

# A Study on the Effect of Rake Angle and depth of cut on Cutting Forces during Orthogonal Cutting

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**ABSTRACT:** This research paper reports the significance of influence of speed, depth of cut, feed rate and type of work materials on cutting forces, while working with HSS single point cutting tool having various rake angles and the work materials of aluminum. These experiments were conducted using PSG 124 / A 124 type lathe is a heavy duty precision lathe. The results have indicated that it is depth of cut, cutting speed and rake angles which has significant influence both on cutting force.

**KEYWORDS :** Cutting Forces, Cutting Speed, Rake Angles, depth of cut

## I . INTRODUCTION

Turning operation using a single point cutting tool has been one of the oldest and popular methods of metal cutting. It has even replaced grinding in several applications with reduced lead time without affecting the surface quality. In this connection, two important aspects which are widely studied in turning operations are cutting forces and surface roughness of the work-piece. Process parameter optimization is of great significance while looking into the process capability of any machining operation. A group of researchers including have found that cutting parameters (Feed rate, Cutting Speed, Depth of Cut, tool geometry and material properties of tool) directly influence the surface finish of machined components. However, among the cutting force, thrust force, and feed force, the former prominently influences power consumption and this work considers only cutting force as one of the endogenous factors. Surface roughness is also a vital measure as it may influence frictional resistance, fatigue strength or creep life of machined components. As far as turned components are concerned, better surface finish (low surface roughness) is important as it can reduce or even completely eliminate the need of further machining.

Cutting force is basically the product of specific cutting energy coefficient (N/mm<sup>2</sup>), depth of cut (mm), and feed (mm/rev). Cutting force is generally resolved into three components, namely feed force (F<sub>x</sub>), thrust force (F<sub>y</sub>), and cutting force (F<sub>z</sub>). The feed force and cutting force has been the focus of this study. The surface finish of any given part is measured in terms of average heights and depths of peaks and valleys on the surface of the work piece.

### Orthogonal Cutting

In order to achieve the basic knowledge of the mechanics in metal removal, the orthogonal two dimensional cutting is going to be explained in this section. The material is removed by the cutting tool edge precisely located perpendicular to the workpiece surface. Therefore, in this shaping process the tool's cutting edge is also perpendicular to the direction of the cutting velocity.



Fig. 1 Orthogonal cutting



**II. RELATD WORK**

The authors by Satyanarayana Kosaraju presented the effects of rake angle and feed rate on cutting forces in orthogonal metal cutting process. On the basis of results they found that with increase in feed rate and rake angle cutting force increases and decreases respectively[1]. In [2] In this paper, effect of rake angle on cutting forces for a single point cutting tool is discussed. During machining, the chip formation depends on the rake angle of the single point cutting tool. Different experiments are carried out to identify the variation in cutting forces with the variation in rake angles. The effect of feed rate on cutting force is also brought under consideration. It was observed that the feed force (Fx) is greater than tangential force (Fy). It is also observed that the radial force (Fz) in the present experimental set-up is very small when compared to the other two force components. As the radial force is negligible, the turning of a cylindrical work piece makes it more closure to the orthogonal machining process. The cutting forces increase with the increase in feed rate. In [3] Different experiments are carried out to identify the variation in cutting forces with the variation in rake angles. The effect of feed rate on cutting force is also brought under consideration. It was observed that the feed force (Fx) is greater than tangential force (Fy). It is also observed that the radial force (Fz). As the radial force is negligible, the turning of a cylindrical work piece makes it more closure to the orthogonal machining process. The cutting forces increase with the increase in feed rate. In [4] presented the effects of rake angle and feed rate on cutting forces in orthogonal metal cutting process. On the basis of results they found that with increase in feed rate and rake angle cutting force increases and decreases respectively.

**III. METHODOLOGY**

- The turning operation was conducted using PSG 124 / A 124 type lathe is a heavy duty precision lathe with a range of spindle speed 31.5 to 1400 rpm and 7.5KW motor drive.
- The instrument used for the measurement of cutting force was Multi-Component Force Indicator. Instrument operates on 230V, 50Hz AC mains. The data was obtained through a USB cable connected to the Dynamometer and stored on a computer.
- The cutting tool was a single point hss cutting tool with 10% cobalt.
- The materials used was aluminium. These bar having daimeter of 24 mm and 150 mm length were machined under dry condition.

Among the speed, feed rate, rake angle, work piece material and depth of cut combinations available on the Lathe.

**Table 1** Cutting conditions

Cutting parameters	Level (-)	Level (+)
Speed ( rpm )	160	360
Feed (mm/rev)	0.12	0.12
Depth of cut (mm)	0.5	0.5
	1	1
Rake angles (°)	5	5
	11	11
Work piece material	Aluminum	Aluminum

Turning tests were conducted using HSS single point cutting tool on a PSG 124 / A 124 type lathe is a heavy duty precision lathe. A cylindrical work piece having diameter of 24 mm and 150 mm length. A total of 4 experiments were performed with 2 different rake angles 5° and 11° at two different speed of 160 rpm and 360 rpm and depth of cut of 0.5 mm and 1mm at feed rate of 0.12 mm/rev respectively.

IV. EXPERIMENTAL RESULTS

The results of the experiments carried out to measure the effects of the change in rake angle and depth of cut on cutting force in two directions are presented in Table .. The cutting forces were measured by using piezoelectric dynamometer and variations were plotted as shown in Figs. 2-5. The turning process has been assumed to be a pure orthogonal process. For such an assumption only 2 components of force must exist in the orthogonal plane.

Table 2 cutting parameters and mesured force values

Group No	Feed (mm/rev)	Rake angle(°)	Speed (rpm)	Depth of cut (mm)	F <sub>x</sub> (N)	F <sub>z</sub> (N)
1	0.12	5°	160	0.5	17	20
				1	28	46
360			0.5	15	16	
			1	39	44	
3	0.12	11°	160	0.5	17	40
				1	26	55
360			0.5	13	32	
			1	23	38	

From Figures 2 to 5, it is clear that the cutting forces decreases with increase in rake angle and the cutting forces were found to increase continuously with an increase in depth of cut for all rake angles. This is due to the fact that the volume of work material coming in contact with the tool or the volume of material being removed also increases with the increase in depth of cut , the cutting forces continuously increase with feed, the increase is more prominent at lower rake angles while less at higher rake angles. This is because the plunging effect of the tool into the workpiece material at a greater rake angle overshadows the effect of increase in cutting force with increase in depth of cut at higher rake angles.

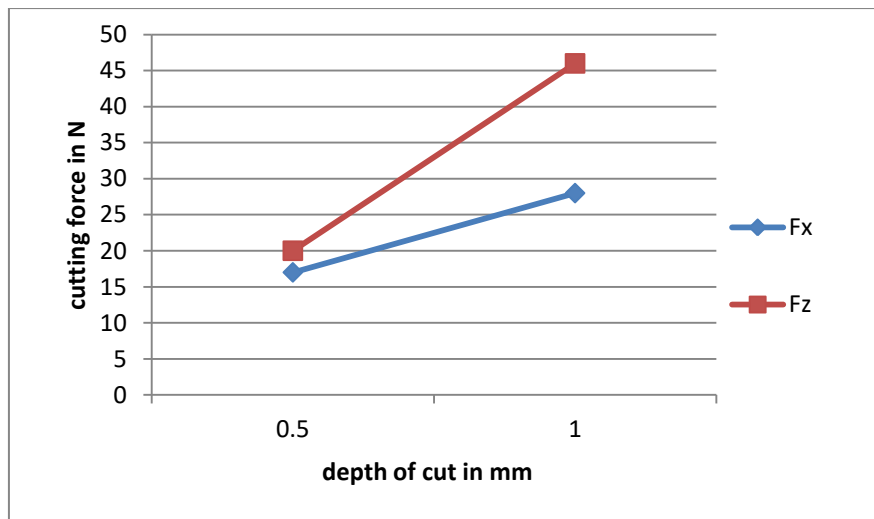


Fig. 2 Effect of depth of cut on cutting forces at 5° rake angle and 160 rpm

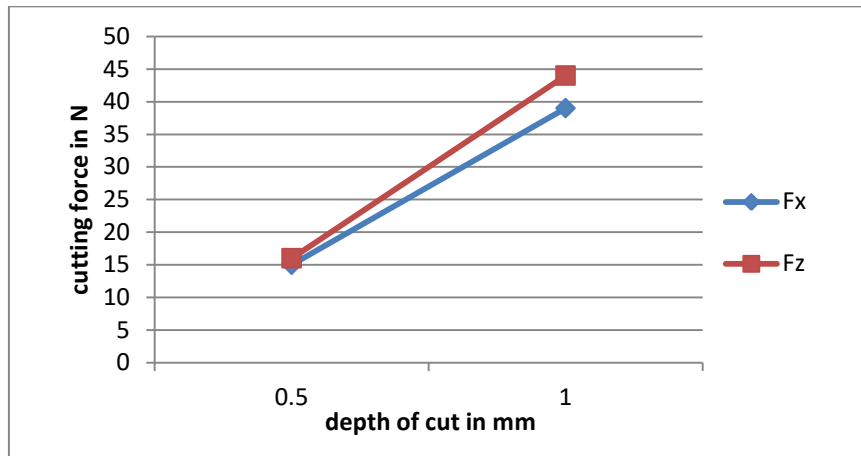


Fig. 3 Effect of depth of cut on cutting forces at 5° rake angle and 360 rpm

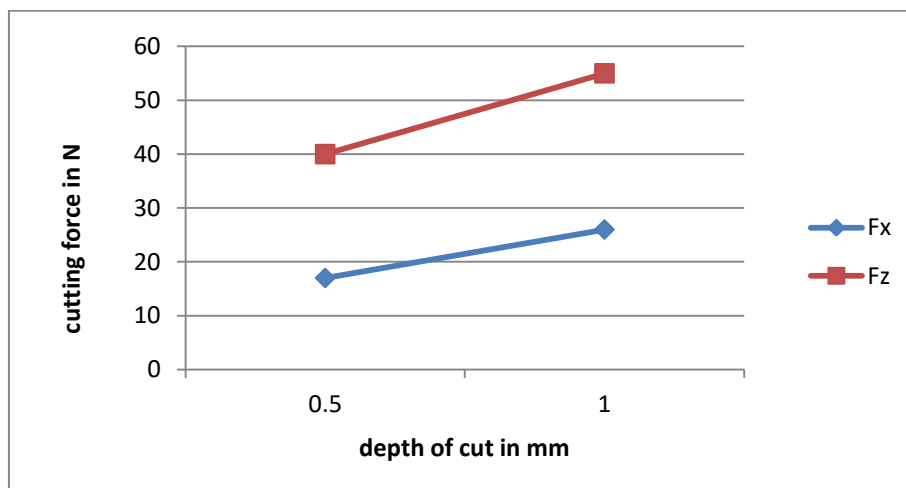


Fig. 4 Effect of depth of cut on cutting forces at 11° rake angle and 160 rpm

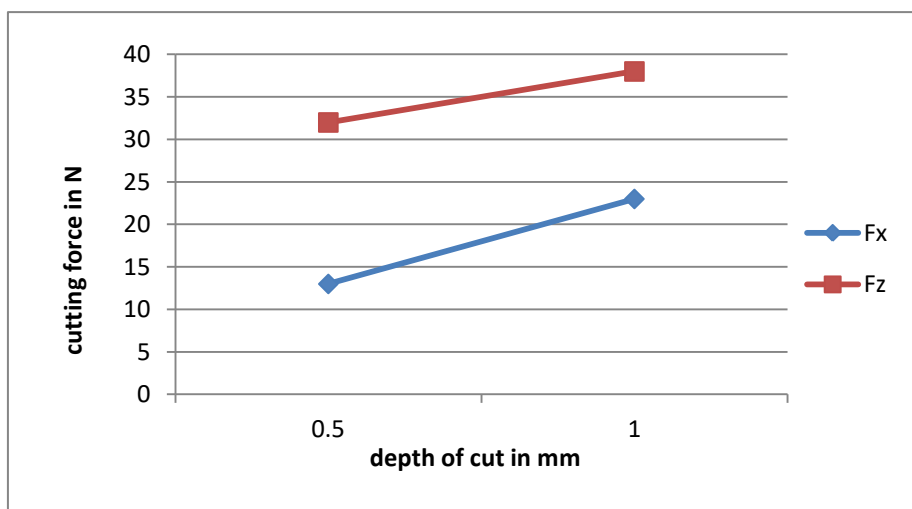


Fig. 5 Effect of depth of cut on cutting forces at 11° rake angle and 360 rpm

## V. CONCLUSION

In this paper, the effect of depth of cut, cutting speed and rake angles on the cutting forces during orthogonal turning of aluminum work piece using tools of high speed steel been investigated. It is also observed that the radial force in the present experimental set-up is very small and negligible when compared to the other two force components. And also observed that

- Cutting forces increases with increase in depth of cut
- Cutting forces decreases with increase in rake angel
- Cutting forces decreases with increase in cutting speed
- Cutting forces increases with increases in feed rate

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