

Effect of Tool Nose Radius and Rake Angle in Turning – A Review

Sunil Maghodiya¹ Jayesh V.Desai²

¹M.E Scholar ²Assistance professor

^{1,2}Department of Mechanical Engineering

^{1,2}LDRP-ITR KSV, Gandhinagar

Abstract— 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. This Review paper presents a survey on variation in tool geometry i.e. tool nose radius, rake angle and their effect on tool wear, surface roughness.

Key words: Rake angle, surface roughness, tool nose radius, tool wear

I. INTRODUCTION

Stringent control on the quality of machined surface and sub-surface during turning is most important consideration a part from considering the tool life. In order to attain sufficiently high production rates at minimum cost, optimization of cutting tool geometry is necessary.

The tool geometry effects on turning performance parameters are mentioned in Figure 1.

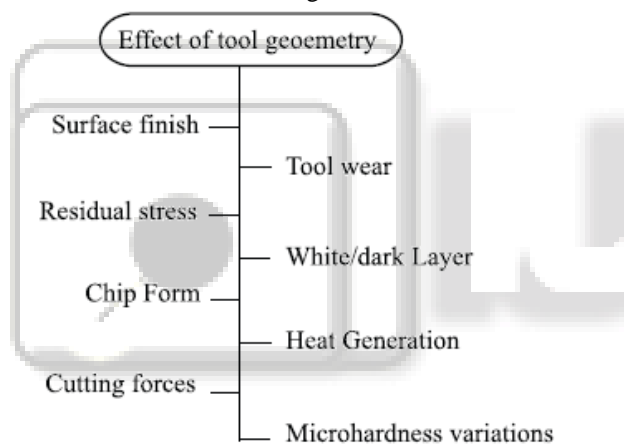


Fig. 1: Effect of tool geometry on performance parameters in turning

Among various machining parameters, tool nose radius has a significant contribution to the cutting dynamics and the stability of a machining process. 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.

For single point cutting tool most important angle is back rake angle. The back rake angle affects the ability of the tool to shear the work material and form the chip. It can be positive or negative.

II. LITERATURE REVIEW

Lungu, N. at al. have studied the finite element analysis of the influence of cutting tool geometrical parameters: nose radius, rake angle and clearance angle – on the some evaluation indicators of the machining process, namely: cutting forces, temperatures and thermal deformations of the tool. The optimum cutting tool geometrical parameters were

found after carrying out the experiments specified by Taguchi's L9 orthogonal array table and analysis of variance. Tungsten carbide was chosen for the tool and AISI 1045 carbon steel for the work piece. Author concluded that the influence of tool geometric parameters on the cutting forces, temperatures and thermal deformation of the tool was investigated. The study involves both, finite element analysis and optimization of cutting tool geometric parameters by Taguchi method. Thus, in agreement with the results obtained it can be concluding that: force values increase with nose radius increase; the lowest forces value were recorded for a nose radius of 0.4mm; the lowest temperature value was also obtained for a nose radius of 0.4mm; with nose radius increasing, the thermal deformation increases; the rake angle and clearance angle value has a small influence on the cutting forces.[1]

Jayesh M. Patel at al. have studied on parametric analysis of dry and wet turning on cnc lathe using design of experiment. Author experimented on effect of side rake angle, feed and depth of cut on surface roughness and cutting force in dry and wet turning. They conducted 27 experiment as per the full-factorial design of dry and wet experiment. ANOVA analysis were also performed to obtain Significant factors influencing Surface Roughness and Cutting Force which gives the percentage contribution of each process parameter.

The author concluded That the application of Full-factorial, ANOVA and Regression analysis to analyze the effect of process parameters (Constant cutting speed, Side rake angle, Feed rate and Depth of cut) on surface roughness and cutting force for EN-9 under dry and wet turning operation. From the analysis of the results obtained following conclusion can be drawn:- The percentage contribution of side rake angle is 15.20%; feed of 62.52% and depth of cut of 18.87% on surface roughness for dry turning operation and the percentage contribution of side rake angle is 14.49%; feed of 53.56% and depth of cut of 30.21% on surface roughness for wet turning operation. From the ANOVA it is conclude that the feed rate is most significant parameter which contributes 62.52% in dry turning and 53.56% in wet turning operation. In regression analysis, the maximum test error for surface roughness regression model on dry turning is 0.066 comparing with wet turning 0.059, which is an acceptable error range. Optimal parameters for surface roughness are side rake angle (-5°), feed 0.20 mm/rev and depth of cut 0.8 mm for dry and wet turning operation. The percentage contribution of side rake angle is 51.68%; feed of 4.11% and depth of cut of 42% on cutting force for dry turning operation and the percentage contribution of side rake angle is 60.36%; feed of 6.28% and depth of cut of 31.01% on cutting force for wet turning operation. From the ANOVA it is conclude that the side rake angle is most significant parameter which contributes 51.68% in dry turning and 60.36% in wet turning operation. In regression analysis, the maximum test error for cutting force regression model on dry turning is

5.15 comparing with wet turning 6.90, which is an acceptable error range. Optimal parameters for cutting force are side rake angle (0°), feed 0.20 mm/rev and depth of cut 0.8 mm for dry and wet turning operation. [2]

Y. Kevin Chou et al. have studied the Tool nose radius effects on finish turning of hardened AISI 52100 steels have been investigated. Surface finish, tool wear, cutting forces, and, particularly, white layer (phase transformation structures) were evaluated at different machining conditions. Results show that large tool nose radii only give finer surface finish, but comparable tool wear compared to small nose radius tools. Specific cutting energy slightly increases with tool nose radius. For new tools, white layers only occur at aggressive feeds ($=0.3$ mm/rev) and small nose radius results in deeper white layers. For worn tools, white layers appear even at mild feeds (0.05 mm/rev), but in contrast, large nose radius leaves deeper

White layers. Smaller tool nose radius gives larger uncut chip thickness, and thus, greater shear plane heat source that may induce deeper white layers for new tool conditions. For worn tools, where the wear-land sliding is the major heat source, temperature analysis at machined surfaces reveals that the larger the tool nose radius, the deeper the temperature penetration due to a shorter transition-material zone from the cutting edge to the final machined surface. The author concluded that Tool nose radius is a geometric parameter in machining and its effects on finish hard turning have been investigated, especially on white layer formations. Large tool nose radii seem to only have the advantage of finer surface finish, yet tool wear is comparable and specific cutting energy is slightly higher. Maximum uncut chip thickness decreases with tool nose radius that may result in higher plowing energy, and thus, higher specific cutting energy. Large nose radius tools generate shallower white layers in new tool cutting; however, leave deeper white layers when cutting by worn tools. For new tools, small nose radius results in larger uncut thickness, and thus, induces deeper white layers. On the other hand, in worn tool cutting, large nose radius has a shorter transition-material zone that results in deeper white layers, qualitatively verified by thermal analysis at machined surfaces. [3]

Dr. Saad Kariem Shather. Have studied the effect of tool nose radius on workpiece run out and surface finish. They focused on effect of tool nose radius on surface roughness and run out which causes tool chatter, the experiments proved that high values of nose radius causes rough surface with high value of run out also in this paper use seven different values of nose radius of cutting tool were (0.3, 0.4, 0.5, 1, 1.5, 2, 2.5mm) under different of cutting conditions (such as feed rate, cutting speed, depth of cut). They conducted 14 experiment. Work piece materials was carbon steel and tool material was High speed steel (HSS). Author concluded that Author concluded that, Increasing nose radius refers to increase surface roughness but not less than 0.4 mm. Maximum roughness value was ($R_a=4.1$ μm) when nose radius = 2.5mm and good surface finish at nose radius = 0.4 mm when $R_a=0.5$ μm . Experimental work proved that small difference between arithmetic roughness values and experimental values except nose values (1.5, 2, 2.5mm). A new relationship was found between nose radius and run out according to tool chatter occurs during turned work

piece surface. Maximum run out occurs at high research recommended use suitable value of nose radius=2.5 mm and surface roughness= 4.1 μm . In order to reduce tool chatter nose radius such as (0.4, 0.5mm) . Also a suitable nose radius for run out was (0.4, 0.5 mm) to get good surface finish (0.5, 1.2 μm). [4]

Ship-Peng Lo. Have done an analysis of cutting under different rake angles using the finite element method. The elastic plastic finite element method is developed in this study to investigate the effect of the tool rake angle on the chip and the machined workpiece during the precision cutting process. Cutting simulations were conducted under a variety of tool rake angles to explore the effect of tool rake angle on cutting force, the geometric shapes of the chip, the equivalent stress distribution, the residual stress and the surface of the machined work piece.

The author concluded that, the elastic plastic finite element method was developed in this study to investigate the effect of tool rake angle on cutting force, chip contour, equivalent stress distribution, residual stress and the machined work piece surface during the precision cutting process. The geometrical separation criterion is adopted as the criterion of chip separation from the work piece. The entire cutting process, from the initial cutting to the formation of steady state, under different tool rake angles is simulated. To validate the accuracy of the present cutting model, the simulated cutting force was also compared with experimental values obtained under the same cutting conditions. The comparison indicates that the error between the simulated cutting force and experimental values falls within acceptable limits. Based on the previous analysis and discussion, the following conclusions may be drawn: The cutting force decreases as the tool rake angle increases. In this paper, the extent of cutting-force reduction is most evident as the rake angle increases from 10 to 15. In contrast, when the rake angle increases from 15 to 20, the cutting force experiences only a slight reduction. The maximum equivalent strain on the section decreases as the tool rake angle increases. The extent of reduction is also most evident when the rake angle increases from 10 to 15. The reduction of maximum equivalent strain is very limited when the rake angle increases from 15 to 20. The top of the chip contour becomes smoother as the tool rake angle increases. The difference between the chip thickness and the under formed chip thickness decreases as the tool rake angle increases. The phenomenon of curvature at the initial cutting end of the work piece becomes more moderate as the tool rake angle increases. As a result, the cutting simulation at the angle of 0 requires a proper fixture to secure the initial cutting end of the work piece to prevent a greater curvature at this end. Both the equivalent stress and the stress was perpendicular to the cutting direction among the residual stress show a more obvious trend of decrease as the tool rake angle increases. As for the stress in the cutting direction, its maximum tensile value on the work piece surface increases as the tool rake angle increases. [5]

Kaisan Muhammad Usman have studied the effect of tool rake angles on tool life. the rake angles of 0° , 5° , 10° , 15° , and 20° and a constant clearance (Relief angle) of 80 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 gave the longest tool life as well as the best surface finish and yielded continuous chips formation. Author concluded that 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]

Z. Karim et al. have studied tool wear and surface finishing by applying the positive and negative rake angle during machining. The experiment was conducted by using conventional lathe machine and aluminium alloy Al6061 as the workpiece. The machining parameters were kept constant while the rake angles were varied from positive to negative values. At every 200mm tool travel distance, the flank wear and surface roughness values were measured using Microscope Motic Images Plus and Handysurf surface roughness tester respectively. author concluded that In this work, the effect of different rake angle toward flank wear and surface roughness was successfully performed and recorded. From the tool wear result, the flank wear increase with respect to the increase of positive rake angle or negative rake angle. The flank wear is at maximum value when the rake angle equal to 15°. The plot of flank wear versus cutting length shows a linear relationship with similar slope which indicate similar rate of wear in the cutting tool. Base on the data that were recorded through the experiment as summarized in Table 1 and Table2, negative and positive rake angle give very close values of flank wear. Thus, It can be concluded that the negative and positive rake angle give the same effect to flank wear during machining process. Surface roughness value shows an inverse relation with the rake angle. When the rake angle is increased, the value of surface roughness will decrease. The result in this work can be used in optimizing machining parameter setting to get the best value of surface roughness with minimum flank wear. [7]

III. CONCLUSION

This paper has presented a brief review on effect of tool nose radius and rake angle in turning operation.

From above study it was found that The nose radius of tool affects the roughness of machined surface, residual stresses of machined surfaces, chip morphology and forces arise during cutting. Further the ratio of the thrust force to cutting force and the ratio of the thrust force to feed force increase with the increase of the tool nose radius. Large tool nose radii seem to have only the advantage of finer surface finish. In comparison to small tool nose radii the large tool nose radii cause almost equal tool wear and a slightly higher specific cutting energy. Large nose radius tools generate shallower white layers in new tool cutting; however, leave deeper white layers when cutting by worn tools. Thus for deciding the life of tool with large nose radius white layer parameter should also be considered a part from flank wear. By increasing rake angle cutting force and surface roughness decrease but flank wear increase with rake angle.

REFERENCES

- [1] Lungu, N.; Croitoru, S. M.; Borzan, M, "optimization of cutting tool geometrical parameters using taguchi method," academic 62 journal of manufacturing engineering, vol. 11, issue 4, pp 62-67, 2013.
- [2] Jayesh M. Patel, Paawan Panchal, "parametric analysis of dry and wet turning on cnc lathe using design of experiment" International Journal For Technological Research Engineering Volume 1, Issue 9, pp 686-694, May-2014.
- [3] Y. Kevin Chou, Hui Song, "Tool nose radius effects on finish hard turning", Journal of Materials Processing Technology 148, pp 259–268, 2004.
- [4] Dr. Saad Kariem Shather, "Studying The Effect of Tool Nose Radius on Workpiece Run Out and Surface Finish", Eng. & Tech. Journal, Vol.27, pp 256-261, 2009.
- [5] Ship-Peng Lo, "An analysis of cutting under different rake angles using the finite element method", Journal of Materials Processing Technology 105, pp 143-151, 2000.
- [6] Engr. Kaisan Muhammad Usman, "Effects of Tool Rake Angle on Tool Life in Turning Tools," International Journal of Scientific & Engineering Research Volume 3, Issue 4, pp 1-6, April-2012.
- [7] Z. Karim, S.A.S. Azuan, A. Yasir. M. S, "A Study on Tool Wear and Surface Finish by Applying Positive and Negative Rake Angle during Machining," Australian Journal of Basic and Applied Sciences, 7(10): 46-51, 2013.