International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161

Available at http://inpressco.com/category/ijcet

Research Article

Development of Tools for Oblique cutting

Mohammed Hussein Faraj Albuzidi* and L . P. Singh

Mechanical Engineering Department, SHUATS, Allahabad, India

Received 10 Oct 2018, Accepted 12 Dec 2018, Available online 14 Dec, **Vol.8, No.6 (Nov/Dec 2018)**

Abstract

Advancement of Machining process depends solely on cutting tools and machine tools. New tools are being developed and tested, every other day. e.g. special tools for oblique cutting or mechatronics tools. Oblique cutting process uses special tools with continued cutting edge and high value of cutting angle, making new possibilities for research. These tools are characterized basically by single continued edge without the corner of the edge. Corner now have the task of current point of contact between the continuous cutting edge and the machined surface. Single edge tools have straight and circular edge. These tools are very useful for surface finishing. In this paper many new solution of cutting tools for oblique cutting both with straight and curvilinear cutting edge with high value of λs angle (60°) are presented. For analyzing the geometry of these tools CAD models are prepared. In this study, an experimental data in review of oblique cutting process is presented for Ti6Al4V, AISI 4340 and AL7075. Data of process parameters such as shear angle, friction angle, shear stress and chip flow angle are reviewed & analyzed.

Keywords: *turning; innovative tools; oblique cutting; straight cutting edge; curvilinear cutting edge*

1. Introduction

Cutting-edge advances are being made both in the way of cutting edge material improvement and in the improvement of cutting tool design, especially in the cutting edges.

Here is a desire to increase productivity and efficiency by intensifying existing methods and introducing qualitatively new methods based on, inter alia, changing the nature of the mechanical impact on the sliced layer. Examples of tools with rectilinear edges without corner were presented.

An additional advantage of single-edged tools is the possibility of increasing the tool life by periodically displacing the worn cutting edge portion by a fraction of the active length of the cutting edge section. In single-edged cutting, a *Ra* area of 0.32 to 1.25 μm is achieved at feeds from 0.2 to 0.4 mm/rev. The disadvantage of using these tools is to limit their use to free surfaces.

As single -edged tools are also used cutting edges in the form of a circular arc. They are used both in orthogonal and oblique cutting. The use of single -edged tools in sloped cutting provides a favorable surface finish characteristic. Was elaborated model of oblique cutting to predict the cutting forces, the chip flow direction, the contact length between the chip and the tool and the temperature distribution at the tool-chip interface which has an important effect on tool wear.

*Corresponding author's ORCID ID: 0000-0002-2879-6472
DOI: https://doi.org/10.14741/ijcet/v.8.6.16

Nomenclature

λ_s Main cutting edge angle [°]
γ_n Normal *r*ake angle [°]
α_n Normal Back angle [°]
r_ε Nose radius [mm]
R*zt*Surface roughness [μm]
f Feed [mm/rev]
d Workpiece diameter [mm]

2. Cutting Tool Geometry & Nomenclature
Single Point Cutting Tool

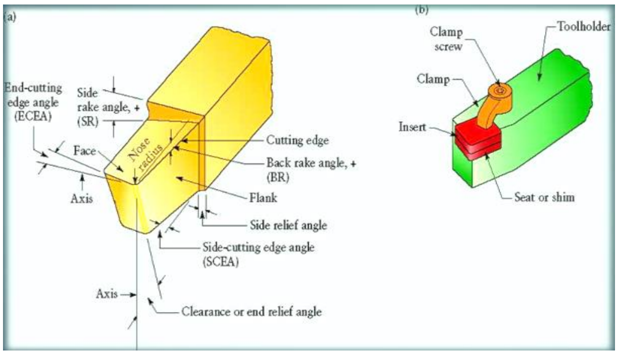


Fig.1 Cutting Tools Terminology

3. Tool Parts Nomenclature

Shank: The portion of tool bit which is not ground to form cutting edges and is rectangular in each portion.

Face: The surface against which chips slide upwards.
Base: Base of the tool is under side of the shank
Flank: The surface which face the work piece
Heel: The lower most portion of side cutting edges
Nose: It is the conjunction of side and end cutting edges. Nose radius increases the tool life and improves the surface finish
Rake: It is the slope of the top away from the cutting edges

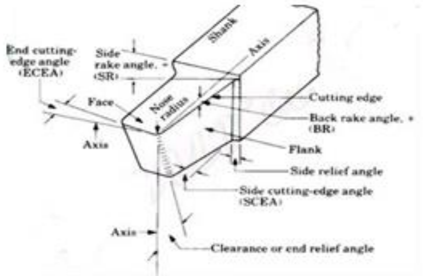


Fig. 2 Cutting Tools' Parts Nomenclature

4. Principle Angles of Single Point Cutting Tools

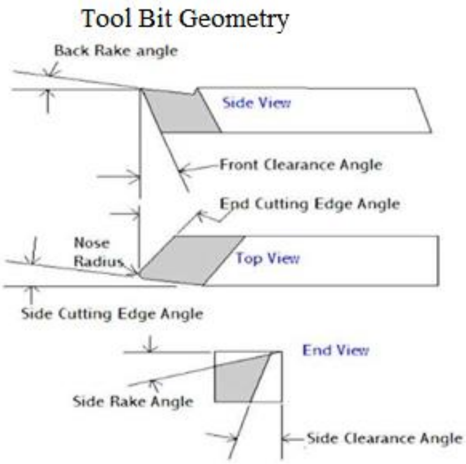


Fig. 3 Principle Angles of Cutting Tools

a) Rake Angles: The angle formed between the base of tool and plane parallel to its base is called Rake angle.

1) If the inclination is towards shank then its known as Back rake angle.
2) If it is measured towards side of the tool then it is called as Side rake angle.

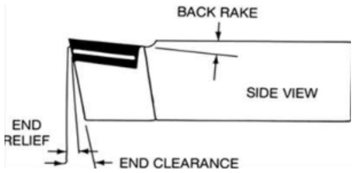
Rake angles guide the chips away from the cutting edge, so that less power is required for cutting.

If the rake angle is increased then it will reduce the strength of the cutting edge, so the tools used for cutting hard metals are having less rake angles & vice versa for soft metals.

b) Clearance Angle

It is the angle formed by the front or side surfaces of the tool which are adjacent or below the cutting edges of when the tool is held horizontal in position.

(a) Front clearance angle



(b) Side clearance angle

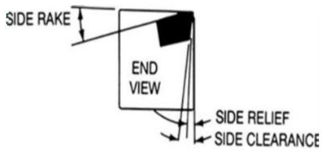


Fig. 4 Clearance Angles

Its main purpose is to allow tool to cut freely without rubbing the surface of work piece.

5. Cutting Angles

The total cutting angle of the tool is the angle formed between the tool face and line, which is a tangent to machined surface of work at that point.

1) End cutting edge angle
2) Side cutting edge angle

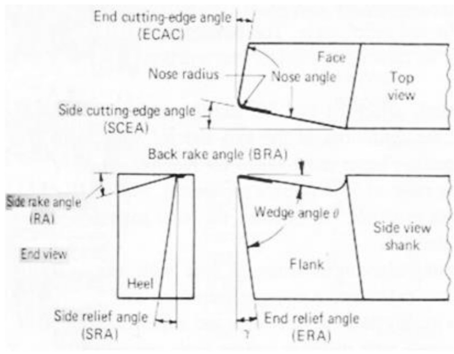


Fig. 5 Cutting Angles

6. Types of Chips

The chips produced during machining of various metals can be broadly classified into the following three types:

1) Continuous Chips
2) Discontinuous Chips
3) Built Up Chips

a) Continuous Chips

- These are formed when machining is done for highly ductile materials.

- Chips are formed due to shearing action and compressive stresses developed on the metal exactly in front of the metal.
- This type of chip formation gives an excellent surface finish and cutting process is smooth.
- Chips have tendency to curl outwards from the cut surface.
- Tools have higher life and process has lower power consumption

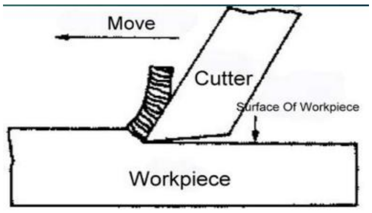


Fig. 6 Continuous Chips

b) Discontinuous Chips

- It means **chips** become broken pieces before it departs from the cutter.
- It is often happened in high brittle materials, such as cast iron or bronze.
- Lower the pressure of the tool surface, less wear happened, so the **tool life** is longer.

Discontinuous chips are formed due to lower cutting speeds and high depth of cut.

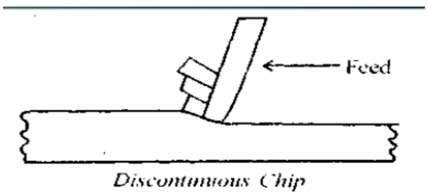


Fig 7. Discontinuous Chips

7. Built up edge chips

- When ductile materials are being machined the physical conditions like high pressure, high temperature associated with high frictional value on the tool chip interface, adheres the work material to the cutting edge of the tool forming a built up edge.
- As the tooling progresses more layers of material are added to this built up edge.

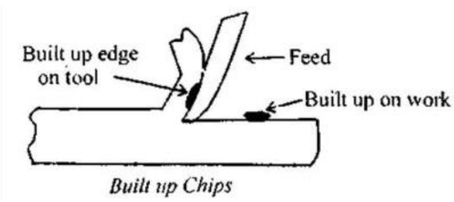


Fig. 8 Built up chips

When it becomes unstable it breaks and some of it is carried along the face of the tool while remaining portion is left over the surface which is to be machined.

8. Tool Life

Tool life is defined as the Time interval for which the tool works satisfactorily between two successive grindings. Thus it can be regarded as functional life of the tool. The tool life can be effectively used as the basis to evaluate the performance of the tool material.

There are three common ways of expressing Tool Life

- As Time Period in minutes between two successive grindings.
- In terms of Number of Components machined between two successive grindings.
- In terms of the Volume of Material removed between two successive grindings.

9. Types of Cutting Fluids

The type of cutting fluid to be used depends upon the work, material and the characteristics of the machining process, for some a cutting fluid which is predominantly a lubricant is desirable.

They are classified in seven main groups they are as follows:

- Water
- Soluble oils
- Straight oils
- Mixed oils
- Chemical-additive oil
- Chemical compounds
- Solid lubricants

This paper describes experimental work carried out to verify the tool temperature distribution model for the SPRT process analyzed. Both self- propelled rotary tool and fixed tool based hard turning experiments are performed. Chip geometry, cutting forces and the tool temperature distribution are measured in these experiments. The following sections describe the experimental procedure and results. Oblique cutting tests are also conducted on Ti6Al4V, AISI 4340 and AL7075 for different tool geometries and cutting parameters. Table 1 shows the test conditions and cutting parameters.

Table 1 Test conditions and cutting parameters for Ti6Al4V, AISI 4340 and AL7075

Material	Cutting Speed	Feed Rate	Rake Angle	Oblique Angle
Ti6Al4V	3-10 m/min	0.06–0.18 mm/rev	0^{o}-5^{0}	7^{0} - 11^{0}
AISI 4340	150-250 m/min	0.1-0.25 mm/rev	0^{o}-5^{0}	7^{0} - 11^{0}
AL7075	250-1000 m/min	0.05-0.2 mm/rev	0^{o}-5^{0}	7^{0} - 11^{0}

The fundamental parameters such as shear and friction angles as well as shear stress are determined from the force and chip measurements. The chip thickness is measured using two different methods. In the first one the chip thickness is measured by a micrometer, and in the second method weight measurements are used for determining the chip thickness.

The results obtained in the orthogonal and oblique cutting tests are compared. In addition, cutting force coefficients are transformed from orthogonal cutting tests and compared with the oblique cutting results. Also, different methods regarding the chip flow angle determination are applied and results are compared. The first method is the application of Stabler's rule, which assumes the chip flow angle is equal to the oblique angle. In the second method, the analytical formulation (Equation 10) is used where the third method was the direct measurement of chip flow angle during the experiments using video recordings.

The data given below are the comparisons of the normal shear angle, the shear stress, the friction angle and the cutting force coefficients measured from Ti6Al4V, AISI 4340 and AL7075 in orthogonal and oblique cutting tests.

a) Experimental conditions

Classical longitudinal turning of the outer diameter of a bar was carried out in these experiments. This kind of process involves a single point that maintains continuous contact with the work piece during cutting. Since the goal is to see the effectiveness of the rotary tool in terms of cutting temperature, dry machining was employed. A customized tool holder with rotary tool cartridge and inserts were used in the experiments . Another cartridge was manufactured to accommodate a fixed insert so that both rotary and fixed processes could be compared. The geometry of the fixed tool cartridge is identical to the rotary cartridge. Circular carbide inserts of 27 mm diameter with TiN coating were used. The geometry of the cartridge and the tool holder give the inserts an effective negative rake angle of 15° and an effective clearance angle of 5°.

The work piece is a hardened AISI 52100 steel round bar. This material has the following nominal chemical composition: C (0.98-1.1% wt.), Cr (1.45% wt.), Fe (97% wt.), Mn (0.35% wt.), P (max 0.025% wt.), S (max 0.025% wt.), Si (0.23% wt.). Its Young's modulus, UTS and hardness are 210 GPa, 2240 MPa and 58 HRC respectively.

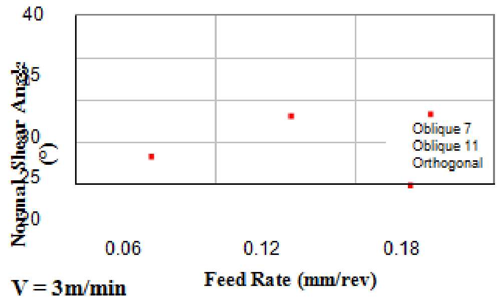
The deformed chip thickness (tc) and the chip width (bc) were measured at different locations with a caliper and a micrometer and the average values were then calculated. Determination of cutting forces is necessary to use the temperature model. The cutting forces were measured using a piezoelectric platform dynamometer (Kistler model 9257B) connected to a computer through a Kistler 5010 charge amplifier unit. A Krohn-Hite model 3384 analog filter was used to filter the measured cutting forces. The output of the Kistler dynamometer consists of three channels of force data carried through a single cable which is the input into the charge amplifier to adequately magnify the output signals.

10. Results

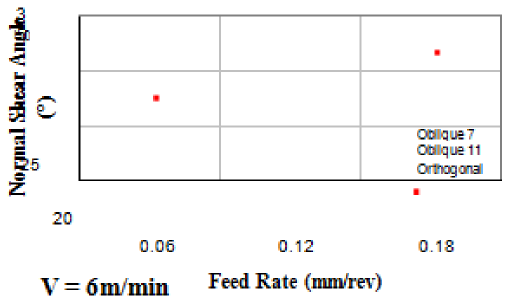
Normal Shear Angle in Oblique Cutting Tests

Shear angle indicates the orientation of shear plane in orthogonal and oblique cutting. Figure below shows the variation in the normal shear angle with feed rate in orthogonal and oblique cutting tests.

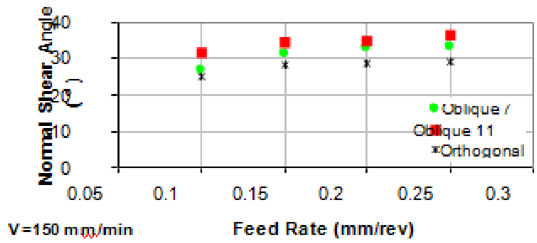
It can be seen from the data that the trends of the shear angle variation in orthogonal and oblique cutting are similar except in the low cutting speeds. For 3 m/min Ti6Al4V cutting tests this discrepancy is more due to the friction on the rake face.



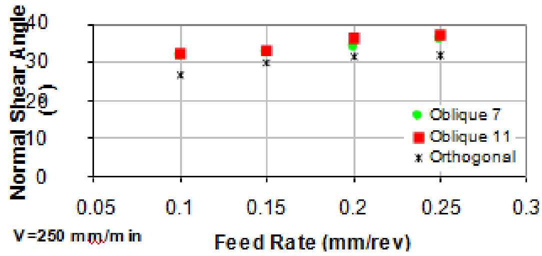
(a)



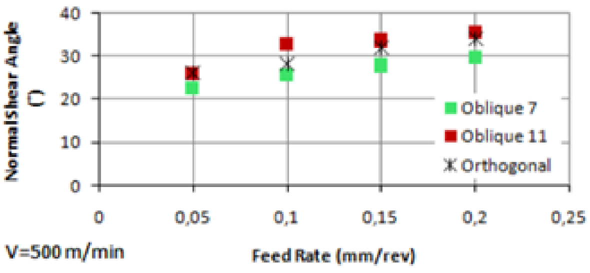
(b)



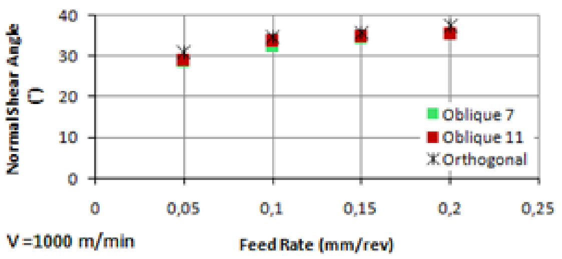
(C)



(d)



(e)



(f)

Fig 7. Variation of normal shear angle with feed rate for different cutting speeds using rake angle of 5^0. (a)-(b) Ti6Al4V (c)-(d) AISI 4340 (e)-(f) AL7075.

Conclusions

On oblique cutting an experimental investigation is presented for Ti6Al4V, AISI 4340 and AL7075 using different cutting conditions and tool geometries. The measurements performed in orthogonal and oblique cutting tests are compared with the model calculations with the objective of determining prediction capabilities and limits. The results are believed to provide a better insight into the mechanics of oblique cutting and effects of cutting conditions on it as well as some guidelines for oblique cutting calculations. The main conclusions from these results are summarized in the following.

The variation trends of the shear and friction angles in orthogonal and oblique cutting are similar where the shear angle increases with the feed rate due to decreasing friction on the rake face. Increase in rake angle results in higher shear angle for all cases, as expected.

The shear stress, on the other hand, is not affected much by the feed rate, cutting speed and the oblique angle for the ranges of these parameters used in the tests. These results confirm the fundamental assumption in the orthogonal-to-oblique transformation method where the shear and friction angles, and the shear stress identified from orthogonal cutting are used in the oblique cutting model.

References

T. Mikolajczyk, Odtwarzanie wlasnosci skrawnych ostrza z krawedzia skrawajaca o luku okregu (2001), Restoration of cutting properties of round inserts), Inzynieria i Aparatura Chemiczna pp 81-82.

S.A. Klimenko, A.S. Manokhin, Hard (2009), oblique turning. Super-hard Materials, 1 pp 58-74.

W. Grzesik, K. Żak. (2011), Investigations of surface textures produced by oblique machining of different workpiece materials. Archives of Materials Science and Engineering, pp 46-53.

W. Grzesik, (1991), A real picture of plastic deformation concentrated in the chip produced by continuous straight-edged oblique cutting. Int. J. Mach. Tools Manuf. 31, pp 329-344.

S.I. Petrushin, A.V. Filippov (2013), The analysis of the geometry of oblique turning peakless cutters. Treatment of Metals. Technology. Equipment. Tools. 2 pp 8-14.

A.V. Filippov (2013), Constructing a model of the equivalent wedge oblique cutting edge, Applied Mechanics and Materials pp 139-144.

A.A. Bakanov(2006), Calculation of cutting force in drilling with indexable insert drills. Fundamental Researches pp 49.

A.V. Filippov (2014), Cut-Layer Cross Section in Oblique Turning, Russian Engineering Research. 34, pp 718-721.

A. Moufki, A.Devillez, D. Dudzinski,, A. (2004) ,Molinari Thermomechanical modelling of oblique cutting and experimental validation. International Journal of Machine Tools & Manufacture, 44(9) pp 971-989.

W. Grzesik, K. Zak, (2011). Investigations of surface textures produced by oblique machining of different workpiece materials, Archives of Material Sciences and Engineering. 52(1).

T. Mikolajczyk, L. Romanowski (2013) Optimisation of single edge tools exploitation process, Applied Mechanics and Materials pp 431-436.

T. Mikolajczyk (2013) ,Edge properties restoration in cutting with single edge tool, Academic Journal of Manufacturing Engineering, pp 72-77.