ANALYSIS OF SURFACE ROUGHNESS WITH VARIATION IN SHEAR AND RAKE ANGLE

Sirajuddin Elyas Khany[1], Mohammed Hissam Uddin[2], Shoaib Ahmed[3], Mohammed Wahee uddin[4] Mohammed Ibrahim[5]
[1]Associate Professor, [2,3,4,5]B.E(student),
Dept. of Mechanical Engineering, Muffakham Jah college of Engineering, Hyderabad

ABSTRACT
The work and study carried out in this paper aims to analyse the effect of surface rake angle on surface finish, which machining with a single point cutting tool. In this experiment a single point cutting tool of material HSS is considered for machining AISI 1080. The machining parameters such as speed, feed, depth of cut, RPM were kept constant. The roughness was measured by using a manual surface roughness tester. It was observed that the surface roughness reduces with the increase in rake angle and same was the case with shear angle.
KEYWORDS: Surface roughness, Rake angle, Shear angle

1. INTRODUCTION:

For obtaining the required surface finish the cutting tool of proper geometry should be used. The evaluation of surface roughness of machined parts using a direct contact method has limited flexibility in handling the different geometrical parts to be measured. Surface roughness also affects several functional attributes of parts, such as friction, wear and tear, light reflection, heat transmission, ability of distributing and holding a lubricant, coating etc. Therefore, the desired surface finish is usually specified and appropriate processes are required to maintain the quality. Hence, the inspection of surface roughness of the work piece is very important to assess the quality of a component. For measuring surface roughness the roughness average/arithmetic average roughness value R_a is taken into consideration.

1.1 SURFACE ROUGHNESS:

R_a, the most commonly used surface roughness definition and is expressed mathematically as

$$R_a = \frac{1}{n}\sum_{i=1}^{n}|y_i|$$

Where n is the total number of data points used in the calculation and Y is the vertical surface position measure from the average surface height.

Surface roughness is a measure of the texture of a manufactured surface, it can be measured using contact methods involving dragging a stylus across the part, or using non-contact optical methods.

The methods of measuring surface finish are Surface inspection by comparison method which includes Visual inspection, Touch inspection, Surface Photographs, Scratch inspection, Microscopic inspection, Micro interferometer, Reflected light intensity, Wallace surface dynamometer and Direct instrument measurement which includes Profilometer, Tomlinson surface meter, Taylor Hobson Talysurf, Profilograph,etc.

The surface roughness of a work piece is affected by numerous factors that can be broadly divided into four main categories: (1) factors due to machining parameters, such as feed rate, cutting speed, and depth of cut, (2) factors due to cutting tool parameters, such as tool wear, tool geometry, tool material, and tool coating, (3) factors due to machining and machine tool conditions, such as dry or wet turning, type of cutting fluid, method of fluid application, machine tool rigidity, and chatter vibration, and (4) factors due to work piece material properties, such as hardness, microstructure, grain size, and inclusions.

The surface roughness of work piece should be controlled to improve the fatigue resistance and the service life of component and to reduce frictional wear, initial wear, corrosion by minimizing depth of irregularities and to have a close dimensional tolerance on the parts for a good appearance and if the surface is not smooth enough, a turning shaft may act like a reamer and the piston rod like a broach.

1.2 TERMINOLOGY FOR SURFACE ROUGHNESS:

Ideal surface: It is a hypothetical perfect surface without any micro-irregularities.

Roughness: It refers to the peaks and valleys which will be observed on the machined surface.

i. Roughness height: it represents heights of peaks or depth of valleys measured from the mean line for five consecutive cycles.
ii. Mean roughness index: it is the arithmetic mean of absolute values of heights of peak or depth of valleys is represented by R_a.
iii. Surface roughness number: it indicates the average departure of the machined surface over standard sampling length (usually 0.8mm to 2.5mm).It is expressed by micron.
iv. Waviness: This is surface irregularity in the form of waves with larger wavelength.
v. Lay: it is the direction of tools marks or scratches or grains of surface, which is represented on drawings with surface finish symbol. It is important to note that the surface roughness is measure at right angle to the direction of lay.

2 RAKE ANGLE (α):

Rake angle is one of the most significant elements in tool geometry Proper selection of rake angle enhances the overall efficiency and economy of cutting operation.

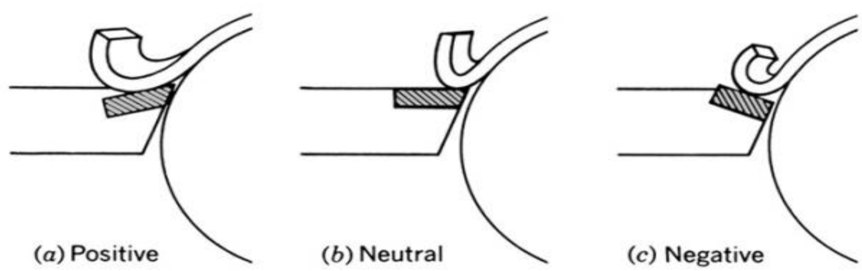

Fig:-1. Different Types of Rake angle

The above Fig:-1 shows all the 3 different rake angles.

Positive rakes are generally used for cutting soft materials, which leads to less cutting force and less power consumption. Whereas the negative rakes are used for cutting hard materials, which contributes for the increase in edge-strength and life of the tool. The zero rake is used because of its simple design and ease in manufacture.

2.1 EFFECTS OF RAKE ANGLE(α):

Increasing rake angle in the positive direction improves sharpness of the tool and decreases cutting edge strength and hence reduces cutting force and power requirement, helps in formation of discontinuous chip in ductile materials and can help to avoid the formation of built-up edges. Increasing rake angle in the negative direction makes the tool blunt and increases cutting resistance, cutting force, strength of cutting edge, friction and temperature and improves surface finish.

A zero or neutral rake angle is the easiest to manufacture, but has a larger crater wear when compared to positive rake angle as the chip slides over the rake face.

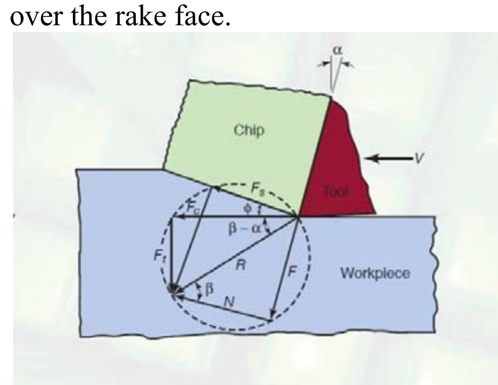

Fig:-2. Merchant's Circle Diagram

2.2 SHEAR ANGLE (∅):

Shear angle is the angle made by shear plane with the direction of tool travel. It is one of the most important parameter because the higher the shear angle, lesser the shear plane area, less separation force, lowers power consumption, less chip

thickness and fine cut. But lesser the shear angle more cutting force & more power consumption.
The value of shear angle depends on many factors such as working material, cutting conditions, tool material and geometry.
In this experiment shear angle value is calculated by using the below relation.

$$\tan \emptyset = \left(\frac{r_c \cos \alpha}{1 - r_c \sin \alpha}\right)$$

Where $\emptyset$ = shear angle
α= rake angle
r_c =chip thickness ratio

3 EXPERIMENTAL SETUP AND PROCEDURE:

The experiment was carried out in two parts. The first part comprised of grinding the cutting tools to 5°, 12°, 17°, 25° and turning the work piece to a length of 50mm on a lathe machine. The speed, feed, depth of cut were 500rpm, 0.045mm/rev, 0.5 mm respectively. The work piece was AISI 1080. Then the chip thickness was calculated using digital vernier callipers followed by chip thickness ratio. After knowing the value of chip thickness ratio shear angle was calculated using the above relation.

Material Properties of workpiece material

The material used was AISI 1080 carbon steel. G10800 is the UNS number. The following properties have been listed below.

Brinell hardness 220-270 BHN
Elastic modulus 210 Gpa
Elongation at break 11 to 12%
Modulus of resilience (Unit resilience) 560 to 860 kJ/m^3
Poisson's ratio 0.29
Strength to weight ratio 99 to 110 KN-m/kg
Tensile strength: Yield (proof) 480 to 600 Mpa
Unit rupture work (Ultimate resilience) 82 to 88 MJ/m^3

Chemical Composition of workpiece material

Table 1: Chemical Composition of AISI 1080 carbon Steel

Iron	.98-.99%
carbon	.75-.88%
manganese	.6-.9%
sulphur	.05(max)
phosphorus	.04(max)

The second part comprised of measuring the surface roughness of each specimen using the surface roughness tester Mitutoyo surftestSJ-301.

Fig:-3. Profilometer

4 RESULTS AND DISCUSSIONS;

The results of surface roughness and rake angle are tabulated in the following Table 2:

Table 2: Variation of Surface roughness with rake angle

Surface roughness in microns	Rake angle in degrees
10.25	5
8.74	12
5.6	17
2.76	25

From the Table 2 it seen that as the rake angle increases the surface roughness decreases

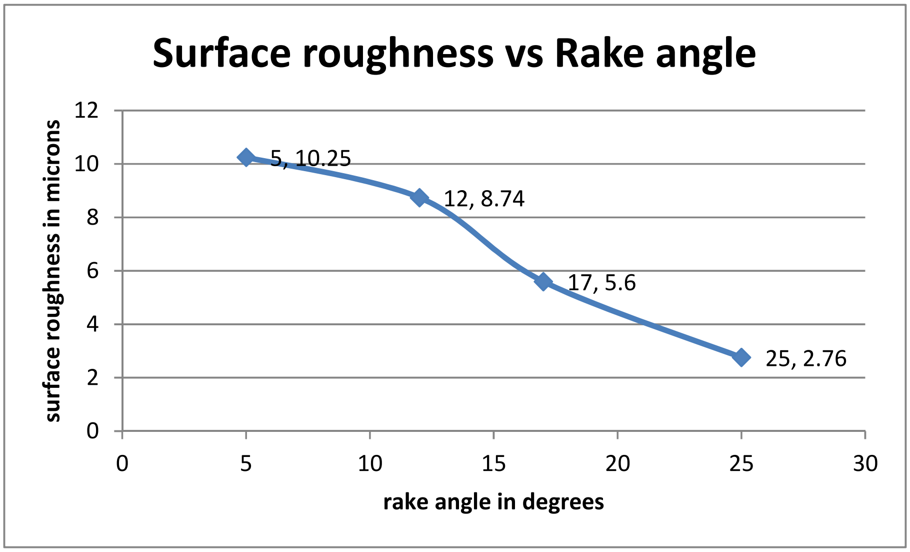

Fig:-4 Surface roughness V/S Rake angle

Table 3: Shear angle and Surface roughness

Shear angle in degrees	Surface roughness in microns
51.31	10.25
69.29	2.76
79.8	5.6
89.5	8.74

The Table 3 below gives the following values for shear angle and surface roughness

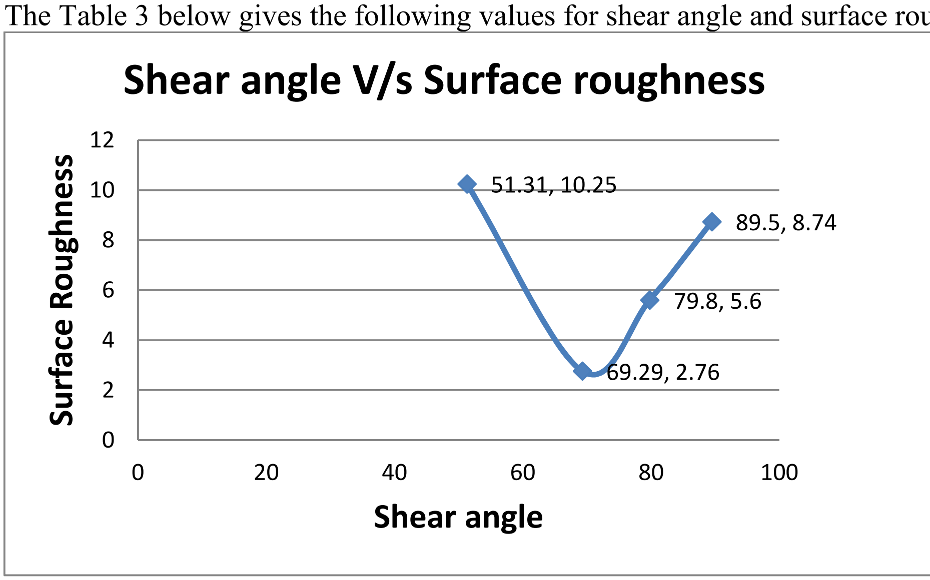

Fig:-5 Shear angle V/S Surface roughness

The above Fig:-5 show the relationship between surface roughness and shear angle. As it can be seen that the surface roughness decreases as the shear angle increases to certain level, there on angle also increases the surface roughness.

5 CONCLUSION:

In this work, the effect of different rake angle and shear angle on surface roughness was successfully studied and recorded. From the rake angle data it is is concluded that as the rake angle increases the surface roughness reduces up to certain levels thereon an increase in shear angle the surface roughness also increases. This can be attributed to the decrease in lip angle of the tool with increase in rake angle which in directly increases the shear angle. The thickness of the tool near the nose gets reduced causing decrease in strength and stiffness of the tool. This causes vibration of the tool with increase in positive rake leading to increase in surface roughness beyond a critical rake and shear angles.

6 REFERANCES

1. Experimental investigation of the effect of cutting tool rake angle on main cutting force, Journal of Materials Processing Technology. 2005,166, 44–49.
2. Experimental investigation of the effect of cutting depth, tool rake angle and workpiece material type on the main cutting force during a turning process. Proceedings of the 3rd International Conference on Manufacturing Engineering (ICMEN), 1-3 October 2008.
3. Investigation of the effect of rake angle and approaching angle on main cutting force and tool tip temperature, International Journal of Machine Tools & Manufacture.2006, 46, 132– 141.
4. Analytical predictions and experimental validation of cutting force ratio, chip thickness, and chip back-flow angle.
5. Experimental investigations of cutting parameters influence on cutting forces and surface roughness in finish hard turning of MDN250 steel, journal of materials processing technology.2008, 206, 167–179.
6. Effects of cutting edge geometry, workpiece hardness, feed rate and cutting speed on surface roughness and forces in finish turning of hardened AISI H13 steel, International Journal of Advanced Manufacturing Technology. 2005, 25, 262–269.