ISSN 2229-5518

Effects of Tool Rake Angle on Tool Life in Turning Tools

Engr. Kaisan Muhammad Usman

ABSTRACT- In this work, the effect of tool rake angles on tool life was studied, the rake angles of 0^0, 5^0, 10^0, 15^0, and 20^0 and a constant clearance (Relief angle) of 8^0 were used to turn bright mild steel on the lathe machine, with a high speed steel of 18mm side as cutting tool and soluble oil was used as coolant. This is all in order to explore the energy savings opportunities during regrinding of tools, useful production time and energy is being wasted due to regrinding or re-sharpening of tools when cutting tools got worn or blunt, selection of the best rake angle which elongates tool life goes a long way in saving these time and energy. It was observed that, the rake angle of 20^0 gave the longest tool life as well as the best surface finish and yielded continuous chips formation.

Index Terms— Bright Mild Steel, Rake Angles, Relieve Angle, Wedge Angle, Tool Life, Turning Tools, Surface Finish

1 INTRODUCTION

Useful production time and energy are being wasted during regrinding or re-sharpening of cutting/turning tools during machining operations. Machining is one of the methods used in manufacturing engineering. Other methods include: casting, forming, grinding, shaping, finishing etc. The quest for profit maximization in manufacturing process makes it necessary for engineers and scientist to explore the optimum processes which requires less time and minimum energy for maximum output. Cutting tools are the basic tools used in machining operations which involve turning, milling, grinding, drilling, boring, planning and shaping and therefore tool life has to be elongated as much as possible in order to save time, energy and resources for optimum profit generation by a production firm. On this account, it has become necessary for us to investigate the effects of cutting parameters on tool life. According to Parson's, (1966) in 1907, Taylor has indicated cutting speed as the major determinant of tool life.

1.1 DEFINATIONS OFTERMS

Rake Angle (α): This is the angle between the tool face and the plane normal to the surface of the cut and pressing through the tool cutting edge (Edwards, 1993).

Clearance angle (β): This is also known as relief angle, it is the angle between the tool face adjacent to the surface of the cut. This angle helps to eliminate rubbing between the tool and the surface being cut and hence reduces friction to the beeriest minimum. According to Charles' (1971) a clearance angle of 6^0 to 8^0 is large enough to prevent excessive rubbing of the tool on the work piece.

Wedge Angle (γ): This is the angle formed by the rake and the relief angle, which is between the rake face and the relief face or between the tool face and the tool relief face.

In general:

$$\alpha + \beta + \gamma = 90^0 \qquad (1)$$

Other useful angles: Other relevant angles are: Share angle, end relief angle, approach angle, end rake angles, nose angles, end cutting angle and the angle of inclination to the main cutting edge.

Tool Life: This is the period of cutting with the tool measured between regrinding. It is simply the time between regrinding or re-sharpening of tools. It refers to the continuous cutting period, regrinding is not generally delayed until the tool has broken down completely, the tool might have to be ground for example, because the quality of the surface finish is deteriorating or there is tendency of the tool not to maintain dimensional accuracy and so on.

• ***Engr. Kaisan Muhammad Usman is a Scientific Officer with Department of Energy Management, Training and Manpower Development, Energy Commission of Nigeria and currently pursuing masters degree program in Energy System Engineering in Ahmadu Bello University, Zaria, Nigeria, PH-+2348036943404.***
E-mail: engineer.kaisan@gmail.com

1.2 MODES OF TOOL FAILURES

There are several ways in which tools fail; tool life is determined as soon as any of the failures is encountered. To elongate tool life, the rate of such failures must be brought to minimum. The following are the modes of failure:

Tool Breakage

Excessive Tool Wear

Rough Surface Finish of Work

Tool Chatter

Over heating

Tool wear is the gradual or the progressive wearing of certain regions of the face or flank of the cutting tool. The three types of wear commonly identified during metal cutting are:

Adhesion

Abrasion and

Diffusion

1.3 COOLANTS

In many cutting operations, fluids are used to cool and lubricate both the cutting tool and the work piece. Such fluids are called coolants. Cooling increases tool life and helps to stabilize the side of the finished parts. Lubrication reduces friction thus, decreases the heat generated and the power required for a given cut. Cutting fluids include water based solutions, chemically inactive oils and synthetic fluids.

2.0 LITERATURE REVIEW

Mustafa G¨unay et al (2004) investigated the effect of cutting tool rake angle on main cutting force, for machining rotational parts by sharp cutting tools. A special dynamometer was designed and produced to measure the forces for this purpose.

Similarly, Erry Yulian T. Adesta et al (2009) investigated tool wear and surface finish in high speed turning using cermet insert by applying negative rake angles, The experimental results showed that by increasing negative rake angles the higher wear occurred shorter duration of tool life and poor surface finish. The different between high Tool Wear and Surface Finish Investigation in High Speed Turning Using Cermet Insert by Applying Negative Rake Angles 181 speed and conventional speed was also observed in that experiment. High speed turning gives shorter tool life, high wear rate but finer surface finish than conventional one.

Alexius Anak An'yan, (2008) worked on to study the effect of grinding process parameters namely depth of cut, number of passes, and use of coolant on grinding force of aluminium alloy (AA6061-T6). A three component force transducer dynamometer (Kistler Model Type 5070) was used to measure grinding forces in this experiment. A full factorial experimental design was used as the approach for the design of experiment. Through the analysis of variance (ANOVA) conducted, it was found that the most significant parameter is the usage of coolant followed by depth of cut.

Viktor P. Astakhov and J. Paulo Davim (2008), worked on Tools (Geometry and Material) and Tool Wear, presents the basic definitions and visualisations of the most important components of the cutting tool geometry essential in the consideration of the machining process. The types and properties of modern tool materials are considered as well, as a closely related topic, as these properties describe to a great extent the restrictions on tool geometry. The basic mechanisms of tool wear are discussed. Criteria and measures of tool life are also considered in terms of Taylor's tool life models as well as in terms of modern tool life assessments for cutting tools used on computer numerical control (CNC) machines, manufacturing cells and production lines.

Finally, Hamidreza Shahabi Haghighi, (2008) in PhD theses, studied the direct effect of tool nose wear which is in contact to the surface profile of work piece directly, on the surface roughness and dimensional deviation of work piece using a developed machine vision in finish turning operation.

In this work however, the effects of tool rake angle on tool life in turning tools was investigated, the details of the experimental procedure is elaborated in the next chapter.

3 .0 MATERIALS AND METHODS

3.1 LIST OF MATERIALS/ EQUIPMENT

The following Machines, materials and apparatus were used in the experiment to investigate the effects of tool rake angles on tool life during turning operations:

Centre Lathe Machine

Universal Grinding Machine

Power Saw Machine

High Speed Steel Turning Tools 18mm, 8^0 clearance angle and 12^0end relief angle

Bright Mild Steel (SAE 1025, Composition: 0.25%C, 0.4%Mn,0.04%P, 0.05%S)

Protractors

Lanterns

Coolant (Solouble Oil)

Vanier Scale

Grease for Lubrication of Centre Drill

Stopped watch

Record Sheet and Pen

3.2 PREPERATION OF CUTTING TOOLS

The high speed steel cutting tools were ground on the universal grinding machine; various rake angles of 00, 50, 100, 150, and 200 were obtained. The clearance angle of 80 was made for all the corresponding rake angles on each HSS turning tool. After complete grinding, the protractor was used to measure the accuracy of all the angles obtained and all were found satisfactory. For 0^0, no need of any grinding, rather the most flat and smooth HSS side was adopted for the purpose.

3.3 WORKPIECE PREPARATIONS

Using the power saw, the bright mild steel bar of 80mm diameter was cut into shorter lengths 200mm lengths to allow for easy mounting on the centre lathe machine, the coolant was used during the cutting process to minimise heating of both the power saw blade and the work pieces. The cylindrically shaped work pieces were obtained.

3.4 TOOL LIFE DETERMINATION

Using 3- jaw chucks, one of the bright mild steel work pieces was mounted on the head stock of centre lathe machine. The work piece was then centre drilled using a small drilled spindle which was attached to the tail stock. The drilled hole was then re-bored using a drilled of larger diameter, and grease was applied to the hole.

The HSS cutting tool of 18mm side, 0^0 rake angles and 8^0 clearance angles was used to turn the work piece. The whole cutting process was cooled continuously with soluble oil.

The cutting process carried out with the following selected conditions:

Depth of cut = 2mm

Cutting Speed = 250 rev / min

The lathe machine was then powered up and the tool was engaged on the work piece, the stopped watch was started as soon as the tool engaged the work piece, as cutting has almost started, the cutting was continued until the tool seized to cut or failed completely, the time taken was measured and recorded. Other distinguished parameters were also recorded during the experiment; these were the length of bar turned, initial and final diameters off the work piece and types of the chips produced.

The whole experiment was repeated using the other tools of 5^0, 10^0, 15^0, and 20^0, with clearance angles and all other conditions being maintained as in the results are presented in Table 4.2 below.

4.0 RESULTS AND DISCUSSIONS

The result of the experiment described in the 3.4 above is presented in the table 4.2, from the table, it can be seen that there are variations in the tool life as well as

ISSN 2229-5518

length of the bar turned when the rake angle varied. The variation in the length of the bar turned makes it possible for us to determine the rates of metal removal for each rake angle. The volume of metal removed is given by:

$$V_m = Ctl \qquad (2)$$

Where:

V_m = volume of metal removed

C = circumference of the work piece

t = depth of cut

l = length of the bar turned

But, $C = \pi D$ (3)

Where:

D = diameter of the work piece

The volume of the metal removed is one of the most important variables in determining the best rake angle during machining operations. Under ideal cutting conditions the best rake angle is expected to yield the highest volume of metal removed before tool failure.

TABLE 4.2

EFFECTS OF TOOL FACE ANGLES ON TOOL LIFE AND VOLUME OF METAL REMOVED

SAMPLES	RAKE ANGLE(α^0)	CLEARANCE ANGLE (β^0)	WEDGE ANGLE (γ^0)	LENGHT OF CUT (mm)	TOOL LIFE (min)	VOLUME OF METAL REMOVED (mm^3)
1	0	8	82	127.0	6.4	63845.550
2	5	8	77	85.8	3.4	43133.376
3	10	8	72	143.5	6.6	72140.320
4	15	8	67	63.0	4.4	31671.360
5	20	8	64	283.0	13.5	142269.760

The results presented in the table 4.2 above are presented in the figures below:

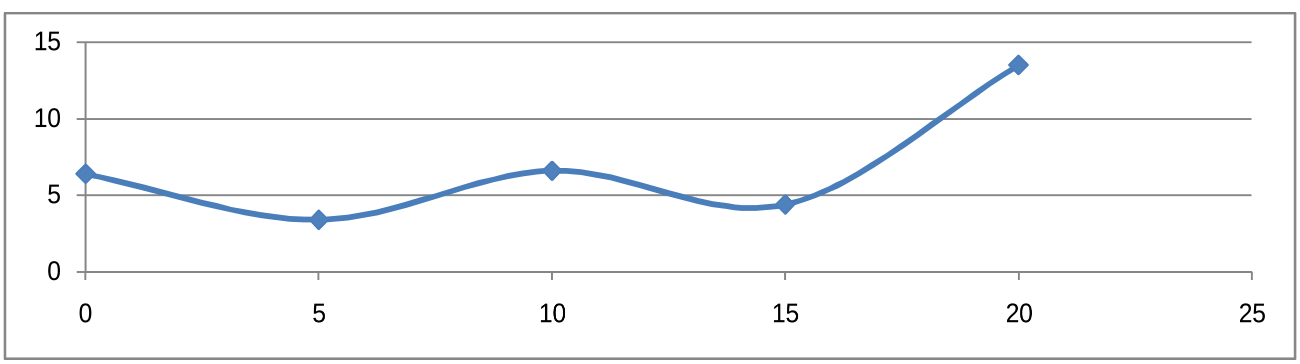

Figure1 Effects of Tool Rake Angles on Tool Life

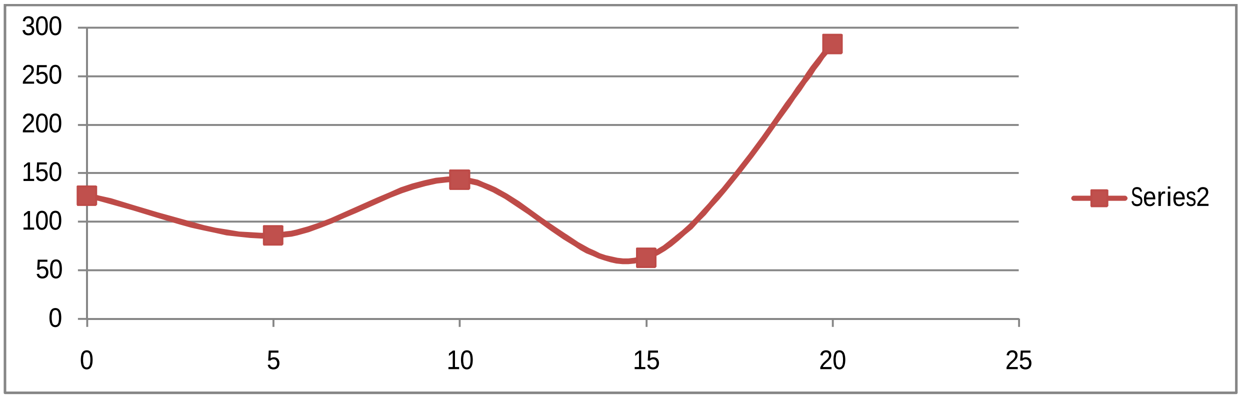

Figure2 Effects of Rake Angle on Length of Cut

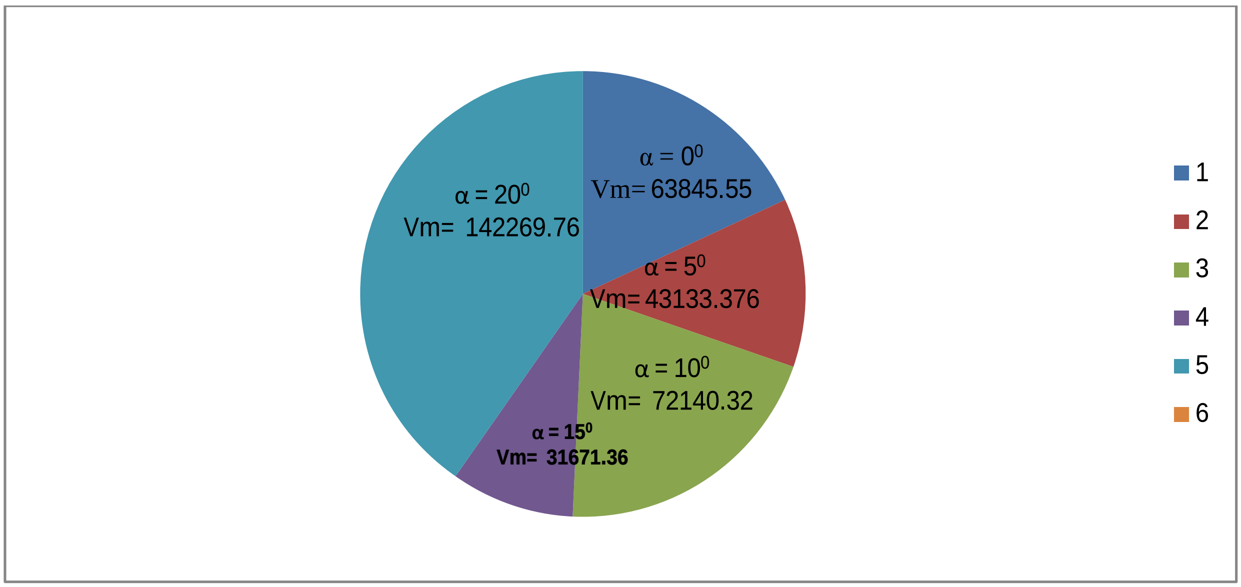

Figure 3 Effects of Rake Angle on Volume of Metal Removed

From the figures above, it would be clearly viewed that the rake angle of 20^0 gave the longest tool life of 13.5mins and the highest volume of metal removed of 142269.76 mm3 and a close observation on the work pieces shown that, only the work piece worked upon by the 20^0 rake angle yielded a continuous chips formation, which is also an evidence of good cutting conditions. The time and energy wasted during regrinding or re-sharpening of tools will be saved using the best rake angle. Time and energy are very important parameters used in optimizing the production capacity of any manufacturing firm, as such, we have to be careful with wasting such important parameters unnecessarily more importantly during machining operations, whence, selection of the best rake angle in turning is very essential.

5.0 CONCLUSION

The tool face angles have effects on tool life in turning tools more specially during turning operations. While machining (Turning) bright mild steel with HSS turning tools, a rake angle of 20 gave the longest tool life, yielded continuous chips formation and produced the best surface finish.

6.0 REFERENCES

1. Charles R. H. (1971), Machine Tools and Process for

Engineers, McGraw Hills Inc., Chapter Eight and Ten

2. Edwards R. (1993), Cutting Tools, The University Press, Cambridge, Chapter Five
3. Persons B. A. J. (1966), Production Tooling Equipment, Macmillan and Company Limited, Chapters Eleven and Twelve
4. Hamidreza Shahabi Haghighi (August, 2008), Study on The Effect of Tool Nose Wear on Surface Roughness and Dimensional Deviation of Work piece in Finish Turning Using Machine Vision, Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy, Malaysia
5.
6. Viktor P. Astakhov and J. Paulo Davim, Tools (Geometry And Material) And Tool Wear, General Motors Business Unit of PSMi, 1255 Beach Ct., Saline MI 48176, USA., Department of Mechanical Engineering, University of Aveiro, Campus Santiago, 3810-193 Aveiro, Portugal, 2008, http://www.springer.com/978-1-84800-212-8
7.
8. Alexius Anak An'yan, Effect of Grinding Process Parameters on Grinding Force of
9. Aluminium Alloys (Aa6061-T6), A final year report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Faculty of Mechanical Engineering, Universiti Malaysia Pahang, November 2008
10.
11. Mustafa G¨unay, Ihsan Korkut, Ersan Aslan, Ulvi S¸eker, Experimental investigation of the effect of cutting tool rake angle on main cutting force, Journal of Materials Processing Technology 166 (2005) 44–49 Received 10 September 2003; received in revised form 22 December 2003; accepted 20 July 2004
12.
13. Erry Yulian T. Adesta, Muhammad Riza, Muataz Hazza, Delvis Agusman and Rosehan, Tool Wear and Surface Finish Investigation in High Speed Turning Using Cermet Insert by Applying Negative Rake Angles, European Journal of Scientific Research, ISSN 1450-216X Vol.38 No.2 (2009), pp.180-188 © EuroJournals Publishing, Inc. 2009, http://www.eurojournals.com/ejsr.htm
14.
15. K. V. Santha Kumari, Dipak Ranjan Jana and Anjani Kumar, Effects of Tool Setting on Tool Cutting Angle on Turning Operation, ARPN Journal of Engineering and Applied Sciences, VOL. 5, NO. 5, MAY 2010, ISSN 1819-6608, www.arpnjournals.com