Experimental Observations of Cutting Forces on Single Point Cutting Tool with Different Rake Angle and Spindle Speed for Constant Depth of Cut

Pradeep Kumar Patil[1], A. I. Khandwawala[2]
[1] *Research Scholar Bhagwant University, Ajmer, Rajasthan,* [2] *Retired Professor, SGSITS, Indore, M.P.*
[1]pradeepkumarpatil207@gmail.com,[2] aikhanwawala@yahoo.co.in

Abstract- **Metal cutting processes are performed on metal cutting machines, more commonly termed as "Machine tools" by means of various types of "cutting tools". One major drawback of metal cutting or machining process is the loss of material in the form of chips. There are many machines which can perform the different operation like: boring machine to make a hole, grinding machine to sharpen the tool, milling machine to make slot, gears, but the most important machine tool is the lathe, which performs many operation. Turning constitutes the majority of lathe work. The cutting forces, resulting from feeding the tool from right to left, removes a surface layer of the work piece is in the form of chips, it will produce three cutting forces components, i.e. main cutting force, which acts in the direction of cutting speed, feed force, which acts in feed rate direction and thrust force, which acts normal to the cutting speed. The research indicate that the cutting forces are directly depends on the cutting parameters like cutting speed, feed rate, depth of cut, work piece material, tool rake angle etc. The present work involves the experimental investigation of friction force on the rake face and normal force on the rake face caused by the change in the rake angle of single point cutting tool for a turning operation in the orthogonal cutting. The experiments are carried on different spindle speeds for the constant depth of cut on specially designed cutting tool dynamometer. The high speed steel single point cutting tools are used. The work piece material in mild steel.**

Key words- **lathe, metal cutting, machine tool, cutting speed, feed, depth of cut, cutting forces, rake angle, depth of cut.**

1. INTRODUCTION

The objective of any manufacturing process is to produce a piece of specified shape and material properties. Therefore, a process, in general will produce changes in configuration and physical properties of the raw material. These can be achieved by carrying out one of the following operations:

1. Constant mass operations (casting, rolling, extrusion, wire drawing, forging, ect.)
2. Material addition operations (bolting, riveting, keying, welding, etc.)
3. Material removal operations (machining, grinding, etc.)

Machining is one of the processes of manufacturing in which the specified shape is imparted to the workpiece by removing surplus material. Conventionally this surplus material from the workpiece is removed in the form of chips by interacting the workpiece with an appropriate tool. This mechanical generation of chips can be carried out by single- or multi-point tools, or by abrasive operations. The process of chip formation in metal cutting is affected by relative motion between tool and the workpiece achieved with the aid of a device called machine tool. The kind of surface that is produced by the operation depends on the shape of the tool and the path it traverses through the material.

1.1 *Orthogonal Cutting*

The cutting edge of the tool is perpendicular to the direction of the cutting velocity. The cutting edge is wider than the workpiece width and extends beyond the workpiece either side. Also the width of the workpiece is much greater than the depth of cut. The chip generated flows on the rake face of the tool with chip velocity perpendicular to the cutting edge.

1.2 *Oblique Cutting*

The cutting edge of the tool is inclined at an inclination angle with the normal to the cutting velocity vector. The chip generated flows on the rake face of the tool t an angle approximately equal to inclination angle with the normal to the cutting edge in the plane of the rake face. The cutting edge extends beyond the width of the workpiece on either side. The cutting forces act along all the three directions.

2.CUTTING TOOL GEOMETRY

Back Rake Angle: It is the angle between the face of the tool and a line parallel to base of the tool and measured in plane (perpendicular) through the side cutting edge.

Side Rake Angle: It is the angle between the tool face and a line parallel to the base of the tool and measured in a plane perpendicular to the base and the side cutting edge. This angle gives the slope of the tool from the cutting edge.

Side Relief Angle: It is the angle between the portion of the side flank immediately below the side cutting edge and a line perpendicular to the base of the tool, and measured at right angle to the side flank.

Side Cutting Edge Angle: It is also known as lead angle, is the angle between the side cutting edge and the side tool shank. It is the angle which prevents interference as the tool enters the work material. The tip of the tool is protected at the start of the cut. This angle affects the tool life and surface finish.

End Relief Angle: It is the angle between the portion of the end flank immediately below the end cutting edge and a line perpendicular to the base of the tool, and measured at right angle to the end flank. The relief angles range from 5^o to 15^o for general turning.

End Cutting Edge Angle: This is the angle between the end cutting edge and a line normal to the tool shank. This angle provides a clearance or relief to the trailing end of the cutting edge to prevent rubbing or drag between the machined surface and the trailing part of the cutting edge. Figure 1 indicates the cutting angles and geometry.

3. PROPERTY OF CUTTING TOOL MATERIAL

The three most important desirable properties of a tool material are wear resistance, hot hardness and toughness. This is because during machining, the tool tip is subject to relatively high temperature, intense normal pressure and frictional stress, abrading action of the work-hardened chip on the rake face, abrading action of the machined surface on the tool flank, impact due to interrupted cutting or hard spots, and vibration.

4. EXPERIMENTAL SETUP

To measure the friction force on the rake face and normal force on the rake face special load cell based tool dynamometer is used. It consists of two load cells each of capacity of 4905 N. he special tool holder is also designed to mount the cutting tool and the load cells to measure the cutting forces.

Fig.: 1 Experimental Setup

5.WORKING CONDITION

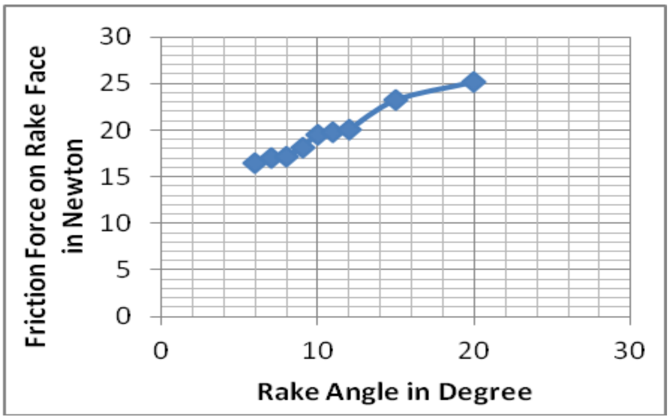
Rake angle: 6^0, 7^0, 8^0, 9^0, 10^0, 12^0, 15^0 and 20^0
Depth of cut: 0.5 mm,
Spindle speed: 187 rpm, 276 rpm and 400 rpm

Workpiece Material: Mild Steel of hardness 60 BHN

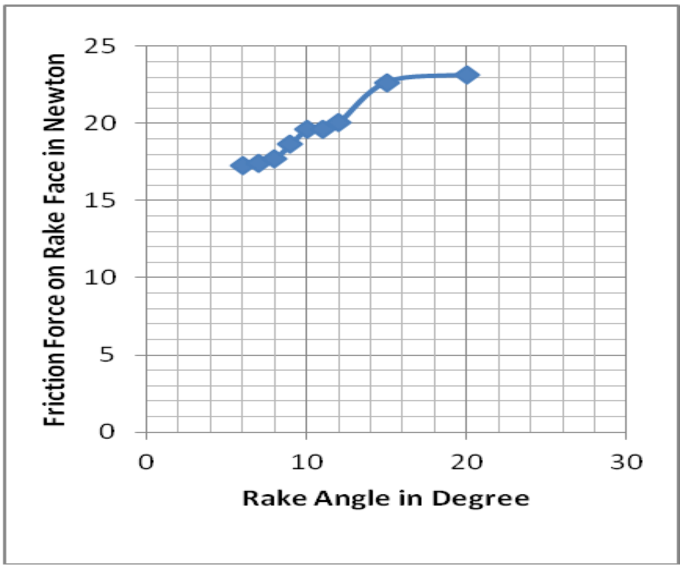
6. TABLE AND GRAPHS

Table: 1

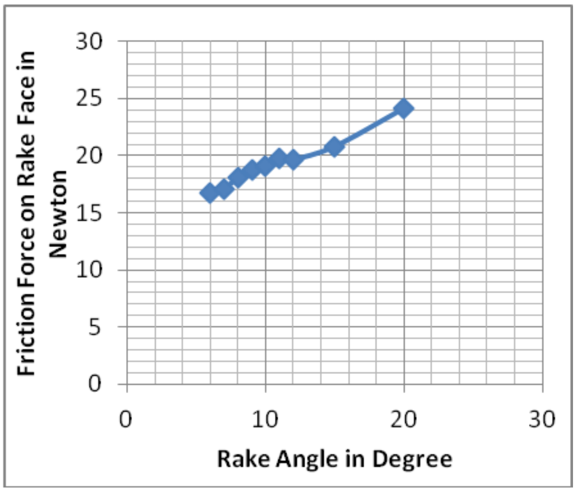
Sr No	Rake Angle	Speed in RPM					
		187		276		400	
		F	N	F	N	F	N
1	6^0	16.40	33.08	17.29	33.32	16.73	33.41
2	7^0	17.05	33.37	17.39	33.00	17.13	32.74
3	8^0	17.20	32.82	17.72	32.61	18.04	32.66
4	9^0	18.13	32.51	18.64	32.10	18.74	31.96
5	10^0	19.46	31.76	19.59	31.90	19.13	31.85
6	11^0	19.73	31.20	19.63	32.01	19.78	32.09
7	12^0	20.05	32.06	20.04	31.35	19.67	31.00
8	15^0	23.21	29.26	22.67	30.41	20.81	29.52
9	20^0	25.17	27.50	23.14	28.28	24.13	27.96



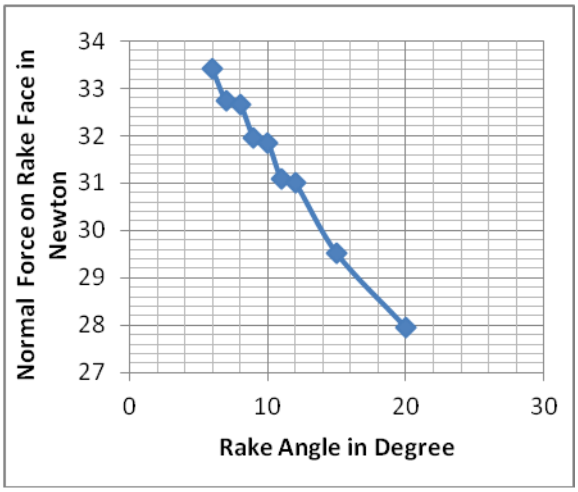
Graph 1(Friction force Vs Rake angle for 187 rpm Spindle speed)



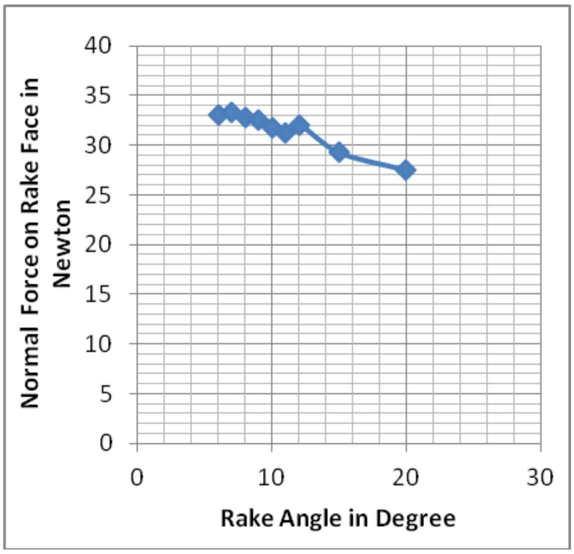
Graph 2(Friction force Vs Rake angle for 276 rpm Spindle speed)



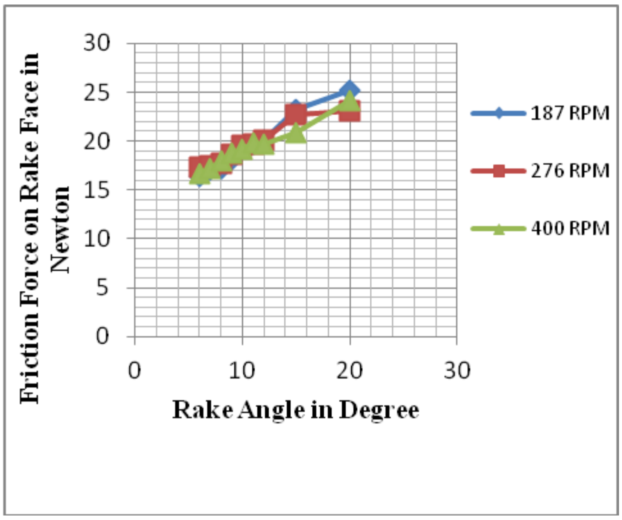
Graph 3(Friction force Vs Rake angle for 400 rpm Spindle speed)



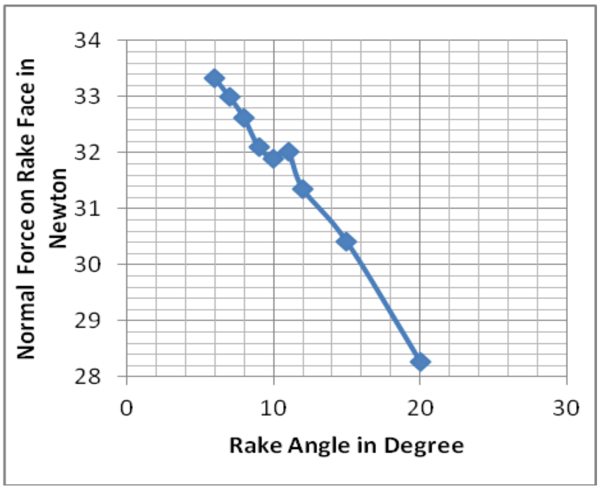
Graph 6(Normal force Vs Rake angle for 400 rpm Spindle speed)



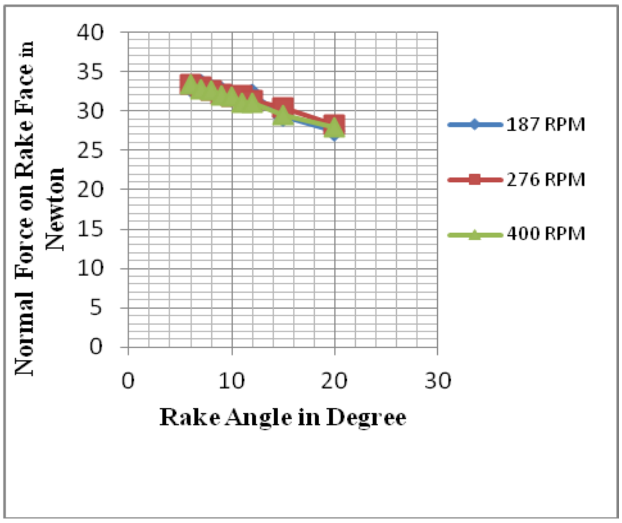
Graph 4 (Normal force Vs Rake angle for 187 rpm Spindle speed)



Graph 7 (Friction force Vs Rake angle for different Spindle speed)



Graph 5(Normal force Vs Rake angle for 276 rpm Spindle speed)



Graph 8 (Normal force Vs Rake angle for different Spindle speed)

8. RESULT AND DISCUSSION

The experimental results indicate that the rake angle influences the cutting forces, power and surface finish. Due to large rake angle, the friction force on rake face will increase because less metal is available to support the tool and conduct the heat generated due to plastic deformation and friction. But for large rake angle the normal forces decreases. The experimental results also indicate that on 400 rpm spindle speed the friction forces are lower as compare to the friction forces at 187 rpm and 276 rpm. The normal force is also decreases uniformly for 400 rpm spindle speed.

9. CONCLUSION

At last, on the basis of experimental analysis it has been concluded that, by increasing the rake angle of the cutting tool, the frictional force on the rake face increases, the cutting forces at 400 rpm spindle speed are less compared to the forces at 187 rpm 276 rpm.

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