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Analysis of Tool Geometry on Cutting Tool during Turning of EN 24 Mild Steel

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Abstract

In this work the experimental investigation has been done on coated carbide insert for reducing the tool wear through the change of nose radius. The factors influencing the tool wear and ways of reducing it during machining of mild steel is analysed in this paper. Tool coating is one among the techniques used for reducing tool wear. The present work is focused on comparision of the coated and uncoated tools on tool wear while machining. The effect of cutting tool geometry is an issue in understanding the mechanics of turning. The tool nose radius is the major factor of tool wear, material removal rate, and cutting time. The experiments are conducted on Computer Numerical Control (CNC) lathe using multilayer (Al_2O_3/TiCN/TiN) coated and uncoated carbide insert. The input factors are cutting speed, feed rate and depth of cut, and the output factors are flank wear,crater wear and the tool wear is measured based on the various nose radius which are to be considered for tool wear.

Keywords: Tool wear, CNC Machining, Mild Steel, Tool Coating, Tool

1. INTRODUCTION

In manufacturing industries, turning operation is a material removal process. Analysis of machining parameters is of great concern in a manufacturing environment, where economy of machining operation plays a key role in the competitiveness in the market (Vereschaka A.A., et.al (2014), Navneet K Prajapati, et.al (2012)). Turning is the removal of metal from the outer diameter of a rotating cylindrical workpiece. Turning is used to reduce the diameter of the workpiece, usually to a specified dimension, and to produce a smooth finish on the metal. Often the workpiece will be turned so that adjacent sections have different diameters. Turning is the machining operation that produces cylindrical parts (Dogra M., et.al, (2011)).

Tool wear is one of the most important issues in machining, which is substantially influenced by the machining environment for giving cutting tool insert and machining parameters such as cutting speed, feed rate and depth of cut (Dogra M., et.al, (2011)). Tool life is an important criterion for tool materials selection. It is essential to consider the tool wear in machining difficult to cut materials (Yuan Yuefeng, et.al, (2010)). The interaction of all these factors during a cutting operation causes a series of physical, chemical and thermo-mechanical phenomena that influence the wear of the tool (Vishal S., S.Sharma, et.al, (2008), Mihir T. Patel et.al,(2014), JakhalePrashant P, et.al,(2013)). EN24 steel is high tensile alloy steel, well known for its wear resistance properties and also where high strength properties are required (Matthew Grover, et.al, (2014)).

EN24 is used in components subject to high stress and with a large cross section. EN24 is used in components such as gears, shafts, studs and bolts.(S.A. Khana, et.al, (2012)).

Figure.1 shows the process in turning operation. (Dogra M., et.al, (2011)).

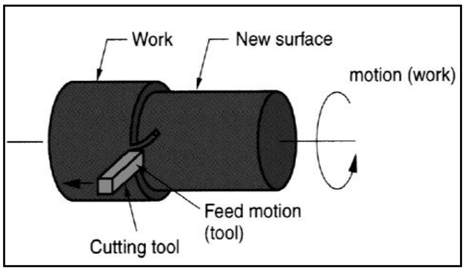

Figure 1 - CNC Turning Operation

The carbide tool, several types of edge preparation can be made for carbide tools, for hard turning operations, including sharp edge, chamfers, hones, and chamfers plus edge hones (Viktor P. Astakhov, et.al, (2004)).The tool wears considered are flank wear and crater wear. Flank wear is the most significant type of tool wear because of its impact and influence on tool life as well the ease of measurement. The width of the flank wear land is a suitable tool wear measure and a predetermined value of flank wear is regarded as a good tool-life criterion. Progressive flank wear is measured at the end of each cut using tool maker's microscope ((Vereschakaa A.A.,et.al (2014)). The objective of this research is to study the effect of cutting speed, feed, and depth of cut, on metal removal rate, and flank wear, crater wear. The turning operation is selected with the various work material and tool combination while machining EN 24 steels with uncoated carbide insert as the cutting tool (Vereschakaa A.A.,et.al (2014). Machining operations are used to produce a desired shape and size by removing excess stock from a blank in the form of chips. New surfaces are generated through a process of plastic deformation and crack propagation (Dogra M., et.al, (2011)).The machining experiments were conducted on all geared lathe using coated cement tool inserts with two levels of factors. The factors considered were cutting speed, workpiece mild steel orientation angle, depth of cut and feed rate(Yuan Yuefeng, et.al, (2010)). Mild Steel is one of the most common of all metals and one of the least expensive steels used. It is to be found in almost every product created from metal. It is weldable, very durable (although it is popular); it is relatively hard and is easily annealed (P. Kulandaivelu, et.al ,(2012)). EN24 is a very popular grade of through-hardening medium carbon steel, which is readily machinable in any condition (R. A. Patil1, et.al ,(2013)). EN24 is suitable for the manufacture of parts such as general-purpose axles and shafts, gears, bolts and studs. It can be further surface-hardened typically to 50-55 HRC by induction processes, producing components with enhanced wear resistance (JaroslavaFulemova, et.al,(2014)).

EN24 steel using single insert cutter under different sets of cutting parameters is machined. The coated carbide turning tool has a high elastic modulus. This leads to the more efficient turning of work material as compared to the tool material (Vishal S., S.Sharma, et.al, (2008)). Tool Materials are Carbon steel, High speed steels, Cast Cobalt alloy, Carbides (Tungsten carbide & titanium carbide), Carbide tool with CVD &PVD, Silicon Nitride, Cubic Boron Nitride (CBN) and Diamond (Jaharah A. Ghani, et.al,(2010)).

The effect of cutting tool geometry has long been an issue in understanding mechanics of turning. Tool geometry has significant influence on chip formation, heat generation, tool wear, surface finish and surface integrity during turning. A review study on variation in tool geometry i.e. tool nose radius, rake angle, groove on the rake face, variable edge geometry, wiper geometry and curvilinear edge tools and their effect on tool wear, surface roughness and surface integrity of the machined surface is already done. (Viktor P. Astakhov, et.al,(2004)). Nose radius is a major factor that affects surface finish of the machined surface. A larger nose radius produces a smoother surface at lower feed rates and a higher cutting speed. Large nose radius tools have, along the whole cutting period, slightly better surface finish than small nose radius tools, (JaroslavaFulemova, et.al,(2014)).

Tool life based on flank wear increases with increase in nose radius. However it reaches a constant at nose radius greater than 0.4 mm. On the other hand, tool life based on surface finish shows a local maximum at 0.8 mm nose radius. It was suggested that large nose radii result in severe groove wear, and therefore, poor surface finish. Other than surface finish aspects, tool nose radius also affects uncut chip geometry, and thus, ratio of uncut chip thickness to edge radius that may affect flowing forces in the hard turning process (JaroslavaFulemova, et.al,(2014)). Tool life is the most important practical consideration while selecting the cutting tools and cutting condition. If the tool wear takes place slowly there will be a low cost as well as it will produce predicable tolerances and surface finishes. An understanding of tool life required an understanding of the ways in which tool fail (A.K. Dutta a,et.al,(2006),JaroslavaFulemova, et.al,(2014)).

Factors affecting the tool wear whenever two machined surfaces come in contact with one another the quality of the mating parts plays an important role in the performance and wear of the mating parts. The height, shape, arrangement and direction of these surface irregularities on the workpiece depend upon a number of factors such as,the machining variables which include, Cutting speed, Feed, and Depth of cut. The tool geometry factors which affect achieved Surface finish includes Nose radius, Rake angle, Side cutting edge angle, Cutting edge. If the quality tool is used the lubrication and vibration will be reduced. (Navneet K Prajapati,et.al,(2012)).

Coated tools have compound material structure, consisting of the substrate covered with a hard, anti-friction chemically inert and thermal isolating layer. As such coated tools compared to uncoated ones, offer better protection and improved wear resistance (Navneet K Prajapati,et.al,(2012)). The surface operations of machining may be affected by several parameters i.e. Geometry of selected cutting tool, coating method, type of material and cutting parameters etc (JakhalePrashant P, et.al,(2013)). Tool wear in machining is defined as the amount of volume loss of tool material on the contact surface due to the interactions between the tool and workpiece. Specifically, tool wear is described by wear rate (volume loss per unit area per unit time) and is strongly determined by temperature, stresses, and relative sliding velocity generated at the contact interface. Mechanical wear is resulted by abrasion and adhesion. The flank wear formation is a serious problem in machining of materials irrespective of their condition (Vishal S.,et.al,(2008), Navneet K Prajapati,et.al,(2012)).

The wear condition depends upon the work material properties and qualities, their alloying elements, condition at which it is being machined (soft or hard condition), operating parameters, types of tool and machine stabilities (Dogra M., et.al, (2011),Vishal S.,et.al,(2008)). Tool wear rate is the rate at which the cutting edge of a tool wears away during machining (Vishal S.,et.al,(2008)). Cutting tool wear is the result of load, friction, and high temperature between the cutting edge and the workpiece. Several wear mechanisms occur during metal cutting: adhesive wear, abrasive wear, diffusion wear, oxidation wear,and fatigue wear (Jaroslava Fulemova, et.al,(2014)).The tool wear is a result of mechanical and chemical interactions of the tool with the workpiece and can be written as Flank wear appears in the form of so-called wear land and is measured by the width of this wear land, VB, Flank wear affects to the great extend the mechanics of cutting (Vishal S., S.Sharma, et.al, (2008). Crater wear affects the mechanics of the process increasing the actual rake angle of the cutting tool and consequently, making cutting easier. At the same time, the crater wear weakens the tool wedge and increases the possibility for tool breakage (Navneet K Prajapati,et.al,(2012)).

The coatings of TiN + AlTiN, TiN + AlTiN + MoS_2, and CrN + CrN:C + C were applied by PVD techniques on WC-Co inserts developing nanostructured layers. Coatings surface qualification included SEM observation with EDS analysis, ball erosion test, Nano indentation, and scratch test [6]. Advanced coating technology has significantly improved the tool life expectancy. Titanium Nitride (TiN), Titanium Carbo-Nitride (TiCN), Titanium Aluminum Nitride (TiAlN or AlTiN), Chromium Nitride (CrN), and Diamond coatings can increase overall tool life, decrease cycle time, and promote better surface finish (R. A. Patil1, et.al ,(2013)).

Red Hardness or Hot Hardness– It is the ability of a material to retain its hardness at high temperature. Toughness relates to the ability of a material to resist shock or impact loads associated with interrupted cuts. Wear resistance enables the cutting tool to retain its shape and cutting efficiency. Other properties are thermal conductivity, specific heat, Hardenability etc. (Gopal Krishna, P,et.al,(2012). Chemical Vapour Deposition (CVD) method deposits thin films on the cutting tools through various chemical reactions. CVD coated cemented carbides have been a huge success, chemical vapour deposition technologies have advanced from single layer to multilayer versions combining TiN, TiCN, TiC and Al_2O_3. Modern CVD coatings combine high temperature and medium temperature processes in complex cycles that produce excellent wear resistant coatings with a total thickness of 4-20 μm (Viktor P. Astakhov, et.al,(2004)).

2. MATERIALS

2.1.Work material

The turning operation is selected with the various work material and tool combination while machining EN 24 steels with coated carbide insert. Machining test is performed on an EN 24 shaft having Diameter 32 mm (Navneet K Prajapati,et.al,(2012)).

EN24 is a high quality, high tensile, alloy steel and it finds its typical applications in the manufacturing of automobile and machine tool parts (Mihir T. Patel et.al,(2014)). Properties of EN24 steel, like low specific heat, and tendency to strain-harden and diffuse between tool and work material, give rise to certain problems in its machining such as large cutting forces, high cutting tool temperatures, poor surface finish and built-up edge formation (Gopal Krishna, P,et.al,(2012). It is observed for EN24 Alloy Steel in CNC turning by the use of different cutting tool geometry (Navneet K Prajapati,et.al,(2012)).

The present research the effects of cutting speed, feed rate, depth of cut, nose radius and cutting environment in lathe turning of mild steel tool. As per the literature survey EN24 is chosen as the workpiece material whose dimension is 32 mm diameter and length 160 mm using machining process. The chemical analysis has been carried out using the spark emission spectrometer. Chemical composition of EN24 is given in the Table.1.

Table 1- Chemical composition of EN24

Compound	Percentage
C	0.36 - 0.44
Si	0.10 - 0.35
Mn	0.45 - 0.70
S	0.04
P	0.035
Cr	1.00 - 1.40
Mo	0.20 - 0.35
Ni	1.30 - 1.70

Figure 2 - Mild Steel EN24

2.2 Tool Material

Coated carbide inserts are used for machining purposes to obtain good surface finish (Vereschakaa A.A.,et.al (2014)). The coated carbide single point cutting tool used is of SANDVIK make. This selection of tool bit depends on many factors like workpiece hardness and tool life required and the operating conditions etc. (Vishal S.,et.al,(2008). The selected uncoated inserts CNMG 120404 SMH13A,coated insert in CNMG 120412 PM4325,Coating reduce the tool wear. Fig.3 and fig.4, show coated and un coated carbide insert.

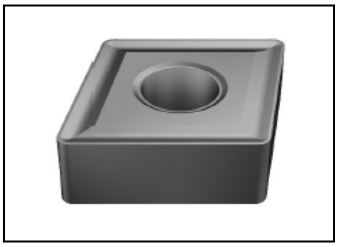

Figure 3 - Uncoated carbide insert

Table 2 - Coated and Uncoated tool specification at 0.4 mm,1.2 mm Nose Radius

Tool	Uncoated Insert		Coated Insert	
Tool style code	CNMG		CNMG	
Insert seat size (mm)	12		12	
Nose radius (mm)	0.4	1.2	0.4	1.2
Coating	UNCOATED		COATED(TiN/Al2 O3/TiCN)	
Grade	H13A		PM4325	
Insert thickness (mm)	4.7625		4.7625	
Dimension (mm)	12X04X04		12X04X04	

Table 3 - Tool holder specification

Description	Dimension
Insert seat size code	12
Adaptive interface machine direction	(Rectangular shank metric) 25 x 25
Connection size code	25 x 25
Tool cutting edge angle (degree)	95
Tool lead angle (degree)	5
Maximum ramping angle(degree)	0
Maximum overhang (mm)	27.2
Functional length (mm)	150
Functional width (mm)	32
Functional height (mm)	25
Weight of item (kg)	0.751

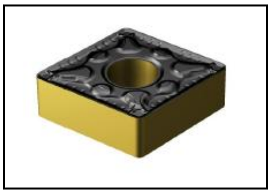

Figure 4 - Coated carbide insert

Figure 5 - Tool holder

The details of tool holder are shown in Fig.5. It is used for machining on PCLNR 2525M 12. Table.3 shows the specification of tool holder. The tool material used for experimental investigation is carbide insert having three pieces of specification CNMG120404.

3. TOOL GEOMETRY

The effect of cutting tool geometry is an issue of mechanics of turning. Tool geometry has significant influence on chip formation, heat generation, tool wear, surface finish and surface integrity during turning. This article presents a survey on variation in tool geometry tool nose radius, rake angle, groove on the rake face, variable edge geometry, wiper geometry and curvilinear edge tools and their effect on tool wear, surface roughness and surface integrity of the machined surface (Viktor P. Astakhov, et.al,(2004)).

Nose radius is a major factor that affects surface finish of the machined surface. A larger nose radius produces a smoother surface at lower feed rates and a higher cutting speed. Large nose radius tools have, along the whole cutting period, slightly better surface finish than small nose radius tools (Viktor P. Astakhov, et.al,(2004)). Nose radius is a major factor that affects surface roughness. A larger nose radius produces a smoother surface at lower feed rates and a higher cutting speed. However, a larger nose radius reduces damping at higher cutting speeds, there by contributing to a rougher surface. The effect of the nose radius on the residual stress distribution decreases greatly with the increase of the tool wear (Viktor P. Astakhov, et.al,(2004)).

As with decreasing uncut chip thickness to edge radius ratio friction factor increases. Further the effect of variable micro-geometry design should be explored with respect to surface integrity i.e. its impact on residual stresses, white layer formation and micro-hardness variation beneath the machined surface (Viktor P. Astakhov, et.al,(2004)). The main plastic deformation takes place due to shear energy in the shear zone. Considering a continuous type chip, as the cutting speed increases for a given rate of feed, the chip thickness decreases and less shear energy is required for chip deformation so the chip is heated less from this deformation (S.A. Khana, et.al,(2012)). The chip-tool interface zone, where secondary plastic deformation due to friction between the heated chip and tool takes place. This causes a further rise in the temperature of the chip. This chip-tool interface contributes 15-20% of heat generated (S.A. Khana, et.al,(2012)). Tool wear on the tool-chip and tool-workpiece interfaces (i.e. flank wear and crater wear) are strongly influenced by the cutting parameters, cutting temperature, tool geometry, tool material, workpiece material, etc. (D. Biermanna,et.al,2011)). The tool nose radius is a main factor based on the survey. This paper compares the tool wear of nose radius 0. 4 mm and 1.2 mm .If nose radius is minimum the flank wear is also minimum. It is shown in fig.6.

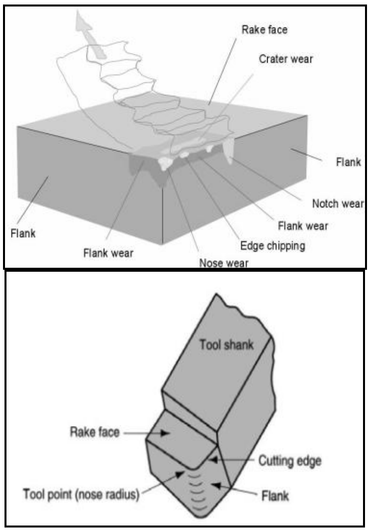

Figure 6 - Tool Geometry

3.1. Tool Wear

F.W. Taylor (1850–1915) has done a great deal of research about tool wear, and it is a widely studied phenomenon. However, the development of new kinds of tools and new materials has expanded the experimental field. This has resulted in a renewed interest in the study of the phenomena of wear. The wear can be defined as the loss of material from the cutting edge due to mechanical or chemical factors associated with the cutting process (S.A. Khana, et.al,(2012)).

Flank wear is the more significant type of tool wear because of its impact and influence of tool life as well as the ease of measurement. The width of the flank wear land is a suitable tool wear measure, and a predetermined value of flank wear is regarded as a good tool-life criterion (Yuan Yuefeng,t.al,(2010)). Tool wear in machining is defined as the amount of volume loss of tool material on the contact surface due to the interactions between the tool and workpiece. Specifically, tool wear is described by wear rate (volume loss per unit area per unit time) and is strongly determined by temperature, stresses, and relative sliding velocity generated at the contact interface (Dogra M., et.al, (2011)). It is common to assume that all the energy used in cutting is converted into to heat (a reasonable assumption) and that 80% of this is carried away in the chip (this will vary and depend upon several factors - particularly the cutting speed). This leaves about 20% of the heat generated going into the cutting tool. During operation, one or more of the following wear modes may occur: Flank, Notch, Crater, Edge rounding, Edge chipping, Edge cracking, Catastrophic failure. Cutting tools are subjected to an extremely severe rubbing process. They are in metal-to metal contact between the chip and workpiece, under conditions of very high stress at high temperature.

Flank wear (Clearance Surface) wear on the flank (relief) face is called flank wear and results in the formation of a wear land. Wear land formation is not always uniform along the major and minor cutting edges of the tool. Flank wear most commonly results from abrasive wear of the cutting edge against the machined surface. Flank wear can be monitored in production by examining the tool or by tracking the change in size of the tool or machined part. Flank wear can be measured by using the average and maximum wear land size VB and VBmax (JaroslavaFulemova,et.al,(2014),D.Biermanna,et.al,2011)).

Crater wear is the chip flow across the rake face, resulting in severe friction between the chip and rake face, and leaves a scar on the rake face which usually parallels to the major cutting edge. The crater wear can increase the working rake angle and reduce the cutting force, but it will also weaken the strength of the cutting edge. The crater depth KT is the most commonly used parameter in evaluating the rake face wear (Dogra M., et.al, (2011), D. Biermanna,et.al,2011).

Cutting tool will experience severe cutting condition such as: metal to metal contact with workpiece and chip, high stress, high temperature, high temperature gradients, high stress gradient (D. Biermanna,et.al,(2011)).

In order to find out suitable way to slow down the wear process, many research works are carried out to analyse the wear mechanism in metal cutting. It is found that tool wear is not formed by a unique tool wear mechanism but a combination of several tool wear mechanisms (D. Biermanna,et.al,2011)). Abrasive wear is mainly caused by the impurities within the workpiece material, such as carbon, nitride and oxide compounds, as well as the built-up fragments. This is a mechanical wear, and it is the main cause of the tool wear at low cutting speed (JaroslavaFulemova, et.al,(2014)).

The simple mechanism of friction and wear proposed by Bowden and Tabor is based on the concept of the formation of welded junctions and subsequent destruction of these. Due to the high pressure and temperature, welding occurs between the fresh surface of the chip and rake face because of the chip flowing on the rake face results in chemically clean surface. Severe wear is characterized by considerable welding and tearing of the softer rubbing surface at high wear rate, and the formation of relatively large wear particles. Adhesion wear occurs mainly at low machining temperatures on tool rake face, such built up edge (BUE). Under mild wear conditions, the surface finish of the sliding surfaces improves.(D. Biermanna,et.al,2011)).

Diffusion wear is a process of atomic transfer at contacting asperities. Oxidation wear occur at high temperature and the presence of air means oxidation for most metals. A slight oxidation of tool face is helpful to reduce the tool wear. It reduces adhesion, diffusion and current by isolating the tool and the workpiece. But at high temperature soft oxide layers, for example WO$_3$, TiO$_2$, are formed rapidly, and then taken away by the chip and the workpiece. This results in a rapid tool material loss, which is oxidation wear (D. Biermanna,et.al,2011)).

The tool wear is measured on tool maker microscope. It is high precision instrument. It is single and multiple objective lens which magnifies the object under observation and by the help of eyepiece lens the object is focused and viewed. The image of tool maker microscope is shown in fig.7 and the specification, is shown in Table.5

Figure 7 - Tool Maker Microscope

Table 4 - Detailed specifications of Tool maker microscope

Description	Dimension
Optical Head	MM200 Monocular Optical Head or CMount Video Head for MM200
XYZ Stroke	50mm X 50mm X 110mm
Stage Accuracy	2.5 + L/50 µm (with LEC), 3 + L/50 µm (L=Measurement Length in mm)
Scale Resolution	0.01/0.1(default)/1/10 µm
Max. Loading Weight	2 kg for Guaranteed Accuracy / 5 kg for Operation
Magnification Accuracy	0.1%
Objective Lenses (W.D.)	Standard: 3x (75.5mm) Optional 1x (79mm), 5x (64mm), 10x (48mm)
Light Sources	Standard: Diascopic/Episcopic (White LED), Optional: 8Segmented Ring Light (White LED)
Dimension & Weight	316 x 455 x 533 (W x D x H), 40 kg
Input Voltage Range	100 240 V (Max. 1.8 A)

4. TOOL COATING

TiN coating increases the wear resistance, and reduces the sticking of the work material. The golden color of the TiN coating helps in wear detection by allowing the operator to distinguish between a used and a new cutting edge corner (Gopal Krishna, P,et.al,(2012), JakhalePrashant P,et.al,(2013)). Mostly carbide tools are processed by Physical Vapour Deposition (PVD) and Chemical Vapour Deposition (CVD) so as to from a coating of material with properties like higher wear resistance and thermal shocks. Titanium based hard thin films are mostly used due to higher wear resistance, thermal shocks and corrosion property and also impart lubricity at the chip tool interface to reduce friction, (Jakhale Prashant P,et.al,(2013)).Titanium Nitride (TiN) has been used in the coating of tool steels since the mid-sixties. The reasons to coat cutting tools in a production situation are to increase tool life, to improve the surface quality of the product, and to increase the production rate. The advantages of TiN coating include high hardness, good ductility, excellent lubricity, high chemical stability and tough resistance to wear, corrosion and temperature (R. A. Patil1, et.al ,(2013)).

TiN, CrN, TiAlN and CrAlN coatings were deposited by vacuum arc. Their thermal stability and oxidation resistance were investigated after annealing in air at different temperatures (500°C-1000°C). TiAlN and CrAlN showed better oxidation resistance than their binary counter parts TiN and CrN. Cr-based coatings exhibited much better oxidation resistance than Ti-based coatings (R. A. Patil1, et.al ,(2013)).

It is generally accepted by industry that popular TiN and Ti (C,N) coatings are now under increasing competition from TiAlN, TiAlCrN and more complex coatings based on TiN/TiAlN and or TiAlCrYN. These coatings are claimed firstly to increase the tool life due to improved tool wear resistance, and secondly to reduce the forces, power and tool temperature due to improved tool surface roughness and its resistance to built-up-edge formation and reduced friction at the tool-chip interface (R. A. Patil1, et.al ,(2013)). Carbon strengthens the lattices of the basic coating TiN, increases the internal stress level and therefore the hardness, reduces the friction coefficient, but only up to 400°C. The TiCN coating is still the most popular coating for taps but is not adequate for dry and high-speed cutting (Jaharah A. Ghani, et.al,(2010)).

The CVD coating is excellent adhesion with high wear performance and good resistance to diffusionwear, and plastic deformation at high temperatures (Jaroslava Fulemova, et.al,(2014)). Also reduces friction and hence the formation of built-up-edges.GC4025 has a thick layer of Al_2O_3 on top of a medium sized TiCN layer. A thin TiN outerlayer gives the grade a yellow colour for easy wear detection. The total thickness of this CVD coating is approx. 12 µm. The substrateis rather hard but has a large gradient zonethat brings toughness and better edge line behaviour to the grade. The combination of a thick wear resistant coating and a hard substrate with excellent edge security has made GC4025 very popular. It works extremely well in P25 applications but also in stainless steels and cast iron. Used in many different operations. Tool coating is reducing the wear (Y. Koren,(1978). In this paper it consists of a 9 µm CVD TiCN- Al2O3-TiN coating used on a substrate with a gradient zone close to the surface.

5. EXPERIMENTAL DETAILS

Combination at different frequencies until maximum flank wear width of 0.6 mm is reached for coated carbide insert. This can be a base for establishing the relationship between vibration, acceleration amplitude and flanks wear (Vereschakaa A.A.,et.al (2014)). Fig.8 shows the CNC Machine used and the Table.5 shows the specifications of machine.

Figure 8 - CNC machine

Table 5 – Properties of CNC machining

Description	Dimension
Main Specifications Sprint	25 TC
Swing over Bed (mm)	600
Turning Diameter(mm)	460
Turning Length (mm)	700
Power Chuck	250
Spindle Speed (Rpm)	35-3500
Spindle Motor (KW)	11 / 15
Z – axis Stroke (mm)	710
X – axis Stroke (mm)	260
Max. No. of Tools in Turret	12
Rapid Traverse (m/min)	20
Turning Length (mm)	1000 optional
Machine With C axis	Live tool turret optional

Optimal machining parameters for minimum surface roughness are determined. The percentage of error between experimental and predicted result is 8.69% and 8.49% in turning and facing process respectively (JakhalePrashant P,et.al,(2013),Gopal Krishna, P,et.al,(2012)). Feed has been found to be most significant parameter for the workpiece surface roughness (Ra) with a percent contribution of 52.55%. Cutting speed is found to be the next significant parameter for Ra with contribution of 25.85%. Depth of cut has a negligible influence incase of Ra (R. A. Patil,et.al,(2013),Matthew Grover,et.al,(2014)). The work-tool interface zone at flanks where frictional rubbing occurs.

This area contributes 1-3% of heat generated. As the portion of heat that flows into the tool cause very high temperature in vicinity of tool tip which in turn decrease the hardness of the tool material and in extreme case may even cause melting. The wear rate of tool therefore increases, resulting in a decrease in useful life of the tool. It is increasingly important to understand how machining temperature is affected by the process variable involved which is cutting speed, feed rate, and tool geometry (S.A. Khana,et.al,(2014),(D. Biermanna,et.al,2011)). The shear zone, where the main plastic deformation takes place due to shear energy. About 80-85% of the heat generated in shear zone. (S.A. Khana,et.al,(2014),(A.K. Dutta,et.al,(2006)). The chip-tool interface zone, where secondary plastic deformation due to friction between the heated chip and tool takes place. This causes a further rise in the temperature of the chip. This chip-tool interface contributes 15-20% of heat generated (S.A. Khana, et.al,(2012)). The experiments have been conducted on a sprint 25TC computer numerical control (CNC) turning machine using carbide tool inserts .

6. RESULTS & DISCUSSION

6.1. Effect of Flank wear at Nose Radius 0.4mm

The flank wear is directly proportional to the depth of cut. When comparing coated and uncoated tool, there is a reduction in flank wear of the coated tool due to the hardness and tool wear resistnce properties of the coating material (Al_2O_3/TiCN/TiN) and also the properties of absorbing high temperature. The difference between uncoated & coated flank wear is shown in Fig 9. From this it is very clear that the overall percentage of the flank wear is reduced for tool with a nose radius of 0.4 mm.

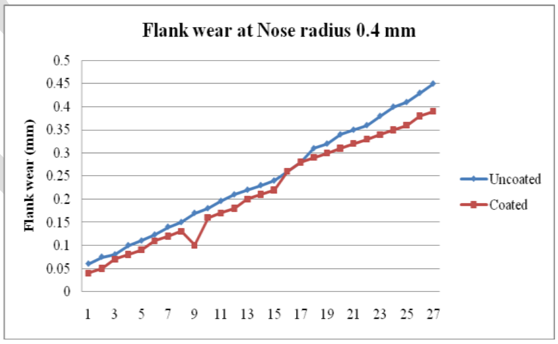

Figure 9 - Flank wear at Nose radius 0.4 mm

6.2. Effect of Flank wear at Nose Radius 0.8 mm

On comparing the coated & uncoated tool's flank wear, it is seen that the coated tool gives a reduced wear during the initial low speed operating conditions. The relation between uncoated & coated flank wear is shown in Fig 10. The reduction in wear is due to the property enhancement achieved by coating a layer of Al_2O_3/TiCN/TiN over the tool. However it seems to exhibit an increased flank wear during the high speed operating conditions. While using a tool with the nose radius of 0.8 mm, it is adviced to operate under low speed conditions for avoiding high flank wear.

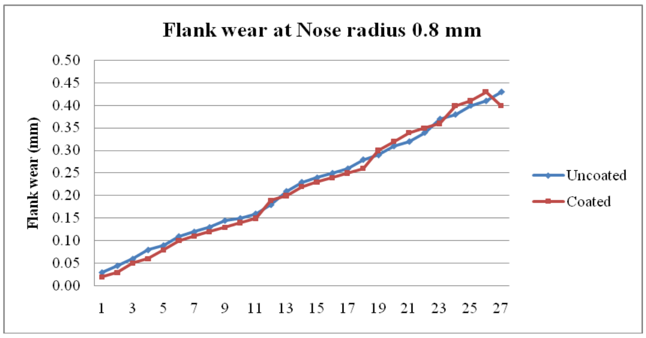

Figure 10- Flank wear at nose radius 0.8 mm

6.3. Effect of Flank wear at Nose Radius 1.2 mm

The relation between uncoated & coated tool flank wear is shown in Fig 11. The flank wear is directly proportional to the depth of cut. It is exhibited in the graph as the wear for coated tool increases at an operating condition with increased depth of cut. When comparing coated and uncoated tool, there is a redction in flank wear of the coated tool during turning at low speeds. From this it is very clear that the overall percentage of the flank wear is reduced for tool with a nose radius of 1.2 mm except for operating conditions with a combination of low feed rate and high depth of cut.

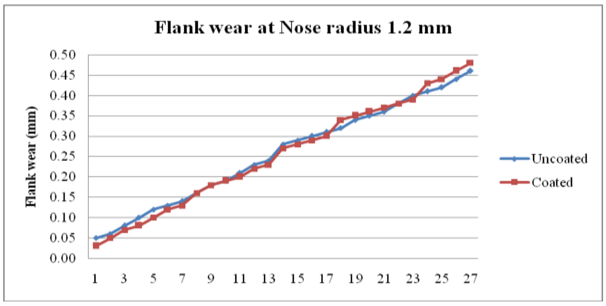

Figure11- Flank wear at nose radius 1.2 mm

6.4. Effect of Crater Wear at Nose Radius 0.4mm

The crater wear is directly proportional to the depth of cut. When comparing coated and uncoated tool, there is a reduction in crater wear of the coated tool due to the hardness and tool wear resistnce properties of the coating material (Al_2O_3/TiCN/TiN) and also the properties of absorbing high temperature. The realtion between uncoated & coated flank wear is shown in Fig 12. from this it is very clear that the overall percentage of the crater wear is reduced for coated tool with a nose radius of 0.4 mm.

6.5. Effect of crater wear at Nose Radius 0.8 mm

The relation between uncoated & coated tool crater wear is shown in Fig 13. While using a tool with the nose radius of 0.8 mm, it is adviced to operate under average speed conditions for avoiding high crater wear. However it seems to exhibit an increased crater wear during the low as well as high speed operating conditions. The coating of tool doesnot seem to have significant effect on crater wear of tool with a nose radius of 0.8 mm. On comparing the coated & uncoated tool's crater wear, it is seen that the coated tool gives a reduced wear during the initial average speed operating conditions.

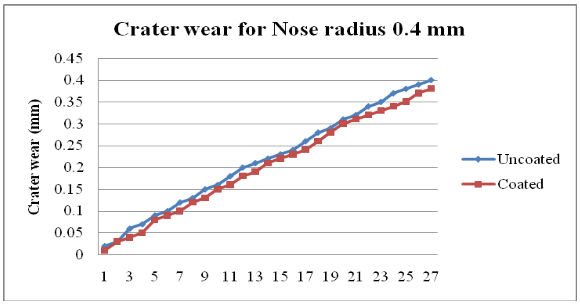

Figure 12 - Crater Wear at Nose radius 0.4mm

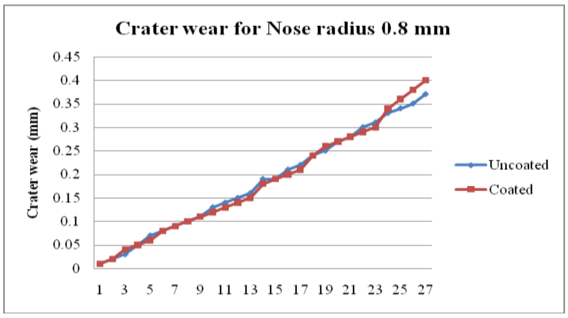

Figure 13 - Crater Wear at Nose radius 0.8 mm

6.6. Effect of crater wear at Nose Radius 1.2mm

The relation between uncoated & coated tool crater wear is shown in Fig 14. The crater wear is directly proportional to the depth of cut. It is exhibited in the graph as the wear for coated tool increases at an operating condition with high depth of cut and low feed. When comparing coated and uncoated tool, there is a redction in flank wear of the coated tool during turning with low depth of cut operations. The overall percentage of the flank wear is reduced for tool with a nose radius of 1.2 mm except for operating conditions with a combination of low feed rate and high depth of cut.

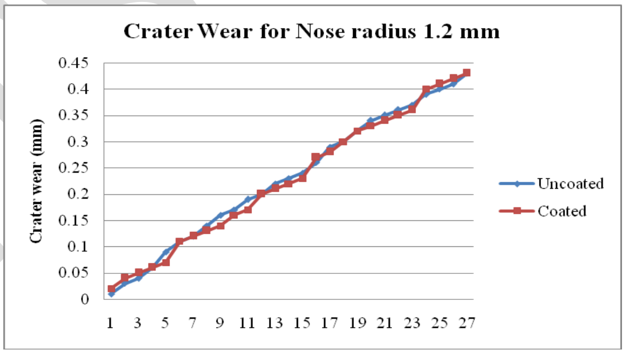

Figure 14 - Crater Wear at Nose radius 1.2 mm

7. CONCLUSIONS

The machining of mild steel using coated inserts is studied. The results of this work infer that the effect of tool coating dominates the tool wear as it reduces the flank and crater wear rates.

- The effect of tool coating causes to increase the hardness of cutting tool.
- The flank wear is considerably reduced for all operating conditions in the cutting tools having a nose radius of 0.4 mm.
- The flank wear of coated tool gets increased only at operating conditions with high speed and high depth of cut.
- The effect of cutting parameter (speed, feed, depth of cut) is directly proportional to crater wear.
- The overall crater wear is reduced for coated tool with a nose radius of 0.4 mm.
- The coated inserts are recommended for high production rates with low wear.

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