EXPERIMENTAL ANALYSIS FOR EFFECT OF RAKE ANGLE ON MACHINING

Mr. Mohammed Obed Ur Rahman[1], Dr. Afroz Mehar[2], Dr. M. Subburaj[3],

PG Scholar M tech CAD/CAM[1], Professor[2,3], Dept of Mechanical Engineering

Shadan College of Engineering and Technology, Hyderabad, India.

Email. id: mohammedobed786@gmail.com[1]

Abstract:

In this study, the main cutting force applied while rotating components with new cutting tools is compared using empirical and experimental data. To measure the forces, a device called a dynamometer was developed. Two strain gauges were suitably positioned on the machine tool and cutting tool at the time of design. When the gauge was placed properly, it picked up tool displacements caused by cutting forces. AISI 1040 served as the workpiece's material. The primary cutting force was measured using eight different rake angles that ranged from negative to positive values at five different cutting speeds (Fc). The feed rate and depth of incision were maintained throughout the tests. Experimental results were compared to empirical findings made utilising the Kienzle method. The rake angle was demonstrated to be decreasing with time as it changed from negative to positive values. The empirical approach and the experiments differed by 10 to 15 percent, on average.

1. INTRODUCTION

The metal cutting process is very useful in most sectors, particularly engineering, and as a result, it plays a vital role in the manufacturing industries and its operations. The material of the workpiece and its qualities, the tool configuration, the machine's settings, the desired output of the workpiece, etc. are only a few of the many variables that affect the outcome of the metal cutting process. By managing the process parameters or by identifying the factors that affect the output or quality of the product and restricting them within the intended limits, the metal cutting or machining process may be made efficient with the desired cost of manufacture. Understanding process characteristics like depth of cut, speed, need for cooling fluids, feed, etc. is crucial to understanding any machining process. One must only rely on empirical formulae to determine cutting forces and tool life throughout the machining process. The empirical equations used for machining processes, however, contain a large number of constants, and the data needed to solve them is difficult to obtain because these constants depend on a wide range of variables. As a result, it is important to develop alternate techniques for estimating tool life, cutting forces, and other parameters.

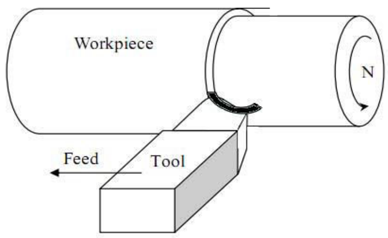


Figure 1.1 Schematic diagram of turning operation

1.2 Parameters to be considered machining

The workpiece's profile geometry and the process parameters typically determine the machining procedure. Since the depth of cut, speed, and feed are defined parameters in the turning operation, the rate of metal removal is also greatly influenced by them. However, there are other, less important parameters that affect the quality of the machined surface, such as surface roughness, tool wear, etc., which must be properly controlled either manually or through programming if a CNC lathe is used.

1.2.1 Cutting Speed

The pace at which the workpiece would rotate so that the cutting tool could execute machining on the workpiece is known as the cutting speed or surface speed. The cutting speed is expressed in m/min or rev/min. The spindle speed and the workpiece's diameter, which is calculated using the formula, both affect cutting speed.

$$V = \frac{\pi DN}{1000} \text{ (m/min)}$$

1.2.2 Feed rate

The amount of tool tip movement along the workpiece in a linear direction for each billet turn is Feed is the amount of material the tool tip moves for each rotation of the work piece along its line of travel. It is given in mm/rev and is indicated by the letter "f." Occasionally, it is also stated as the spindle speed in mm/min as

F m = f N where, f = Feed in mm/rev
N = Spindle speed in rpm

1.2.3 Depth of cut

The depth of cut (d), which is measured in millimetres, is used to define the amount of material that must be removed from the workpiece in order to obtain the desired profile. This quantity is also referred to as the thickness of the material that must be removed in order to obtain the desired finished surface.

When the workpiece is rotating and material is being removed, the depth of cut must be measured in terms of the penetration depth. As a result, the kind of operation that has to be completed on the workpiece, such as facing or turning, etc., determines the direction and depth of penetration for the depth of cut in the lathe operations.

1.2.4 Rake Angle (α)

Rake angle is one of the most important tool geometry factors whenever any machining operations need to be performed on a lathe machine. By carefully choosing the rake angle, the total effectiveness may be increased. The increase of the cost reduction for the manufacturing immediately benefits from the development of the machining operation's efficiency.

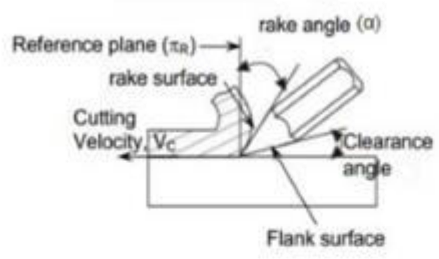


Figure 1.2 Schematic diagram of Rake angle

2. LITERATURE REVIEW

C. J. Raoa et al.,[1] studied about the tools, input work materials, machine parameter settings influence on process efficiency and output quality characteristics. A significant improvement in process efficiency may be obtained by process parameter optimization that identifies and determines the regions of critical process control factors leading to desired outputs or responses with acceptable variations ensuring a lower cost of manufacturing.

Mustafa Sekmena et al.,[2] has studied about the experimental investigation of the effect of cutting tool rake angle during machining of AA 2011 and AA 7075 aluminium alloys was carried out. For this purpose, a previously designed and manufactured dynamometer incorporating load cells was used to measure the cutting forces during turning. This system enabled the tool holder to rotate so that the cutting tool's rake angle could be adjusted. The machining tests were conducted at six different rake angles, five different cutting speeds while feed rate and depth of cut were kept constant. During the tests, primary cutting force (Fc) and feed force (Fa) components were_measured and recorded on a personal computer (PC). Theoretical cutting force values were also determined using Kienzle approach. The results showed that cutting forces decreased with increasing rake angle and increasing cutting speed for the both alloys.

Jayeshbhai et al.,[3] presented the analytical model which will give best result for AISI304 material.

By using

1. Ernst and merchant.
2. Lee and Schaffer and
3. Dautzenberg C.S model theoretically and comparing with each with experimental data.
4. Experiments are carried out for different cutting condition and also reason for this is found out and behaviour of shear angle is studied for different cutting condition.

Bashistakumar et al., [4] focussed on the Force modelling. Force Modelling in metal cutting is important for various purposes, including Thermal analysis, tool life estimation, chatter prediction, and tool condition monitoring. Numerous approaches have been proposed to model metal cutting forces with various degrees of success. In addition to the effect of work piece materials, cutting parameters, and process configurations, cutting tool thermal properties can also contribute to the level of cutting forces. The process of orthogonal metal cutting is studied with the finite element method under plane strain conditions. A numerical procedure has been developed for simulating orthogonal metal cutting using a general-purpose finite element method. The focus of the results presented in this work is on the effect of forces on the tool by variation of cutting parameters. The result is simulated with the analytical value for evolution of effective force for cutting material under various cutting condition.

Rahul Kshetri et al.,[5] investigated the effect of input cutting parameters (Cutting speed, feed rate and depth of cut) on cutting forces (feed force, thrust force and cutting force). Experimental values have been compared to the values calculated by regression equation, and surface plots, interaction plots and mean effect plots are drawn for all cutting force component. The results obtained in this study shows that while machining to the red brass (C23000) the depth of cut found the more dominant contributor through all component of cutting forces. With the help of Regression model surface plots are drawn, all interaction on surface for different parameters and their main effects in to all input parameters have also been discussed in this work.

3. METHODOLOGY

3.1 CUTTING FORCES IN ORTHOGONAL CUTTING

In orthogonal cutting the resultant force applied by the tool to the chip lies in a plane normal to the cutting edge. This can be determined experimentally by measuring its orthogonal components in the direction of cutting (known as cutting force) and other normal to the direction of cutting (known as thrust force) with the help of dynamometers. The magnitude of resultant force may be found out as follows

$$R = \sqrt{F_h^2 + F_v^2}$$

The component of R in the direction of width b is zero.

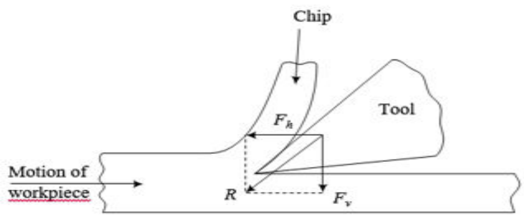
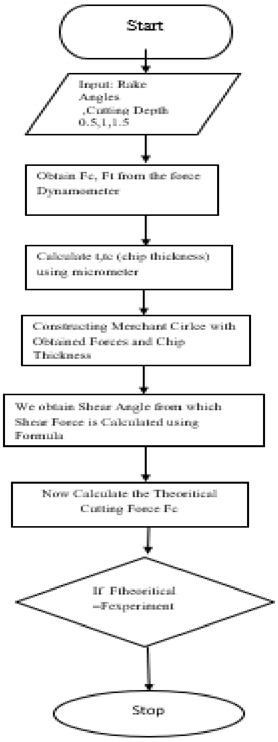


Fig 3.1: Orthogonal component of cutting force

3.2 FLOWCHART



4. EXPERIMENTATION

The aim of this study is to experimentally the influence of cutting depth, tool rake angle and workpiece material type on the main cutting force and chip morphology during a turning process.

UNS G10200, UNSA92014 and Red Brass specimens were used as workpiece materials. Totally 4 experiments per material type were performed in order to measure the main cutting force (Fc).

The experiments were obtained with constant cutting speed (66.6 m/min) and feed rate (0.2 mm/r.e.v.), cutting depth (1.5 mm) and four different tool rake angles (0o-20o).

4.1 Lathe and cutting tool

The cutting tests have been carried out on an CNC lathe. The combined geometry of the selected tool is:

- Rake angle: = 0,6 ,12,20
- Cutting angle radius: re= 1.0 mm
- Relief angle: = 8

The tool side cutting angle for the experimental tests was K= 45, for this purpose the tool post was rotated at 45 from the vertical to the specimen axis anticlockwise angle.

4.2 Cutting conditions

Cutting parameters, i.e. cutting speed, cutting depth and feed rate, were selected according to the following two criteria, firstly, the experimentally measured cutting force should not exceed the upper limit of the dynamometer working rage and secondly, the selected cutting parameters can be applied successfully on the three types of workpiece materials. The cutting parameters were suggested by cutting tool supplier and finally selected as follows:

- Cutting speed: v= 66.6 m/min
- Feed rate: s= 0.2 ,0.19, 0.18 mm/rev
- Cutting depth: a= 2 mm,1.5mm,1mm,0.5mm

Each experiment was carried out with new sharp tools in order to keep the cutting conditions unchanged. The cutting-test were conducted without coolant and, as result, totally 12experiments per material type were performed

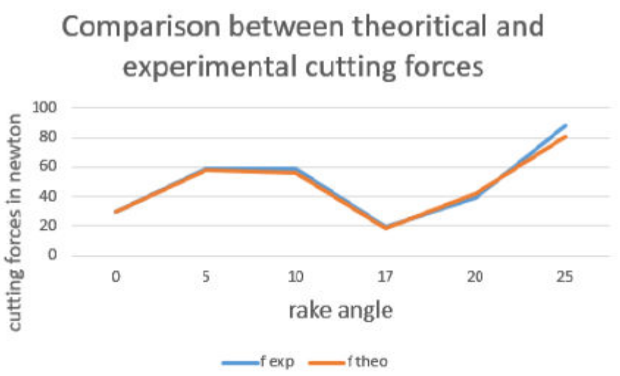
4.3 Chip Morphology

During machining, three main types of chip are formed i.e. discontinuous chip, continuous chip and continuous chip with built up edge. On the other hand, in practice, more complex chip types could be produced.

5. RESULTS

5.1 Material: AISI 1018								
S.No	Rake Angle in degrees	Chip Thickness	Chip thickness Ratio	Shear Angle In degrees	Experimental Cutting Forces(N)			
					Fx	Fy(Fc)	Fz	Ftheoritical
1	0	0.74	0.6757	33.88	29.4	29.4	117.6	29.4
2	5	0.76	0.65	34.66	49	58.8	68.6	58.19
3	10	0.55	0.9	46.41	39.2	58.8	117.6	55.98
4	17	0.87	0.57	38.18	9.8	19.6	137.2	18.43
5	18	0.88	0.56	32.78	29.4	58.8	68.6	57.1
6	20	0.75	0.66	38.7	19.6	39.2	29.4	42.03
7	25	0.51	0.98	56.6	29.4	88.2	117.6	80.77

Table 5.1 AISI 1018 with depth of cut 1mm and feed rate 0.20mm/rev

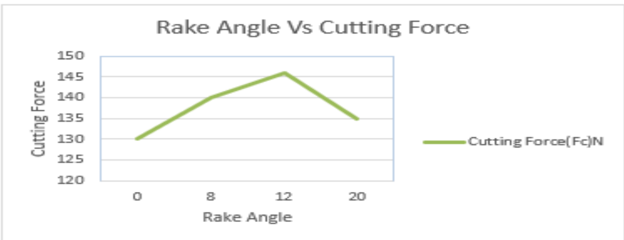


Graph 5.1 Comparison of Experimental and theoretical Cutting forces of AISI 1018

DEPTH OF CUT 2MM AND FEED RATE 0.20MM/REV

5.2Material :UNSC2300				Depth of Cut: 2mm			feedrate:0.20mm/rev		
S.No	Rake Angle(Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	128.10	130	128.10	2	2.43	0.82	27.99	53
2	8	139.64	140	102.89	2	2.13	0.93	31	65.5
3	12	144.5	146	85.87	2	2.08	0.98	33	70
4	20	134.93	135	63	2	2.06	0.97	39	65.26

Table 5.2 UNSC2300 with depth of cut 2mm and feed rate 0.20mm/rev

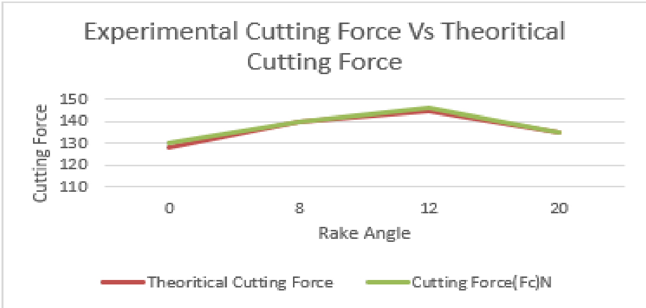


Graph 5.2 Rake Angle Vs Cutting Force of UNSC2300 with depth of cut 2mm and feed rate 0.20mm/rev

Percentage of Deviation

Material :UNSC2300 Depth of Cut: 2mm		
S.No	Rake Angle	Percentage of Deviation
1	0	1.46%
2	8	0.25%
3	12	1.02%
4	20	0.05%

Table 5.3 Percentage of Deviation UNSC2300 with depth of cut 2mm and feed rate 0.20mm/rev

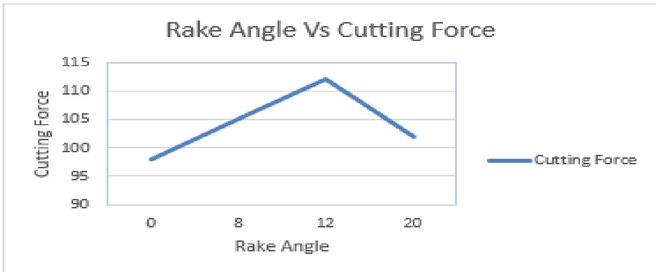


Graph 5.3 Comparison of Experimental and theoretical Cutting forces of UNSC2300 with depth of cut 2mm and feed rate 0.20mm/rev

DEPTH OF CUT 1.5MM AND FEED RATE 0.20MM/REV

5.3Material :UNSC2300					Depth of Cut: 1.5		feedrate:0.20mm/rev		
S. No	Rake Angle(Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	99.11	98	97	1.5	2.8	0.53	27.92	41.17
2	8	102.84	105	76	1.5	2.4	0.62	29.45	51.45
3	12	111.39	112	70	1.5	2.1	0.71	30.81	58.62
4	20	101.62	102.06	48	1.5	1.8	0.83	31.02	62.67

Table 5.4 UNSC2300 with depth of cut 1.5mm and feed rate 0.20mm/rev

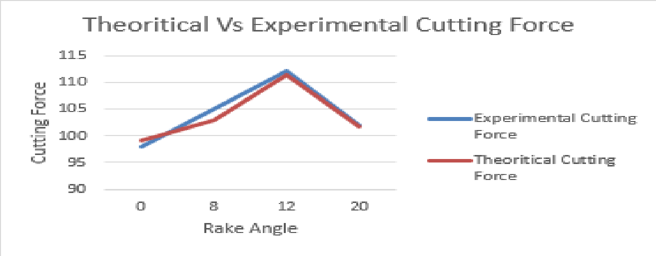


Graph 5.4 Rake Angle Vs Cutting Force of UNSC2300 with depth of cut 1.5mm and feed rate 0.20mm/rev

Percentage of Deviation

Material :UNSC2300		Depth of Cut: 1.5mm
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	1.11%
2	8	2.05%
3	12	0.54%
4	20	0.43%

Table 5.5 Comparison of Experimental and theoretical Cutting forces of UNSC2300 with depth of cut 1.5mm and feed rate 0.20mm/rev

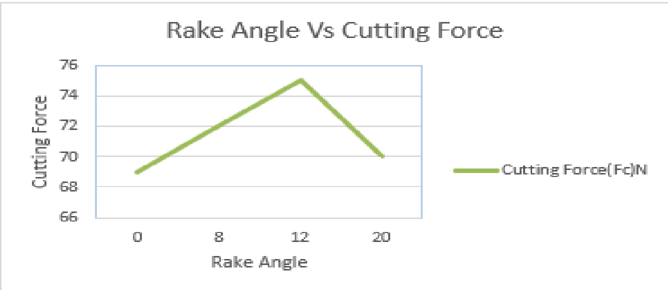


Graph 5.5 Comparison of Experimental and theoretical Cutting forces of UNSC2300 with depth of cut 1.5mm and feed rate 0.20mm/rev

DEPTH OF CUT 1MM AND FEED RATE 0.19MM/REV

5.4 Material :UNSC2300			Depth of Cut:1mm			feedrate:0.19mm/rev			
S.No	Rake Angle(Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	70.21	69	64	1	1.96	0.51	27.10	30.52
2	8	72.22	72	54	1	1.67	0.59	28.46	37.56
3	12	74.72	75	49	1	1.46	0.68	29.90	40.59
4	20	68.31	70	33	1	1.23	0.81	30.56	42.63

Table 5.6 Rake Angle Vs Cutting Force of UNSC2300 with depth of cut 1mm and feed rate 0.19mm/rev

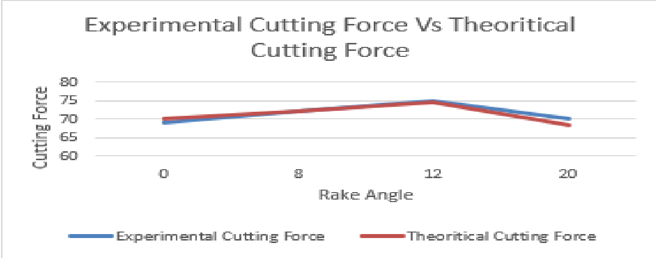


Graph 5.6 Rake Angle Vs Cutting Force of UNSC2300 with depth of cut 1mm and feed rate 0.19mm/rev

Percentage of Deviation

Material :UNSC2300		Depth of Cut: 1mm
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	1.72%
2	8	0.3%
3	12	0.37%
4	20	2.41%

Table 5.7 Percentage of Deviation UNSC2300 with depth of cut 1 mm and feed rate 0.19mm/rev



Graph 5.7 Comparison of Experimental and theoretical Cutting forces of UNSC2300 with depth of cut 1mm and feed rate 0.19mm/rev

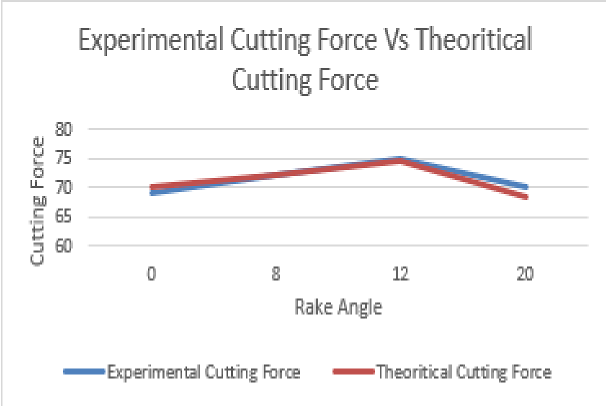
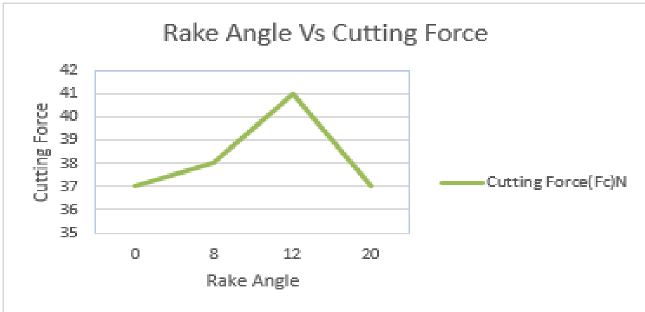


Table 5.8 UNSC2300 with depth of cut 0.5 mm and feed rate 0.18mm/rev

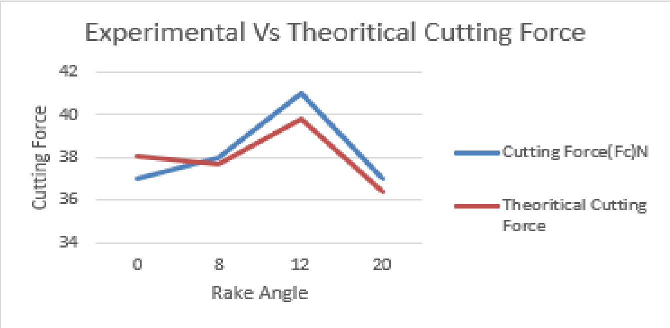


Graph 5.8 Rake Angle Vs Cutting Force of UNSC2300 with depth of cut 0.5mm and feed rate 0.18mm/rev

Percentage of Deviation

Material :UNSC2300		Depth of Cut: 0.5mm
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	2.7%
2	8	0.86%
3	12	2.92%
4	20	1.64%

Table 5.9 Percentage of Deviation UNSC2300 with depth of cut 0.5 mm and feed rate 0.18mm/rev

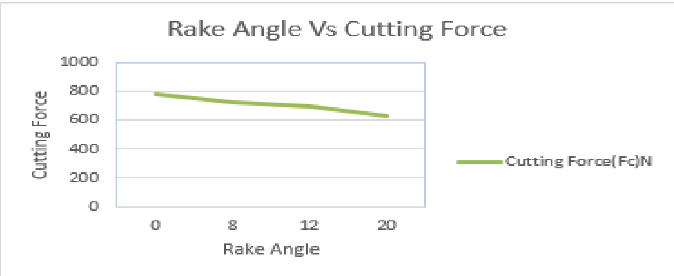


Graph 5.9 Comparison of Experimental and theoretical Cutting forces of UNSC2300 with depth of cut 0.5mm and feed rate 0.18mm/rev

DEPTH OF CUT 2MM AND FEED RATE 0.20MM/REV

5.6Material : UNS G10200			Depth of Cut: 2mm federate:0.20mm/rev						
S.No	Rake Angle(Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut Chip(tc)	Chip thickness ratio(t/tc)	Shear Angle (Degrees)	Shear Force(Fs) N
1	0	777.48	780	774	2	2.93	0.68	31	266
2	8	719.30	720	420.90	2	2.31	0.86	32.8	311
3	12	698.28	700	600	2	2.10	0.95	33.5	332
4	20	630.57	632	441.50	2	2.06	0.97	39	306.79

Table 5.10 UNSG10200 with depth of cut 2mm and feed rate 0.20mm/rev

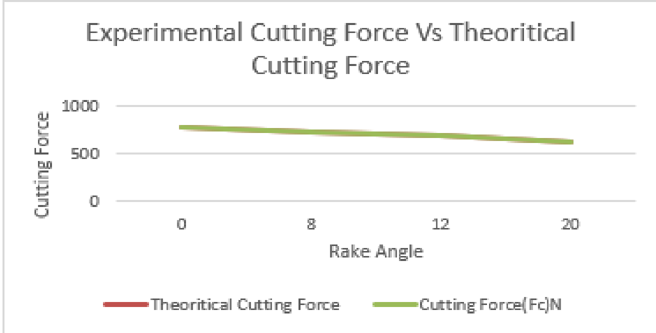


Graph 5.10 Rake Angle Vs Cutting Force of UNSG10200 with depth of cut 2mm and feed rate 0.20mm/rev

Percentage of Deviation

Material : UNS G10200 Depth of Cut:2mm		
S.No	Rake Angle	Percentage of Deviation
1	0	0.32%
2	8	0.09%
3	12	0.24%
4	20	0.22%

Table 5.11 Percentage of Deviation UNSG10200 with depth of cut 2mm and feed rate 0.20mm/rev

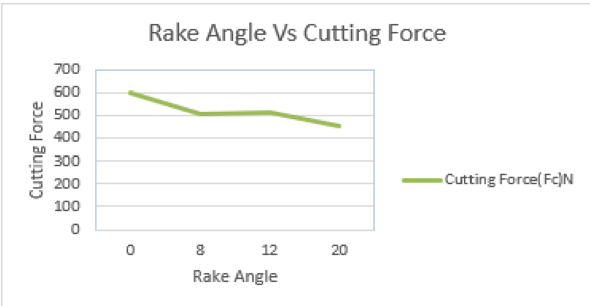


Graph 5.11 Comparison of Experimental and theoretical Cutting forces of UNSG10200 with depth of cut 2mm and feed rate 0.20mm/rev

DEPTH OF CUT 1.5MM AND FEED RATE 0.20MM/REV

5.7Material : UNS G10200			Depth of Cut: 1.5mm federate:0.20mm/rev						
S. No	Rake Angle (Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut Chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	593.44	597	585	1.5	2.67	0.56	29.35	226.40
2	8	511.98	509	400	1.5	2.4	0.621	29.45	256.14
3	12	517.74	516	340	1.5	2.1	0.71	30.81	272.46
4	20	447.71	451	210	1.5	1.8	0.83	31.02	275.70

Table 5.12 UNSG10200 with depth of cut 1.5mm and feed rate 0.20mm/rev

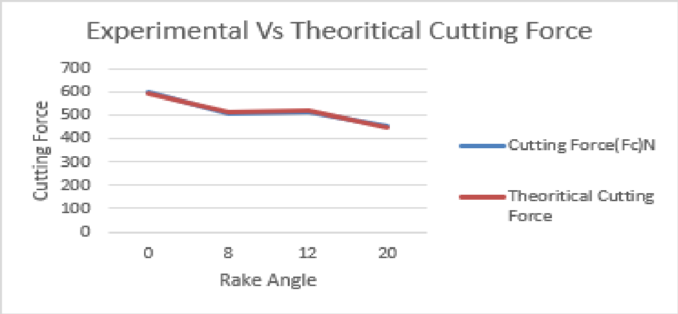


Graph 5.12 Rake Angle Vs Cutting Force of UNSG10200 with depth of cut 1.5mm and feed rate 0.20mm/rev

Percentage of Deviation

Material : UNS G10200 Depth of Cut:1.5mm		
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	0.59%
2	8	0.58%
3	12	0.33%
4	20	0.72%

Table 5.13 Percentage of Deviation UNSG10200 with depth of cut 1.5mm and feed rate 0.20mm/rev

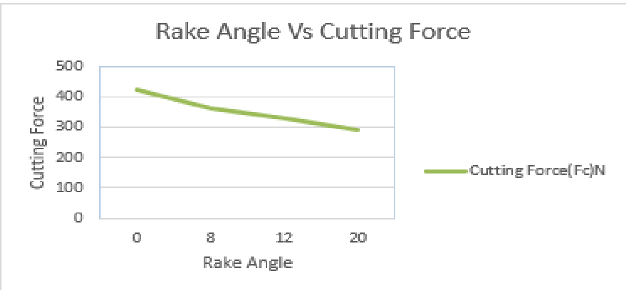


Graph 5.13 Comparison of Experimental and theoretical Cutting forces of UNSG10200 with depth of cut 1.5mm and feed rate 0.20mm/rev

DEPTH OF CUT 1 MM AND FEED RATE 0.19MM/REV

5.8 Material : UNS G10200				Depth of Cut:1mm			feederate:0.19mm/rev		
S.No	Rake Angle(Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut Chip(tc)	Chip thickness ratio(t/tc)	Shear Angle (Degrees)	Shear Force(Fs)N
1	0	423.64	425	417	1.0	1.74	0.57	28.81	167.05
2	8	360.17	362	280	1.0	1.62	0.61	29.28	181.42
3	12	324.75	328	220	1.0	1.46	0.68	29.90	176.40
4	20	288.85	291	140	1.0	1.23	0.81	30.56	180.25

Table 5.14 UNSG10200 with depth of cut 1 mm and feed rate 0.19mm/rev



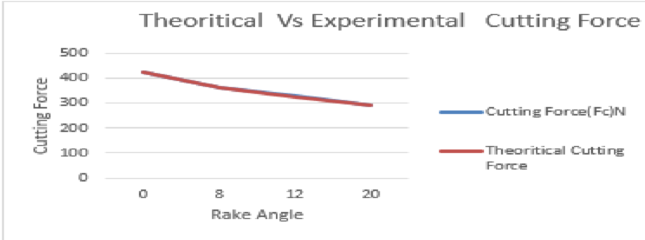
Graph 5.14 UNSG10200 with depth of cut 1 mm and feed rate 0.19mm/rev

Material : UNS G10200		Depth of Cut:1mm
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	0.32%
2	8	0.50%
3	12	0.99%
4	20	0.73%

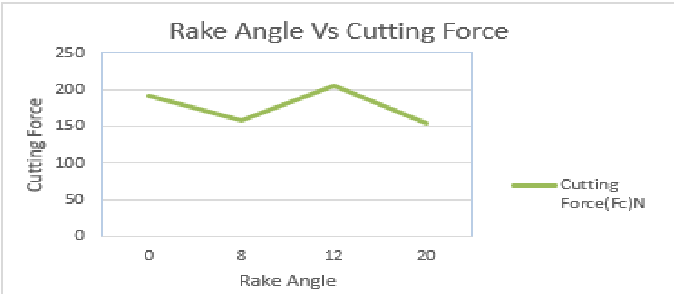
DEPTH OF CUT 0.5 MM AND FEED RATE 0.18MM/REV

5.9Material : UNS G10200				Depth of Cut:0.5mm		feederate:0.18mm/rev			
S.No	Rake Angle(Degrees)	Theoritical Cutting Force	Cutting Force (Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut Chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	190.78	192	185	0.5	0.96	0.52	27.03	83.24
2	8	155.92	158	125	0.5	0.84	0.59	28.46	81.09
3	12	203.57	205	140	0.5	0.74	0.67	29.52	112.01
4	20	152.70	154	70	0.5	0.62	0.80	30.22	96.11

Table 5.16 UNSG10200 with depth of cut 0.5 mm and feed rate 0.18mm/rev



Graph 5.15 Comparison of Experimental and theoretical Cutting forces of UNSG10200 with depth of cut 1mm and feed rate 0.19mm/rev

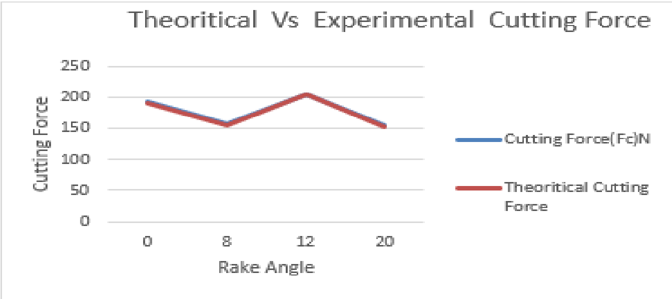


Graph 5.16 UNSG10200 with depth of cut 0.5 mm and feed rate 0.18mm/rev

Percentage of Deviation

Material : UNS G10200		Depth of Cut:0.5mm
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	0.63%
2	8	1.31%
3	12	0.69%
4	20	0.84%

Table 5.17 Percentage of Deviation UNSG10200 with depth of cut 0.5 mm and feed rate 0.18mm/rev

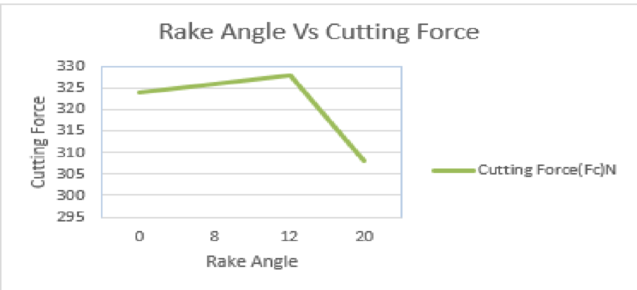


Graph 5.17 Percentage of Deviation UNSG10200 with depth of cut 0.5 mm and feed rate 0.18mm/rev

DEPTH OF CUT 2MM AND FEED RATE 0.20MM/REV

5.10Material: UNSA92014			Depth of Cut:2mm			feederate:0.20mm/rev			
S. No	Rake Angle (Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	322.84	324	319	2	2.89	0.69	30.8	112
2	8	324.57	326	275	2	2.34	0.85	33	139
3	12	326.78	328	238.54	2	2.12	0.94	33.8	153.5
4	20	307.40	308	127.63	2	2.06	0.97	39	149.51

Table 5.18 UNSA92014 with depth of cut 2mm and feed rate 0.20mm/rev

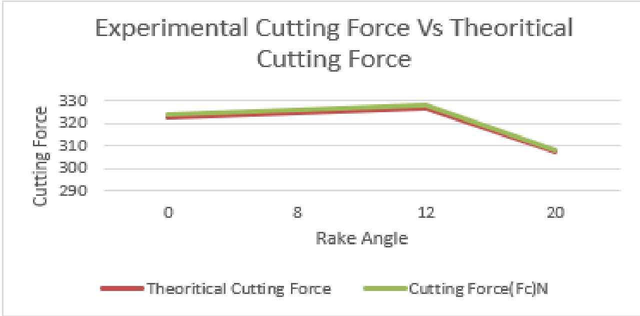


Graph 5.18 UNSA92014 with depth of cut 2mm and feed rate 0.20mm/rev

Percentage of Deviation

Material : UNSA92014		Depth of Cut: 2mm
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	0.35%
2	8	0.43%
3	12	0.37%
4	20	0.19%

Table 5.19 Percentage of Deviation UNSA92014 with depth of cut 2mm and feed rate 0.20mm/rev

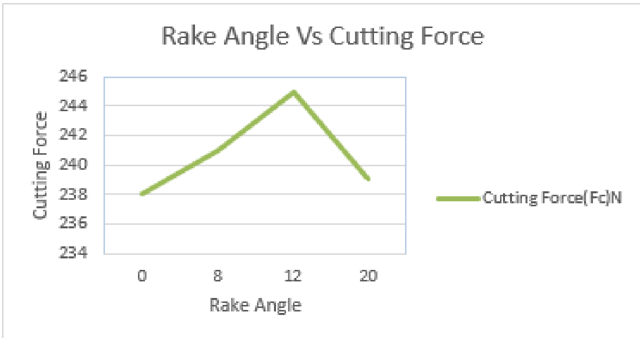


Graph 5.19 Percentage of Deviation UNSA92014 with depth of cut 2mm and feed rate 0.20mm/rev

DEPTH OF CUT 1.5 MM AND FEED RATE 0.20MM/REV

5.11 Material : UNSA92014			Depth of Cut:1.5mm			feederate:0.20mm/rev			
S. No	Rake Angle (Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft) N	Thickness of Uncut Chip(t)	Thickness of Cut chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	237.11	238	234	1.5	2.5	0.60	31.37	79.02
2	8	240.8	241	183.33	1.5	2.1	0.71	32.70	104.60
3	12	244.6	245	157.33	1.5	1.9	0.78	33.11	118.13
4	20	237.1	239	107.66	1.5	1.6	0.93	33.62	136.21

Table 5.20 UNSA92014 with depth of cut 1.5 mm and feed rate 0.20mm/rev

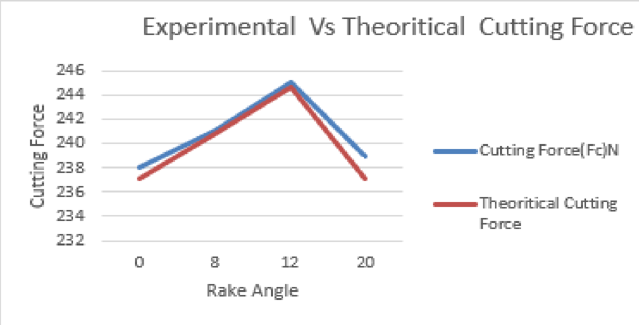


Graph 5.20 Rake Angle Vs Cutting Force of UNSA92014with depth of cut 1.5mm and feed rate 0.20mm/rev

Percentage of Deviation

Material : UNSA92014		Depth of Cut: 1.5mm
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	0.37%
2	8	0.08%
3	12	0.16%
4	20	0.79%

Table 5.21 Percentage of Deviation UNSA92014 with depth of cut 1.5 mm and feed rate 0.20mm/rev

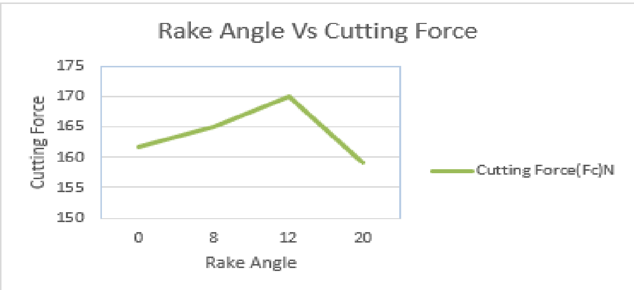


Graph 5.21 Comparison of Experimental and theoretical Cutting forces of UNSA92014 with depth of cut 1.5mm and feed rate 0.20mm/rev

DEPTH OF CUT 1 MM AND FEED RATE 0.18MM/REV

5.12 Material : UNSA92014			Depth of Cut: 1mm				feederate:0.19mm/rev		
S. No	Rake Angle (Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs) N
1	0	163	161.8	158	1	1.75	0.57	30.11	59.25
2	8	164.7	165	123	1	1.46	0.68	31.81	74.53
3	12	169.2	170	108	1	1.3	0.76	32.40	83.97
4	20	157.7	159	74	1	1.08	0.92	32.97	92.28

Table 5.22 UNSA92014 with depth of cut 1 mm and feed rate 0.18mm/rev

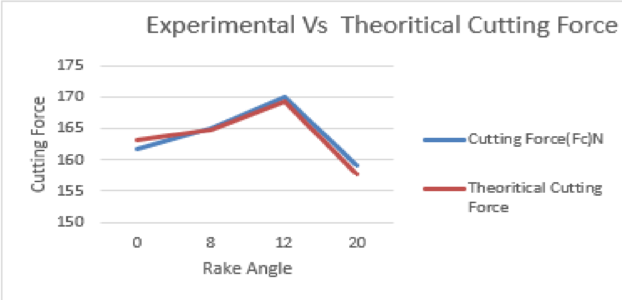


Graph 5.22 Rake Angle Vs Cutting Force of UNSA92014with depth of cut 1mm and feed rate 0.19mm/rev

Percentage of Deviation

Material : UNSA92014	Depth of Cut: 1mm	
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	0.73%
2	8	0.18%
3	12	0.47%
4	20	0.81%

Table 5.23 Percentage of Deviation UNSA92014 with depth of cut 1 mm and feed rate 0.18mm/rev

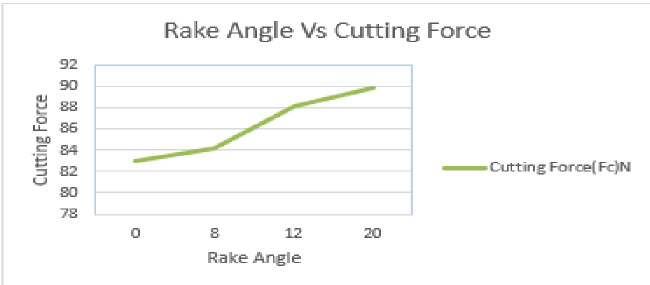


Graph 5.23 Comparison of Experimental and theoretical Cutting forces of UNSA92014 with depth of cut 1mm and feed rate 0.19mm/rev

DEPTH OF CUT 0.5 MM AND FEED RATE 0.18MM/REV

5.13Material : UNSA92014			Depth of Cut: 0.5mm				feederate:0.18mm/rev		
S. No	Rake Angle(Degrees)	Theoritical Cutting Force	Cutting Force(Fc)N	Tangential Force(Ft)N	Thickness of Uncut Chip(t)	Thickness of Cut chip(tc)	Chip thickness ratio(t/tc)	Shear Angle(Degrees)	Shear Force(Fs)N
1	0	83.52	83	79	0.5	0.92	0.54	28.53	33.49
2	8	83.78	84.12	63.13	0.5	0.77	0.64	30.25	40.57
3	12	88.78	88.12	57.65	0.5	0.68	0.73	31.55	45.49
4	20	89.96	89.9	42	0.5	0.58	0.86	31.48	54.82

Table 5.24 UNSA92014 with depth of cut 0.5 mm and feed rate 0.18mm/rev

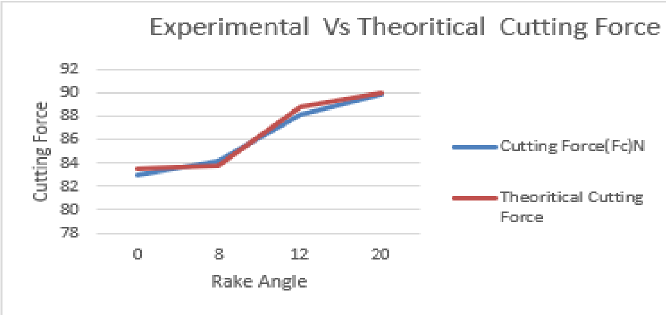


Graph 5.24 UNSA92014 with depth of cut 0.5 mm and feed rate 0.18mm/rev

Percentage of Deviation

Material : UNSA92014	Depth of Cut: 0.5mm	
S.No	**Rake Angle**	**Percentage of Deviation**
1	0	0.62%
2	8	0.40%
3	12	0.74%
4	20	0.06%

Table 5.25 Percentage of Deviation UNSA92014 with depth of cut 0.5 mm and feed rate 0.18mm/rev



Graph 5.25 Comparison of Experimental and theoretical Cutting forces of UNSA92014 with depth of cut 0.5mm and feed rate 0.18mm/rev

CONCLUSIONS

- Merchants force analysis can very well be applied to measure the forces while cutting different materials the forces while cutting different materials such as UNS G10200, UNS C23000 and UNSA92014can be seen from the graphs. Where the theoretical and experimental forces values for a given range of rake angle are in agreement.
- For example, when the feed rate is reduced the maximum cutting force is reduced can be seen in feed rate f=0.18mm/sec
  Max force is 41 N.
  where as for feed rate of 0.19mm/rev.
  The max force in the given range of rake angle is 75N
- Hence performing machining at lower feed rates reduces the forces acting on the tool rake face and hence increases the life of the tool as the tool wear rate will be minimum at lower forces.
- We can also conclude from this study that when the rake angle increases the cutting force decreases as is seen in the graphs for various materials
- While cutting some materials the force initially increases and then decreases This can be attributed to the fact that material surface is usually hard as it is cold rolled and also due to presence of some oxides on the outer surface the force values are observed to be higher initially which then decreases as the rake angle value exceeds a given value
- For higher depth of cut the Max force will be higher because of higher contact area and the tool is likely to break due to shear load and wear out quickly due to higher friction between the tool and chip and tool and workpiece.
- For the estimation of the material type influence on the main cutting force, the experiments were performed with the same cutting conditions and tool characteristics on the three workpiece materials. The influence of the tool rake angle on the main cutting force depends on the type of workpiece material, i.e., for UNS G10200 specimens the main cutting force has a decreasing trend as the rake angle increases from to but for UNS C23000 and UNSA92014 specimens, the main cutting force observed almost unchanged for the same tool rake angle range. Evaluating the chip formation according to the corresponding main cutting force, it could be resulted that the optimum rake angle for UNS G10200 specimen is, for UNS C23000 specimen is and for UNSA92014 specimen is.

Future Scope

Can apply the principles of machine learning to adjust its parameters autonomously during the machining process to determine optimum parameters and have maximum output or higher material removal rate with less tool wear.

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