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Effect of Surface Texturing & Coatings on Cutting Tool in Turning of Oil Hardened Non Shrinking Die Steel

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ABSTRACT

Machining of Oil Hardened Non Shrinking Die Steel (OHNS) requires high strength and precision tools for providing good surface finish. In this experimental work turning operation of OHNS with various coated/ uncoated and surface textured carbide inserts was performed, and parameters like tool wear, tool life, cutting force, and surface roughness were measured for different cutting speeds and the results were compared. Coatings like Titanium aluminium nitride (TiAlN) and Titanium nitride (TiN) and surface texturing on the carbide tool provides increased tool life, hardness and reduced tool wear in machining operation.

KEYWORDS

Oil Hardened Non Shrinking Die Steel (OHNS), Non coated carbide tools, Titanium aluminium nitride (TiAlN), Titanium nitride (TiN), Surface texturing.

INTRODUCTION

Oil Hardened Non Shrinking Die Steel (OHNS) is economical and dependable for gauging, cutting and blanking tools.It is chemically composed of approximately 0.95 percent carbon, 1.1 percent manganese, 0.6 percent chromium, 0.6 percent tungsten and 0.1 percent vanadium.The temperature of the hardening lies between 790˚C to 850˚C.

Coatings are used to improve the tool life characteristics such as hardness, wear resistance, surface lubricity etc. Titanium aluminium nitride (TiAlN) and Titanium nitride (TiN) were coated on the carbide tools by using Physical vapor deposition (PVD) method. Titanium Nitride appears in golden color and Titanium Aluminum Nitride bronze with violet color.

Table 1 Physical Properties of TiN & TiAlN

Physical properties	Titanium Nitride	Titanium Aluminium Nitride
Vickers Hardness	2290 HV	2790 HV
Temperature at oxidation	549˚C	799˚C
co-efficient of friction	0.65	0.70
Thickness	2 to 4 microns	2 to 4 microns
Surface Roughness	0.19	0.41

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Texturing on the carbide tools imposes high degree of applications by means of increased tribological characteristics on the material. Various patterns of common microstructures are circular dimples like depressions, linear grooves,and crossed grooves were recorded on the carbide tool.

EXPERIMENTATION

COATING PROCESS:

PVD Coating process was carried out under the temperature of 150˚C to 500˚C. In this process, Coating material which is in the solid form is heated and evaporated. At the same time nitrogen gas passed into the vacuum chamber. It forms the vapor which contains metals was deposited on the tool material. TiN & TiAlN was deposited on the carbide tool by this process.

Fig 1 TiN Coated Tool

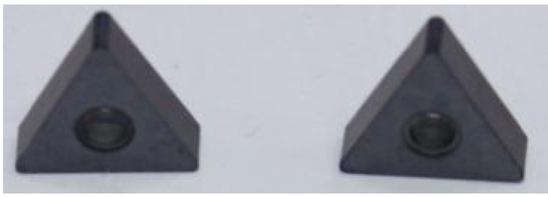

Fig 2 TiAlN Coated Tool

SURFACE TEXTURING PROCESS:

Surface texturing process was carried out in a laser texturing machine with the following machine specification and different patterns were recorded on the carbide tool.

Table 2 Machine Specification

Machine make	MLS F20
Laser source	Fibre
Wavelength	1064mm
Cutting Speed	100mm/s
Power	20W
Laser Diameter	2Micron

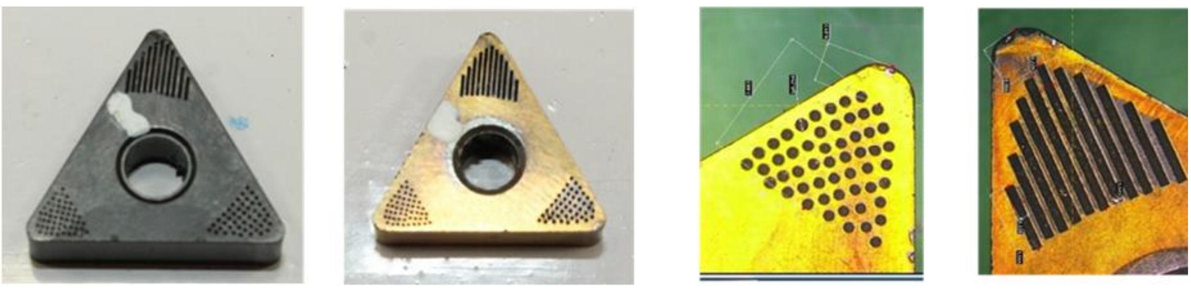

Fig 3 Surface textured coated tools

Table 3 Insert Specification

Type	Turning Insert
Material	Carbide,TiN&TiALN
Item Code	TNMA 160408
Shape	Triangle
Length	16.5mm
Thickness	4.76mm
Corner Radius	0.8mm
Number of cutting edges	6
Coating Process	PVD
Hardness for Carbide Insert	600HV
Hardness for TiN Insert	1880HV
Hardness for TiALN Insert	1905HV

Table 4 Machining Operation

Description	Unit	LL20T L5
Maximum Turning diameter	mm	320
Maximum Chuck dia	mm	200
Spindle Speed	rpm	3500
Number of stations	nos	8
CNC System controller	-	FANUC
Cross travel X-axis	mm	185
Longitudinal travel Z-axis	mm	560
Machine weight	kg	3700

Totally 6 OHNS rods were turned at the diameter of 70mm to 45mm for the length of 100mm.

RESULTS AND DISCUSSIONS

Table 5 Machining parameters

Parameters	Trial 1	Trial 2	Trial 3
Speed (RPM)	570	1140	1300
Feed(mm/rev)	0.05	0.10	0.15
Depth of Cut (mm)	1	1	1
Cycle Time (min & Sec)	19.51s	6.09s	3.40s

Totally 3 trails were performed with different parameters and the specifications were tabulated.

TOOL WEAR MEASUREMENT:

Tool wear was measured using Vision Measurement system. It consists of a projector, Camera, Work table which can rotate up to 360 degree. The tool can be hold on the work table. The projector which passes the light on the tool wear of the part and the 200X camera magnifies the tool wear portion to the bigger image in the screen of the desktop. The accuracy of the measurement is 4 microns, and here tool wear was measured using the software VMS 3.1 in an accurate manner. The machine specification and the tool wear for the different inserts were given below.

Table 6 Vision Measurement system machine specification

Make	OLM 3020
Overall dimensions	766 x 803 x 1015mm
Effective measuring size	300 x 200 x 200mm
Camera	1/3"high resolution colour CCD Camera
Software used	VMS3.1
Working Environment	20°C ± 2K
Magnification	Manual Zoom(30x to 180x)

TOOL WEAR RATE

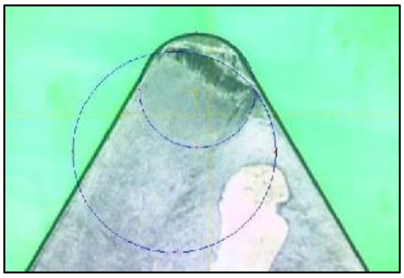

Fig 4 Carbide

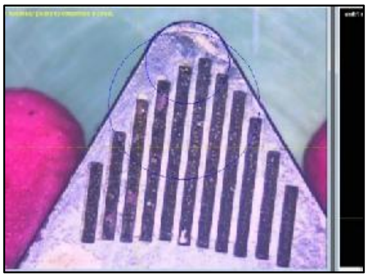

Fig 5 Carbide Texturing

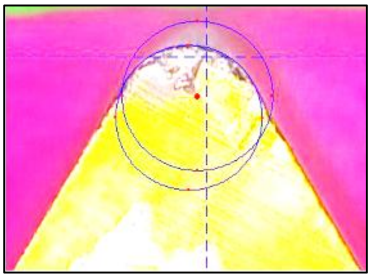

Fig 6 TiN

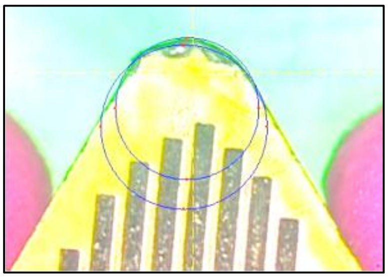

Fig 7 TiN Texturing

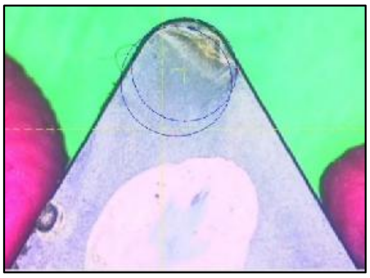

Fig 8 TiAlN

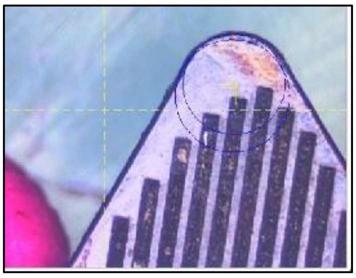

Fig 9 TiAlN Texturing

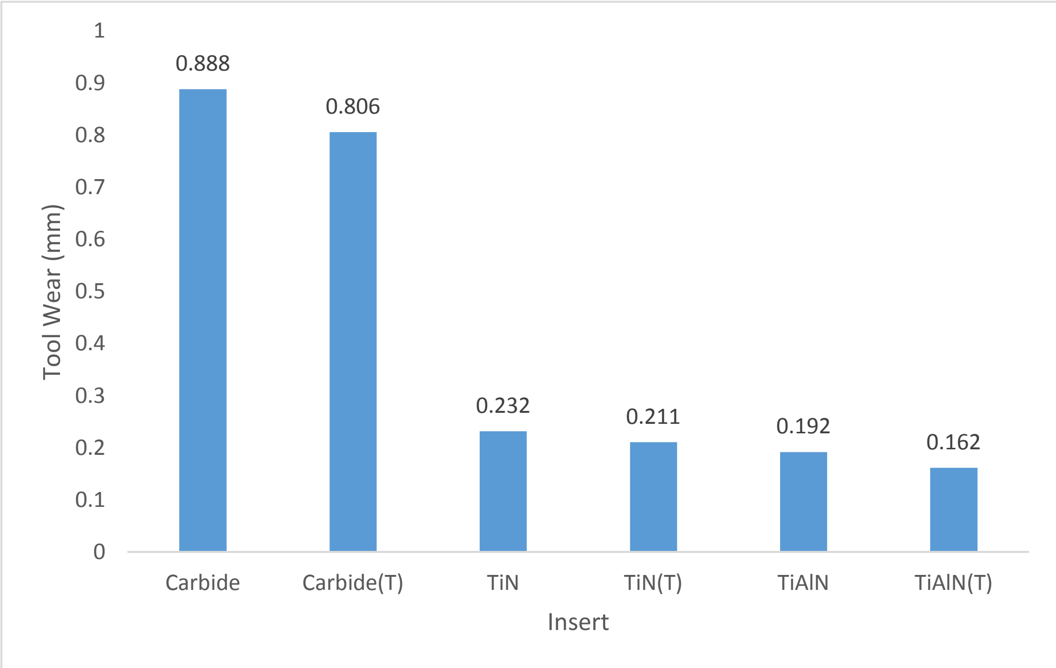

Fig 10 Tool wear of different Inserts.

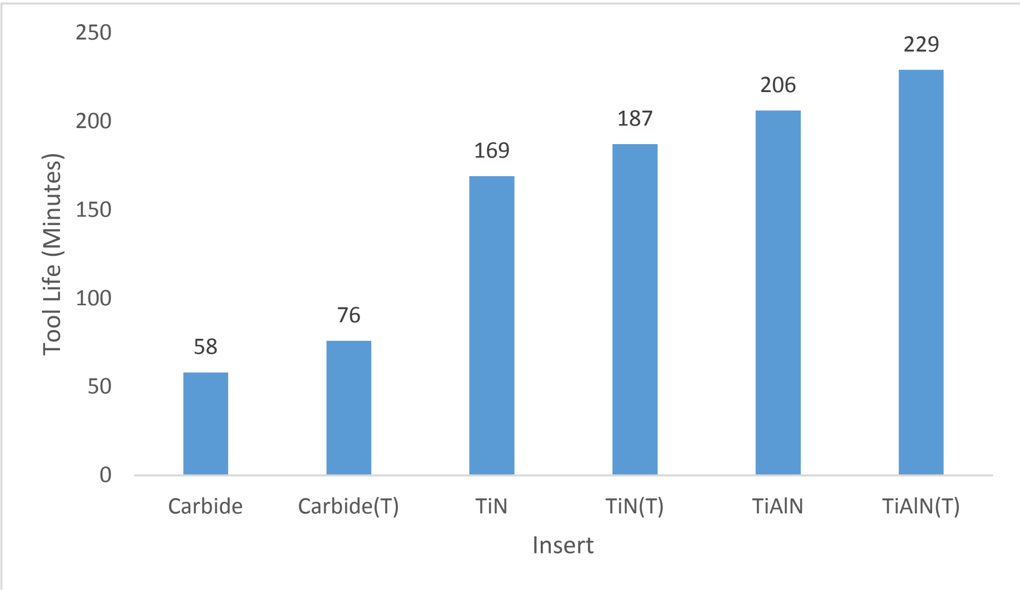

Fig 10 Tool Life of the Inserts

CUTTING FORCE ANALYSIS RESULTS

The forces acting on the cutting tool was measured using lathe tool dynamometer. The horizontal force(Ft) and vertical force (Fx) acting on the tool were measured.

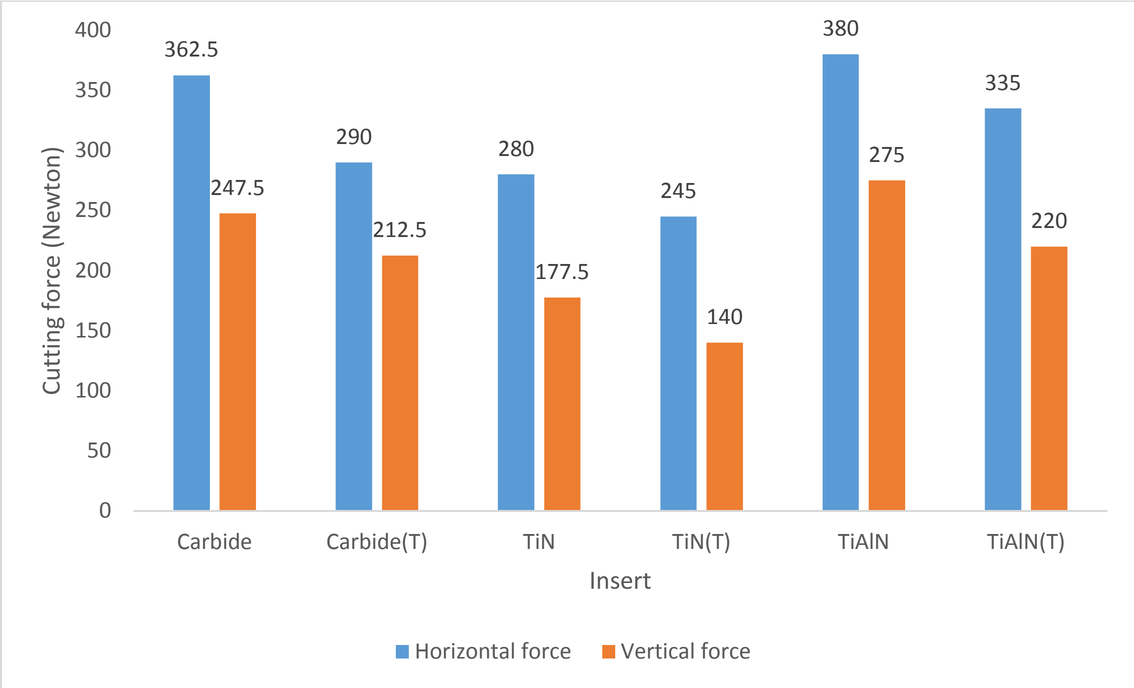

Fig 11 Cutting Force Analysis

CHEMICAL COMPOSITION OFTiAlN &TiN :

The chemical composition of the different coated carbide inserts were analyzed using XRF analyzer. XRF Analyzer means X-ray fluorescence Analyzer. It consists of the two components named as X-ray source and detector.The sample which can be examined located on the table. And the XRF analyzer passes the X-Rays on the sample. The rays hit the atoms in the sample which can be reacted and generate reacted x-rays, and the reacted X-Rays are collected by the detector. It can be analyzed by the analyzer which can be intensity peaks vs energy. The peak energy identifies the element and its peak area gives the composition of the sample.

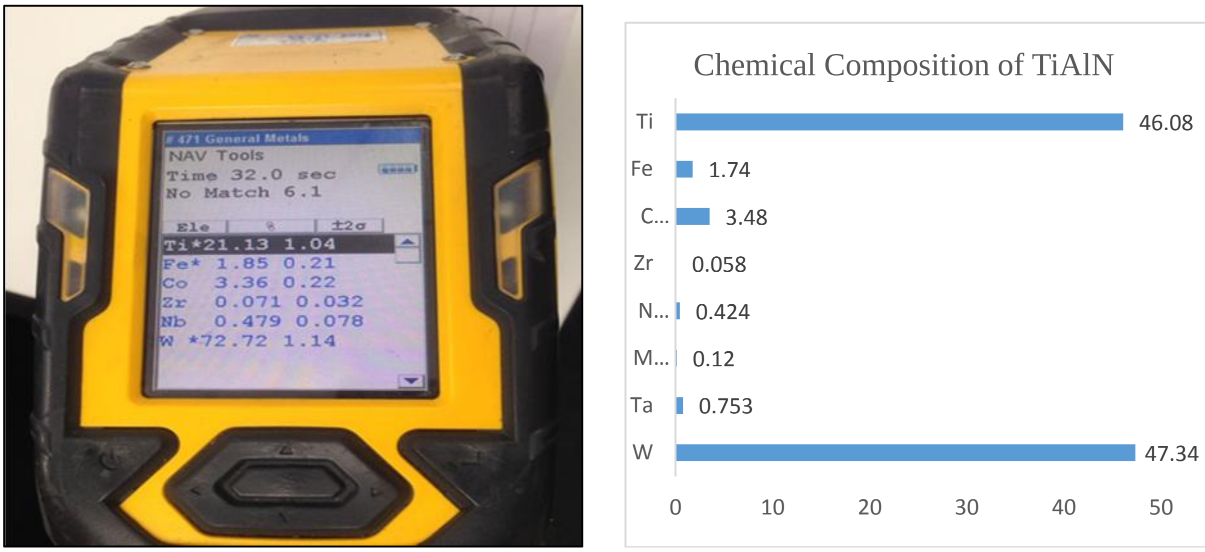

Fig 11 Chemical Composition ofTiAlN & TiN

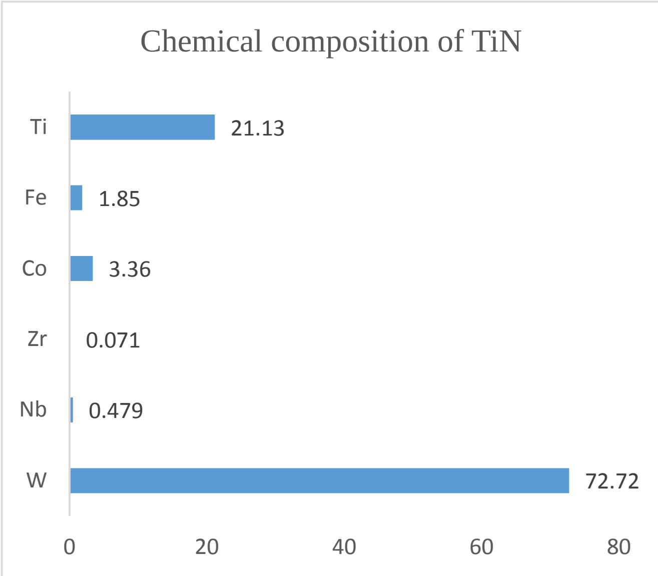

Fig 12Chemical Composition of TiN

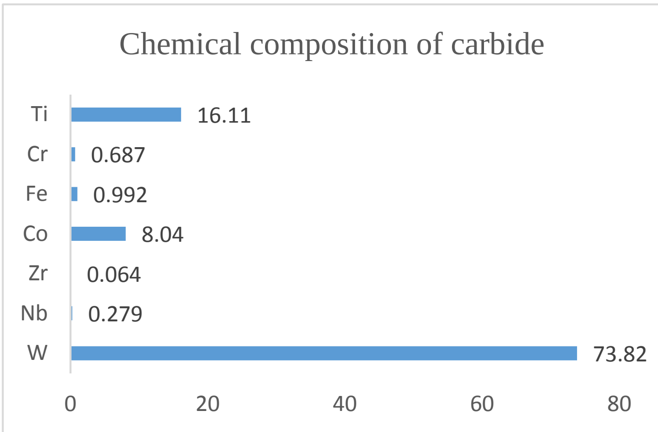

Fig 12Chemical Composition of Carbide

SURFACE ROUGHNESS TEST RESULTS:

Surface roughness was measured using profilo meter with the following specification. It consists of two units named as tracer and amplifier. Tracer is moved on the surface to be tested. When the tracer is moved across the surface, it will move up and down due to surface irregularities. This induces the voltage which will be amplified and recorded.

Table 7 Profilometer specification

Model No	SJ 210
Make	Mitutoyo
Display Unit	Compact Unit
Stylus tip radius	2µm

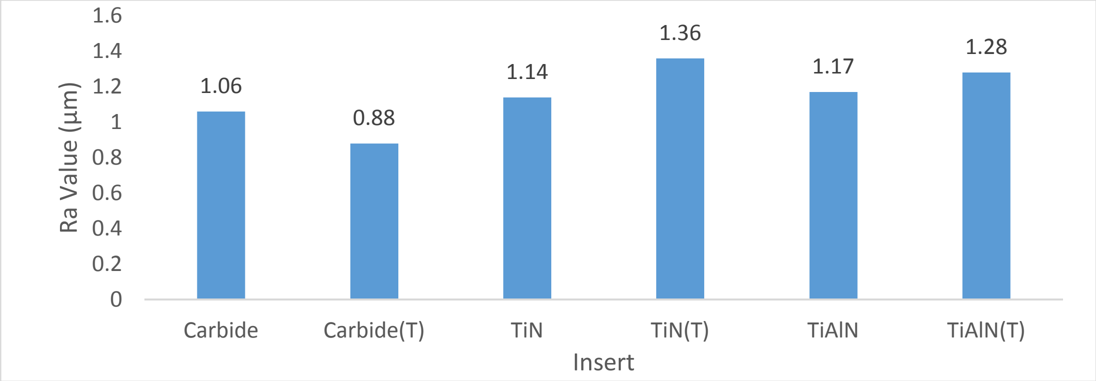

Fig 13Surface Roughness of Different Machined Work Piece

CONCLUSION

From the analysis, the following results were obtained:

- For the results of tool life & Tool Wear, TiAlN, TiN Coatings gave the better tool life compared to Carbide.
- During machining, Titanium Nitride combined with the oxygen to form Titanium Oxide & Titanium Aluminium Nitride combined with the oxygen to form Titanium Oxide & Aluminium Oxide
- For the results of the surface roughness, Carbide & Titanium Aluminium Nitride gave the better surface finish compared to Titanium Nitride.
- The reason behind that why TiN gives low surface finish is, while machining Titanium Aluminium Nitride heat was dissipated with the chip. But in the case of Titanium Nitride, heat was dissipated in the tool itself.
- Titanium Aluminium Nitride, Titanium Nitride Inserts gave Better tool life with average Surface finish.
- Titanium Aluminium Nitride(T), Titanium Nitride(T) inserts gave best tool life with average Surface finish
- Carbide, Carbide (T) gave lower tool life with good Surface finish than TiN & TiAlN.

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