides are the most popular and most common high production tool materials available today.

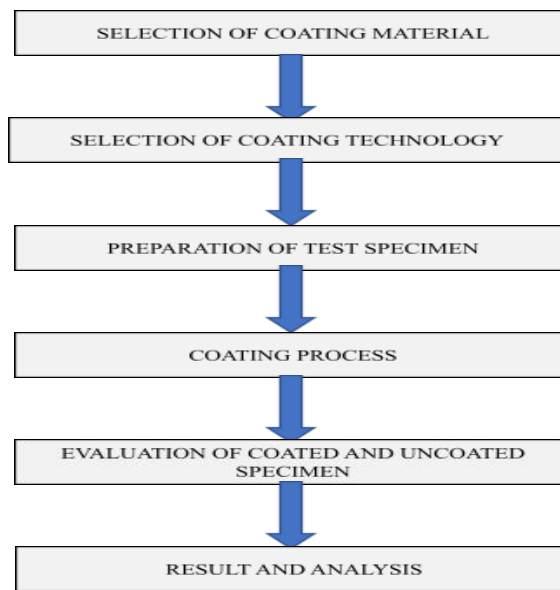
The productivity enhancement of manufacturing processes is the acceleration of improved cutting tools with respect to the achievement of a superior tribological attainment and wear-resistance. This resulted in developing hard coating for cutting tools; these hard coatings are thin films of one layer to hundreds of layers. These hard coatings have been proven to increase the tool life by as much as 10 folds through slowing down the wear phenomenon of the cutting tools. This increase in tool life allows for less frequent tool changes, therefore increasing the batch sizes that could be manufactured and in turn, not only reducing manufacturing cost, but also reducing the setup time as well as the setup cost. In addition to increasing the tool life, hard coating deposited on cutting tools allows for improved and more consistent surface roughness of the machined work piece. The surface roughness of the machined work piece changes as the geometry of the cutting tool changes due to wear, and slowing down the wear process means more consistency and better surface finish. As the wear rate is increased with the rise in temperature at tool work piece interface materials with low thermal conductivity are applied as thermal barrier coatings to reduce the heat transfer and thus the rise in temperature.

II. LITERATURE REVIEW

Among different coating, nitrides and carbides have attracted attention due to their high hardness and excellent wear resistance [1-6]. Hard coatings of AlCrN and AlTiN on carbide milling tools have exhibited better performance in cryogenic conditions than in dry and wet conditions [7]. AlCrN coated tools show better performance in terms of tool life and machining quality when machining medium carbon and heat resistant steels for wide range of cutting



speeds[8]. The rise in temperature at the tool chip interface leads to more wear and lessen the tool life and quality of machining. Tool chip interface temperature increases with increase in cutting speed because of high thermal conductivity of base material. The removal of generated heat is to be addressed in order to minimize the effects of increase in temperature. The rise in temperature at the tool-work piece interface is to be reduced/ prevented by applying suitable coating technique and material to improve the wear characteristics and thus to increase the tool life and improve the machining quality. In this study AlCrN and AlTiN coatings were deposited by cathodic Arc Deposition process on the cemented carbide tool specimens and their influence on the hardness and wear of the tool surface are investigated.



III. METHODOLOGY AND MATERIALS

Cemented Carbide tool inserts were coated with AlCrN and AlTiN coatings by Cathodic Arc Deposition technique and the coatings were tested for their adhesion and hardness by subjecting to standard wear and micro hardness test to ensure that the coatings are stable and improves the wear resistance of the substrate material.

IV. EXPERIMENTAL WORK

Cathodic Arc Deposition technique was used to coat the cemented carbide tool specimens. Table.1 shows the process parameters for coating AlCrN and AlTiN on cemented carbide tool inserts.

Coating material	AlTiN	AlCrN
Coating technology	Arc	Arc
Micro harness	33+/-3	36+/-3
Coefficient of friction	0.6	0.6
Maximum service temperature	700 ⁰ C	1100 ⁰ C
process temperature	< 350 ⁰ C	< 500 ⁰ C
Deposition pressure	8.5 × 10 ⁻² -6.5 × 10 ⁻² mbar	8.5 × 10 ⁻² -6.5 × 10 ⁻² mbar
Bias voltage	80 and -100 V	80 and -100 V
Deposition rate	3.5 μm/h	4.0 μm/h
Coating thickness	4.5 ± 0.5 μm	4.5 ± 0.5 μm



Hardness Test

Hardness is a measure of the resistance to localized plastic deformation induced by either mechanical indentation or abrasion. Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity. Common indentation hardness scales are Rockwell, Vickers, Shore, and Brinell. To assess the hardness of surface coatings micro hardness tests Vickers diamond pyramid or the Knoop elongated diamond pyramid tests are done. In this work Vickers microhardness test is done to assess the hardness of the coated specimens. The hardness test was carried at three different locations for each specimen.

Wear Test

The friction and wear behaviour of the uncoated specimens were evaluated by wear friction monitor Ducom-TR LT, under unlubricated contact condition at room temperature and relative humidity 65%. There are three parameters followed on wear monitoring: track diameter 80mm, sliding speed 477 rpm and load 1, 1.5 and 2 kg. The wear test was carried out as per ASTM standard G99 at a constant velocity of 1m/s.

Parameter	Set value
Applied load	1, 1.5 and 2kg
Velocity	1 m/s
Track diameter	80 mm
Time	60 min
Speed	477 rpm

Table 1. Wear Test parameters

V. RESULTS AND DISCUSSION

The results of the hardness test is shown in Table.2

Table.2 Hardness values of coated and uncoated samples

S. No	Sample Name	Hardness Value (HV)	Average Hardness Value (HV)
1	Uncoated Specimen	1890.4	1884.9
		1860.2	
		1904.2	
2	AlTiN coated specimen	2360.6	2383.7
		2380.3	
		2410.2	
3	AlCrN coated specimen	2650.2	2691.7
		2720.5	
		2704.5	

The hardness values suggest that the coated specimens exhibit higher hardness than the tool material and the wear test conducted on the samples reveal that the coatings have good adhesion with the tool substrate.

VI. CONCLUSION

In this investigation the cemented carbide tools were coated with AlCrN and AlTiN coatings in order to act as thermal barriers for protecting the substrate from heating up so as to reduce the tool wear and thus to improve the tool life and machining quality. The coatings were tested for wear rate and found to be having good wear resistance and the hardness was tested and found to be better than the substrate.



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