called cutting shaping process. Example: Turning, Drilling, Milling, Boring Etc.

1.5 Relative motion between work piece and cutting tool

1. Rotation of work against the tool. Example: Turning
2. Rotation of tool against work piece. Example: Drilling, Milling
3. Linear movement of the work piece against the tool. Example: Planer
4. Linear movement of the tool against the work. Example: Shaper

1.6 Tool signature

The various angles of tools are mentioned in a numerical number in practice order. That order is known as tool signature.

The effect of back rake angle and mention the types

Back rake angle of the tool increases the strength of cutting tool and cutting action.
It is classified into two types.

a) Positive rake angle
b) Negative rake angle

a) Negative Rake Angle
The slope given away from the cutting edge is called negative rake angle.

1. To machine high strength.
2. The machine tools are more rigid.
3. The feed rates are high.
4. To give heavy and interrupted cuts.

Side Rake Angle and Mention Its Effects

The angle between the tool face and the line parallel to the base of the tool is known as side rake angle. It is used to control chip flow.

Clearance angle and mention the types

These are the slopes ground downwards from the cutting edges.
The clearance angle can be classified into two types.

a) Side relief angle
b) End relief angle

The nose radius

It is the joining of side and end cutting edges by means of small radius in order to increase the tool life and better surface.

All condition for using positive rake angle

1. To machine the work hardened materials.
2. To machine low strength ferrous and non-ferrous metals.
3. To turn the strong shaft of small diameters.
4. To machine the metal below recommended cutting speeds.
5. To machine the work piece using small machine tools with low horsepower.

1.7 Types of metal cutting process

The metal cutting processes are mainly classified into two types.

a) Orthogonal cutting process (Two dimensional cutting)
b) Oblique cutting process (Three dimensional cutting)

a) Orthogonal Cutting
The cutting edge of tool is perpendicular to the work piece axis.
b) Oblique Cutting
The cutting edge is inclined at an acute angle with normal to the cutting velocity vector is called oblique cutting process.

1.8 Tool Life

Tool Life is defined as the time elapsed between two consecutive tool reshaping. During this period the tool serves effectively and efficiently.

Taylor's Tool Life Equation

Vtn = C
Where V = Cutting speed in M/Min
T = Tool life in minute
C = Constant
N = Index depends upon tool and work

The Ways of Representing Tool Life

The following are some of the ways of expressing tool life.

1. Volume of metal removed expressing tool life
2. Number of work piece machined per grind
3. Time unit

The Factors Affecting Tool Life

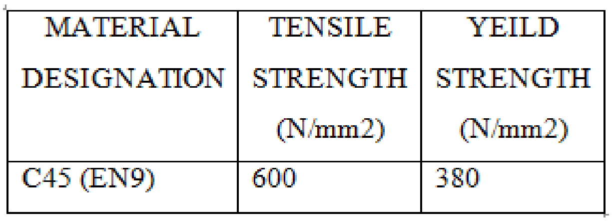
1. Cutting speed
2. Feed and depth of cut
3. Tool geometry
4. Tool material
5. Cutting fluid
6. Work material
7. Rigidity of work, tool and machine

Input Data

1. Machine : Center Lathe
2. Material : Mild Steel (C45)
3. Brinell hardness : 85-125
4. Cutting tool : HSS(S-400)
5. Type : HSS tool ground to give rake and cutting edge angle
6. Recommended speed & feed : 450 rpm & 0.3 mm/rev
7. Selected depth of cut : Maximum depth of cut 3.mm
8. Roughing operation
9. Fit : Clearance
10. Tolerance : USL (50.2), LSL (50.00)

2. Experimental work

1. A heavy precision lathe machine was used for experimentation as shown in figure.
2. The lathe gives us wide variety of feeds, cutting speeds and depth of cut.
3. The lathe has provision for automatic translator motion so as to minimize the variation in cutting conditions.
4. It has high degree of accuracy and rigidity, which are required for the metal machining process.
5. This machine motor horse power is 5 H.P and spindle rotation ranges from 30 rpm to 500 rpm. There are six spindle rotational spindle speed selectable.
6. Work piece is selected with below specifications.
    a) Work piece material: - MILD STEEL
    b) Ref: - PSG DESIGN DATA (1.10&12 1.17)



MATERIAL DESIGNATION	TENSILE STRENGTH (N/mm2)	YEILD STRENGTH (N/mm2)
C45 (EN9)	600	380

7. The work piece is mounted in the chuck as shown in figure.
8. Desired depth of cuts has been applied to the work piece respectively for selected set of rake angle and nose radius by carbide cutting tool (HSS). Tool Material: - High speed steel (S-400)
9. A constant feed (mm/rev) and speed (RPM) is selected for each set of rake angle and nose radius.
    a) Speed: -450 (rpm)
    b) Feed: -0.3 (mm/rev)
    c) Depth of cut:-3(mm)
10. Motor has to be started to carry out the turning operation.
11. Normal force is measured using the dynamometer; the experimental set up is as shown in figure 3.2 & 3.3.
12. Cutting force is measured using the dynamometer; the experimental set up is as shown in figure 3.4 & 3.5.
13. Same work has been carried out for different sets of rake angles and nose radius.
14. Cutting forces are measured and tabulated as shown in table 3.1.

2.1 Set-I

Conducting the test on specimen of EN9 material for first set of readings with 3^0 rake angle and 0.3 mm nose radius

a) Test -1

Measurement of normal force while machining EN9 material with HSS tool 3^0 rake angle and 0.3 mm nose radius

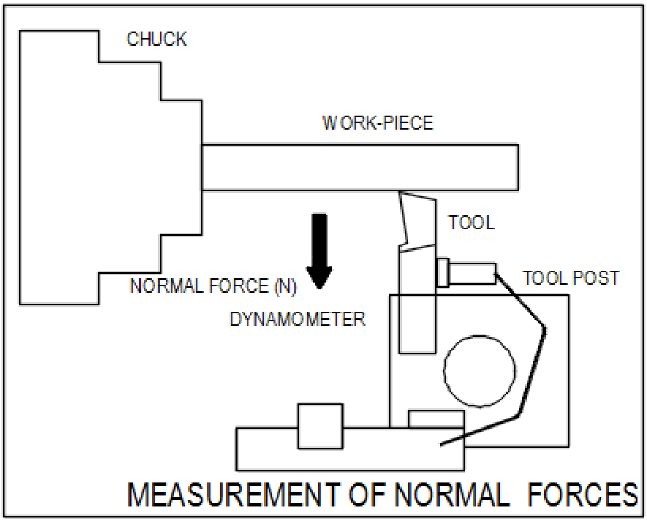


Figure 2: Experimental set up to measure normal force

Figure 3: Actual experimental set up to measure normal force

b) Test -2

Measurement of cutting force while machining EN9 material with tool 3^0 rake angle and 0.3 mm nose radius

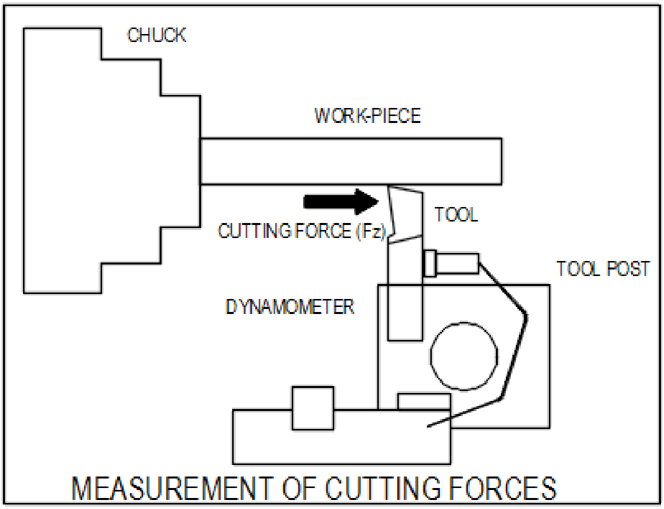


Figure 4: Experimental set up to measure cutting force

Figure 5: Actual experimental set up to measure cutting force

c) Stress calculation

TEST-1
RESULT: Normal force = 1168 N
Direct Tensile or Compressive stress due to a normal load

$$fc\ (act) = \frac{W}{A}$$

$$fc\ (act) = \frac{1168}{20x16}$$

⇒fc act =3.65 N/mm2
As fc (act) < fc all; tool is safe in Compressive.

TEST-2
RESULT: Cutting force = 1168 N
Direct shear stress due to a cutting force

$$fc\ (act) = \frac{W}{A}$$

$$fc\ (act) = \frac{1564}{20x20}$$

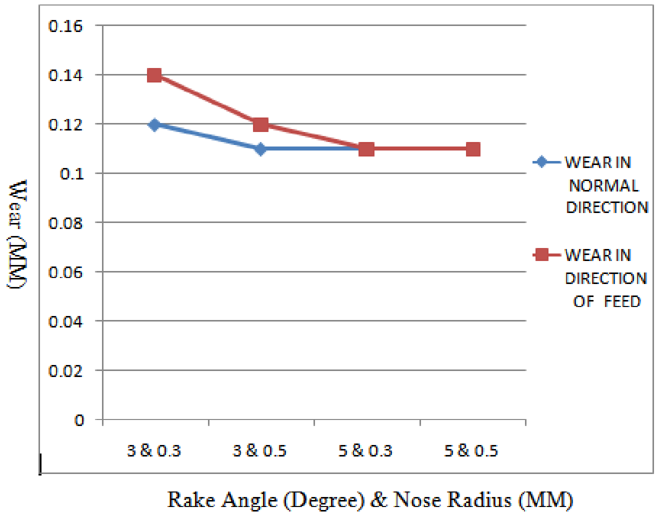
⇒fc act =3.91 N/mm2
As fc (act) < fc all; tool is safe in shear

d) Observation of experimental results

SPEED = 450 RPM
FEED = 0.3 MM/REV
DEPTH OF CUT = 3.0 MM

Table 1: Actual forces & stresses at different sets of rake angles and nose radii

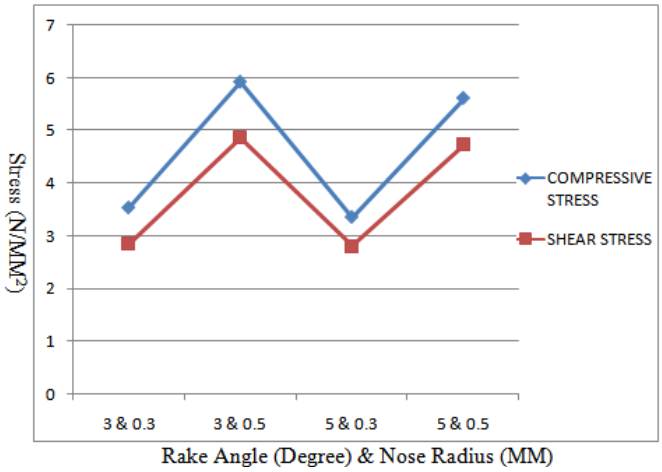
No. of Samples	Rake Angle (Degree)	Nose Radius (mm)	Normal Force (N)	Cutting Force (N)	Compressive Stress (N/mm2)	Shear Stress (N/mm2)
1.	3	0.3	1130	1140	3.53	2.85
2.	3	0.5	1896	1946	5.93	4.87
3.	5	0.3	1072	1124	3.35	2.81
4.	5	0.5	1798	1894	5.62	4.74



Graph 1: Actual stress vs rake angle and nose radius

Table 2: Actual wear at different sets of rake angles and nose radii

No. of Samples	Rake Angle (Degree)	Nose Radius (mm)	Normal Force (N)	Cutting Force (N)	Wear in Normal Direction (mm)	Wear in Direction of Feed (mm)
1.	3	0.3	1130	1140	0.12	0.14
2.	3	0.5	1896	1946	0.11	0.12
3.	5	0.3	1072	1124	0.11	0.11
4.	5	0.5	1798	1894	0.11	0.11



Graph 2: Actual wear vs rake angle and nose radius

3. Conclusion

1. Tool shows better performance with 5 degree rake and 0.3 mm radius with minimal tool wear and there by better tool life.
2. Study the effect of rake angle and nose radius on tool edge integrity and stress produced in the tool material leading to tool edge failure.
3. The result then obtained will be further useful in selecting appropriate rake angle and nose radius for various conditions of speed, feed and depth of cut further leading to economical machining and improved productivity.

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