Experimental Investigation of surface Roughness on Quenched Hardened EN31 using Different Shim Material

[1]V.D GOLAKIYA, [2]SHAH NIRAV
[1]Assistant Professor Mechanical Engg.,[2]PG student.
[1]Mechanical Engg. Deptt
[1]Government Engg. College, Dahod,Gujarat, India

Abstract

Aim of present work and study is to investigate the surface roughness of hardened EN31 material and using different Shim material during high speed machining. Three process parameters are considered that are cutting speed, shim material and depth of cut and experiments are conducted using. Process response of surface roughness are measured for different cutting speed, depth of cut and shim material. For different cutting speed and different depth of cut comparison can be made of which shim is good for high and low cutting speed. Less surface roughness value shows good finishing process and makes it more suitable for assembly and handling .For getting better surface roughness which parameters plays major role among cutting speed,depth of cut and shim material was found out and it was found that depth of cut plays major role.

***IndexTerms* – surface roughness, aluminium shim, Brass shim,**

1. Introduction

High speed machining:

The main objective of latest standard machinging industries is to focus on getting high quality in terms of surface roughness, work dimensional accuracy because economy of machining operations plays a major role in this competitive world. The output during Machining with high speed Machining (HSM) is one of the modern technologies, which in comparison with conventional cutting enables to increase efficiency, accuracy and quality of work pieces and at the same time to decrease costs and machining time. Practically, it can be noted that HSM is not simply high cutting speed. It should be regarded as a process where the operations are performed with very specific methods and production equipment.Definition of high speed Machining (HSM) means using cutting speeds that are significantly higher than those used in conventional machining operations. Range of high speed machining is 1000-18000. High speed machining is use for high production. CNC machine is the high speed machine. CNC machine are present many type of capacity and specification. The objective of modern machining industries is primarily focused on the achievement of high quality, in term of work dimensional accuracy, surface finish because the economy of machining operations plays a key role in competitiveness in the market. The surface roughness has the significant effect, on some non-easily controllable factors such as surface friction, wear, lubricant holding capacity, surface reflection, corrosion resistant. There are many controllable factors which affect the surface roughness i.e., cutting conditions (cutting speed, depth of cut, feed rate), tool variables. Tool variables include the tool material, tool rake angle, nose radius and tool cutting geometry. But it is very difficult to consider all the parameters (cutting and tool variables) that determine the surface roughness during turning operation. The Taguchi design is a statistical tool that helps to investigate the influence of cutting parameters such as cutting speed, feed rate and depth of cut on the surface roughness. Analysis of Variance (ANOVA) is used to optimize the experiments results from Taguchi method i.e., surface roughness.

2. Experimental procedure

2.1 Base material

EN31 is corrosion resistant steel. It has optimal combination of hardness, strength and ductility. It is easy to bend, machine and weld [8]. It is having applications in areas like Shipping and Chemical machinery, marine application, knives, feeders, slurry pipe systems, screw conveyor. [8]. Composition of EN31 is shown in Fig 2.

	%	Std. Value
CARBON	1.061	0.91-1.21
SILICON	0.291	0.11-0.36
MANGANESE	0.561	0.31-.76
PHOSPHORUS	0.041	0.051Max
SULPHUR	0.035	0.051Max
CHROMIUM	1.051	1.01-1.61
HARDNESS IN HRC	45/46/46	-

Experimental Setup:

It is noted that En31 mild steel is harden by solid Harding up to 45 HRC. Therefore ,initial study to determine feasible cutting conditions are required before machining tests. Cutting speed, feed rate and depth of cut are specified in accordance with recommendations from the insert supplier for that application and each one are tested at different levels, within the recommended range. Cutting speed values are 150, 175 and 200m/min, feed rate is 0.08 mm/rev and the depth of cut values are 0.3, 0.4 and 0.5 mm. The cutting tests are performed using CNC Lath as shown in Figure

Input parameters of Experiment work are:

1. Shim material: a) Carbide
   b) Aluminum
   c) Brass
2. Cutting Speed: a) 150 mm/min
   b) 175 mm/min
   c) 200 mm/min
3. Depth of Cut: a) 0.2mm
   b) 0.3mm
   c) 0.4mm
   d) 0.5mm
   e) 0.6 mm

Output Parameters of Experiment work are:

1. Surface roughness value of work piece
2. Vibration data

Figure 1 : Experimental Setup

The details of work piece, cutting tool, machine tool and cutting conditions, instruments details are presented in Table (1)

Table 1: Experimental Setup and Instruments.

MACHINE	CNC Turning lath
WORKPIECE	
1. MATERIALS	En31
2. HARDNESS	45HRC
3. SIZE	200MM LENGTH and 48MM DIAMETER
CUTTING TOOL	
1. CUTTING INSERT	CNMG CBN650
2. TOOL HOLDER	DCLN 2020K12
3. SHIM	CARBIDE, BRASS, ALUMINUM
CUTTING CONDITION	
1. CUTTING SPEED	150 m/min to 200 m/min
2. FEED RATE	0.08 mm/rev
3. DEPTH OF CUT	0.3 mm to 0.5 mm
VIBROMETER	CoCo-80 Dynamic Analyzer
SURFACE ROUGHNESS	Mitutoy SJ 210 surface rougness tester (-200µm to 150µm)

Figure 2: CNC Lath machine.

Acceleration sensors are used for the vibration measurement. Two piezoelectric accelerometers (uni-axial) are used for picking up the vibration signals from various stations on the tool post. These special piezoelectric pickup type sensors are used with a frequency range of 1-30 KHz, a measurement range +/-500g peak, resolution of 0.005 g and resonant frequency of 70 KHz. The sensitivity of sensor 107 mV/g with integral electronics piezoelectric accelerometer (IEPE). The vibration was measured in both X-direction (Thrust force direction) and Y-direction (Cutting force direction). Data are analyzed with sampling frequency of 5.12 KHz.

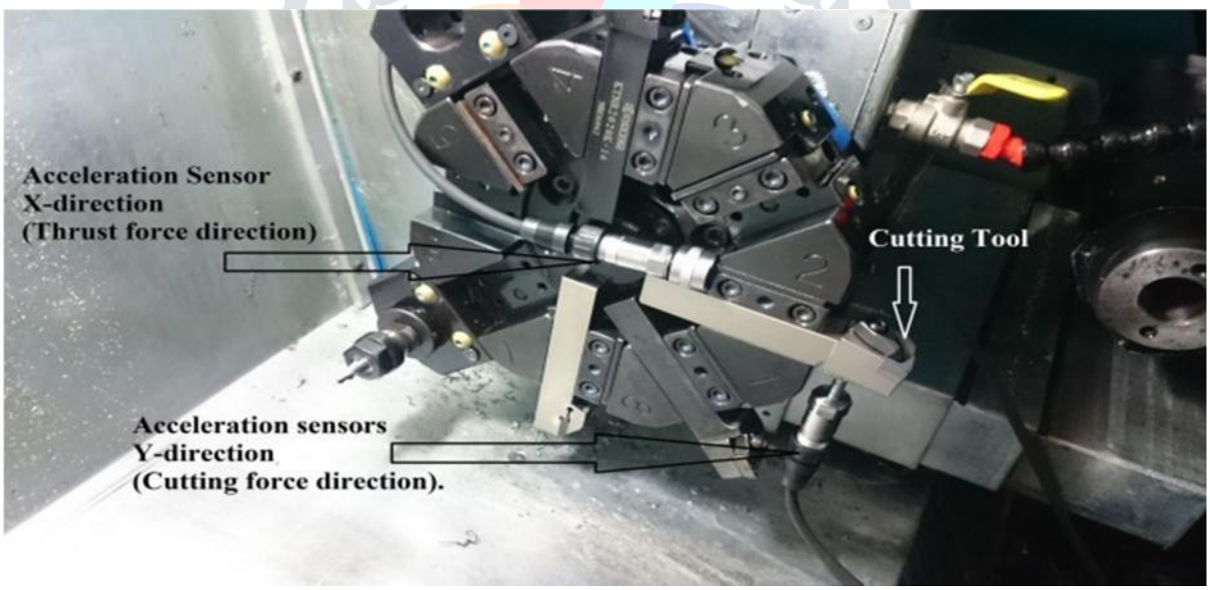


Figure 3: Station of sensor for collecting acceleration data.

Table 2: Specification of Surface Roughness Tester

Sr. No.	Specifications	Units
1	Method	Differential inductance
2	Stylus	Diamond TIP

3	TIP radius	5µm(200 µ inch)
4	Make	Mitutoyo
5	Model	SJ-201
6	Measuring range	-200 µm to +150µm
7	Measuring Force	4Mn(0.4gf)

Figure 4: Surface Roughness Tester and Work Piece

Design of Experiment

DOE is a technique of defining and investigating all possible combinations in an experiment involving multiple factors and to identify the best combination. In this different factors and their levels are identified.

Planning of experiments has been employed in order to fulfill the following requirements:

- To get the data uniformly distributed over the whole range of controllable factors to be investigated.
- To minimize the total number of experiments.
- To establish a relationship between different input variables and the output parameters accurately within the selected range of investigation.

Three different shim are used for experiment Aluminum, Brass and carbide. Cutting speed 150, 175 and 200 m/min. Depth of cut 0.3, 0.4, 0.5 mm. using these input parameters the experiment work table is made which is shown in Table (2).

Experiments are conducted on the CNC plasma arc cutting machine (Digicut, M.A engineering) as shown in fig2. Airis used as cutting gas. A plate of Inconel 625 having dimensions of 500mm×50mm×6mm was prepared for the experimental work. In this research, three levels of cutting speed (mm/min), three levels of pressure (psi) and three levels of Arc voltage (A) were taken as shown in Table 1.

LEVEL	CUTTING SPEED	DEPTH OF CUT	SHIM MATERIAL
1	125	0.2	CARBIDE ALMINIUM BRASS
2	150	0.3	CARBIDE ALUMINIUM BRASS
3	175	0.4	BRASS, ALUMINIUM BRASS
4	200	0.5	CARBIDE ALUMINIUM BRASS
5	225	0.6	CARBIDE ALUMINIUM BRASS

A plate was cut in 9 pieces (50mm×50mm×6mm) with all combinations of process parameters by computer numerical controlled plasma cutting machine. Experiments were carried out with current setting of 132 volts. The distance between the torch and the plate was 3 mm.

2.3 Material removal rate, surface roughness measurement and Kerf Angle

To measure MRR, the weight was calculated after cutting. Material removal rate (MRR) of plasma arc cutting process was calculated by following formula:

$$MRR = \frac{Change\ in\ Material\ Weight}{Cutting\ Time}$$

Where,

MRR: Metal Removal Rate T: cutting time(s)

Surface roughness was measured by surface roughness tester (Mitutoyo SJ210, Taylor Hobson) as shown in fig 3 and R_a value was considered for 3 sides of cut work-piece because at one side where the plasma flame enters is having slightly irregular surface having some peak of dross formed making impossible to measure R_a value on that side. That peak was forming because of high density of dross accumulation when flame starts suddenly with high intensity making melting of more metal and all of that molten metal could not be carried away by high velocity plasma gas coming out from torch. Mean of R_a values of 3 sides was considered as mean surface roughness in this experiment.

Kerf angle is measured with help of verniercaliper with the following equation

$$\sin\alpha = \frac{Thickness\ of\ plate}{Distance\ between\ plate\ at\ bottom}$$

Figure 3

2.4 Design

Experiment design was done using Taguchi Method. A Taguchi design contains all Best possible combinations of a set of factors. This is the most conservative design approach, and it is also gives the most suitable results in experiment [1]. Authors have randomized experiment run order to remove effect of environment if any as shown in below Table 2

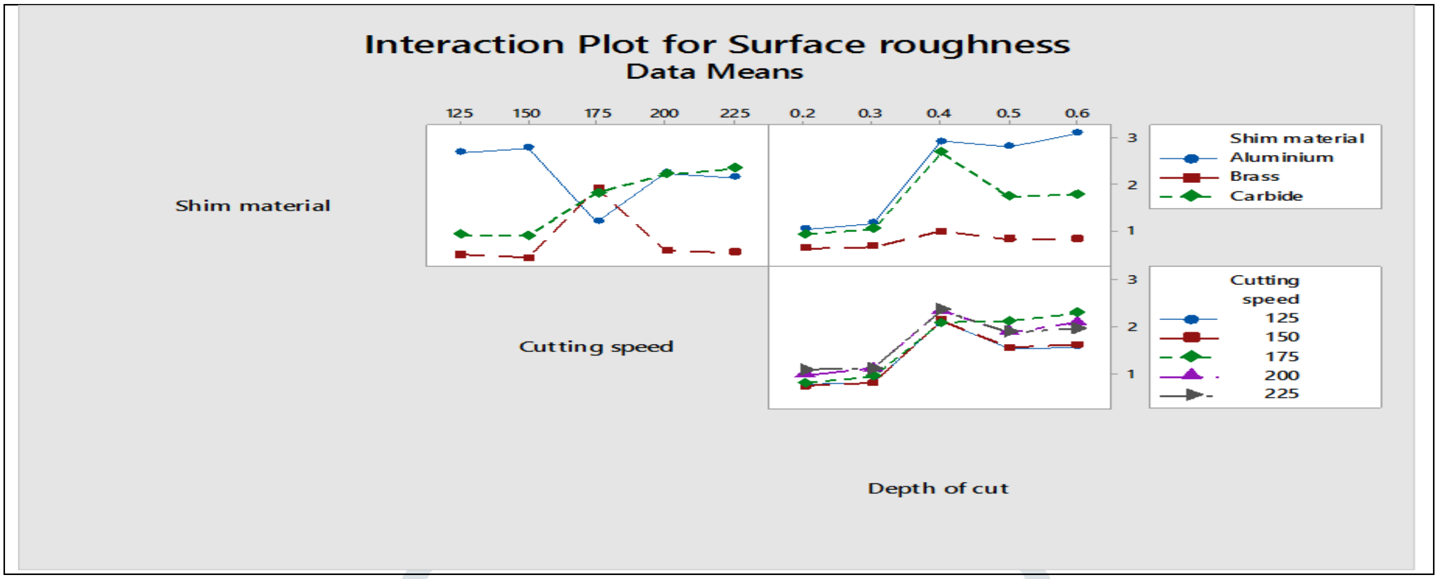
Table 2. Experimental results for EN31 rod

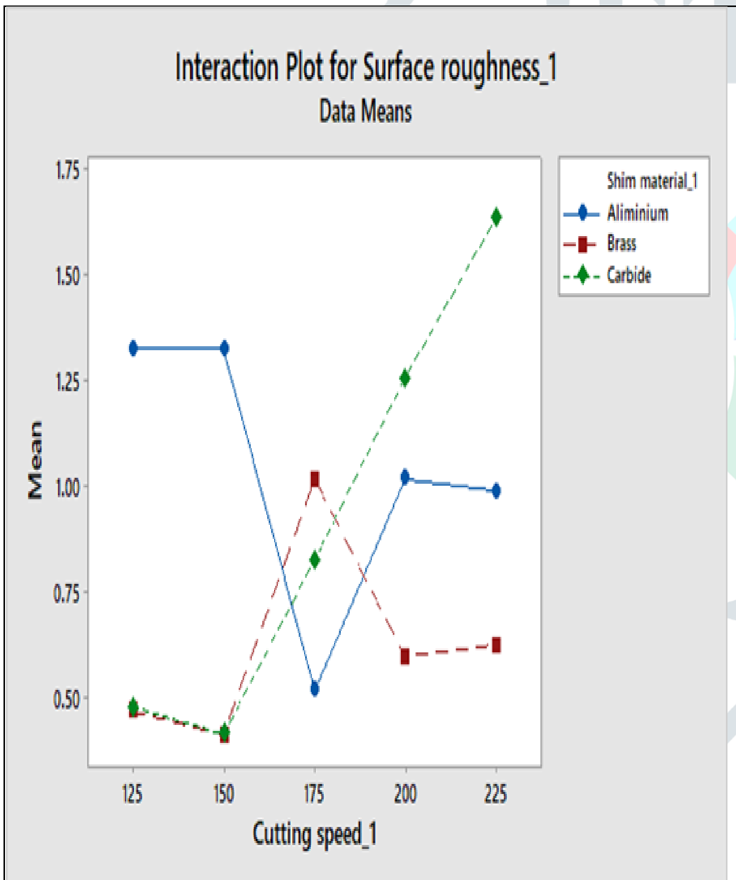
Sr. No	Shim	Cutting speed (m/min)	Depth of cut (mm)	Acceleration Peak Value (mm/s^2)		Surface Roughness (µm)
				X-Direction	Y-Direction	
1	Carbide	150	0.3			
2		150	0.4			
3		150	0.5			
4		175	0.3			
5		175	0.4			
6		175	0.5			
7		200	0.3			
8		200	0.4			
9		200	0.5			
10	Aluminum	150	0.3			
11		150	0.4			
12		150	0.5			
13		175	0.3			
14		175	0.4			
15		175	0.5			
16		200	0.3			
17		200	0.4			
18		200	0.5			
19	Brass	150	0.3			
20		150	0.4			
21		150	0.5			
22		175	0.3			
23		175	0.4			
24		175	0.5			
25		200	0.3			
26		200	0.4			
27		200	0.5			

3. Result and Conclusion

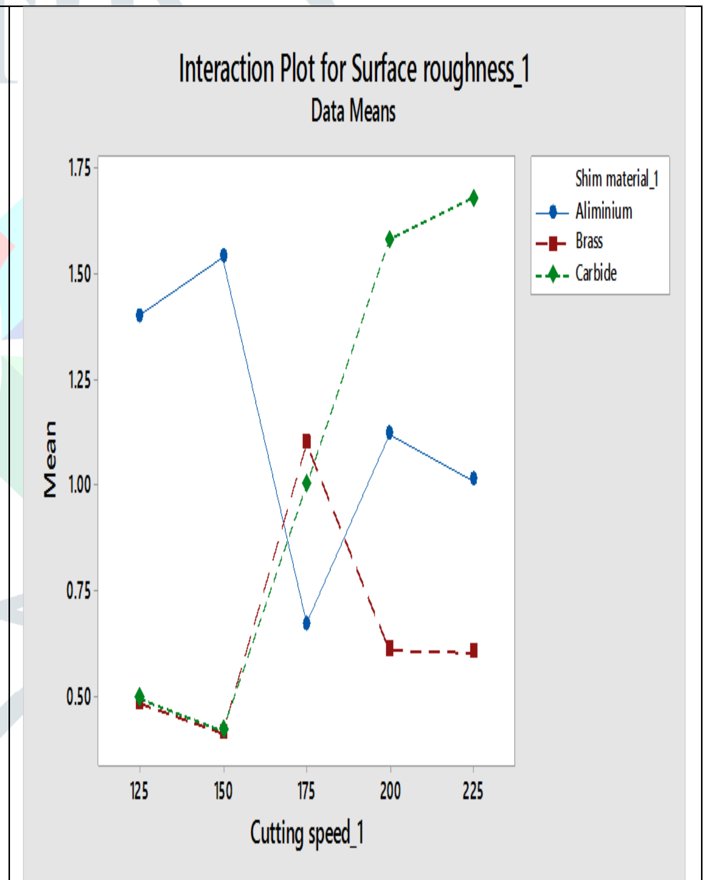
	Shim material	Cutting Speed	Depth of cut	Surface Roughness
1	Carbide	125	0.2	0.475
2	Carbide	125	0.3	0.495
3	Carbide	125	0.4	2.55
4	Carbide	125	0.5	0.497
5	Carbide	125	0.6	0.498
6	Carbide	150	0.2	0.411
7	Carbide	150	0.3	0.42
8	Carbide	150	0.4	2.75
9	Carbide	150	0.5	0.411
10	Carbide	150	0.6	0.423
11	Carbide	175	0.2	0.824
12	Carbide	175	0.3	1.001
13	Carbide	175	0.4	2.627
14	Carbide	175	0.5	2.225
15	Carbide	175	0.6	2.342
16	Carbide	200	0.2	1.253
17	Carbide	200	0.3	1.581
18	Carbide	200	0.4	2.746
19	Carbide	200	0.5	2.701
20	Carbide	200	0.6	2.731
21	Carbide	225	0.2	1.632
22	Carbide	225	0.3	1.68
23	Carbide	225	0.4	2.748
24	Carbide	225	0.5	2.79
25	Carbide	225	0.6	2.856
26	Aluminium	125	0.2	1.325
27	Aluminium	125	0.3	1.4
28	Aluminium	125	0.4	3.4
29	Aluminium	125	0.5	3.6
30	Aluminium	125	0.6	3.66
31	Aluminium	150	0.2	1.325
32	Aluminium	150	0.3	1.541
33	Aluminium	150	0.4	3.201
34	Aluminium	150	0.5	3.811
35	Aluminium	150	0.6	4.013
36	Aluminium	175	0.2	0.514
37	Aluminium	175	0.3	0.673
38	Aluminium	175	0.4	0.399
39	Aluminium	175	0.5	2.068
40	Aluminium	175	0.6	2.314

41	Aluminium	200	0.2	1.015
42	Aluminium	200	0.3	1.121
43	Aluminium	200	0.4	3.761
44	Aluminium	200	0.5	2.26
45	Aluminium	200	0.6	3.016
46	Aluminium	225	0.2	0.986
47	Aluminium	225	0.3	1.013
48	Aluminium	225	0.4	3.85
49	Aluminium	225	0.5	2.36
50	Aluminium	225	0.6	2.516
51	Brass	125	0.2	0.465
52	Brass	125	0.3	0.485
53	Brass	125	0.4	0.4
54	Brass	125	0.5	0.49
55	Brass	125	0.6	0.494
56	Brass	150	0.2	0.41
57	Brass	150	0.3	0.415
58	Brass	150	0.4	0.416
59	Brass	150	0.5	0.385
60	Brass	150	0.6	0.392
61	Brass	175	0.2	1.012
62	Brass	175	0.3	1.1
63	Brass	175	0.4	3.204
64	Brass	175	0.5	2.038
65	Brass	175	0.6	2.21
66	Brass	200	0.2	0.594
67	Brass	200	0.3	0.611
68	Brass	200	0.4	0.458
69	Brass	200	0.5	0.64
70	Brass	200	0.6	0.504
71	Brass	225	0.2	0.62
72	Brass	225	0.3	0.605
73	Brass	225	0.4	0.432
74	Brass	225	0.5	0.48
75	Brass	225	0.6	0.47

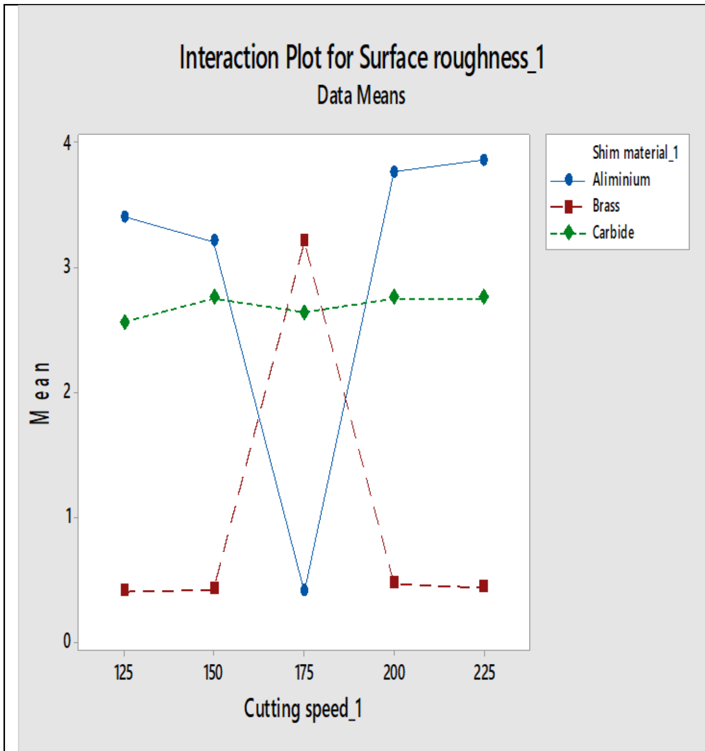




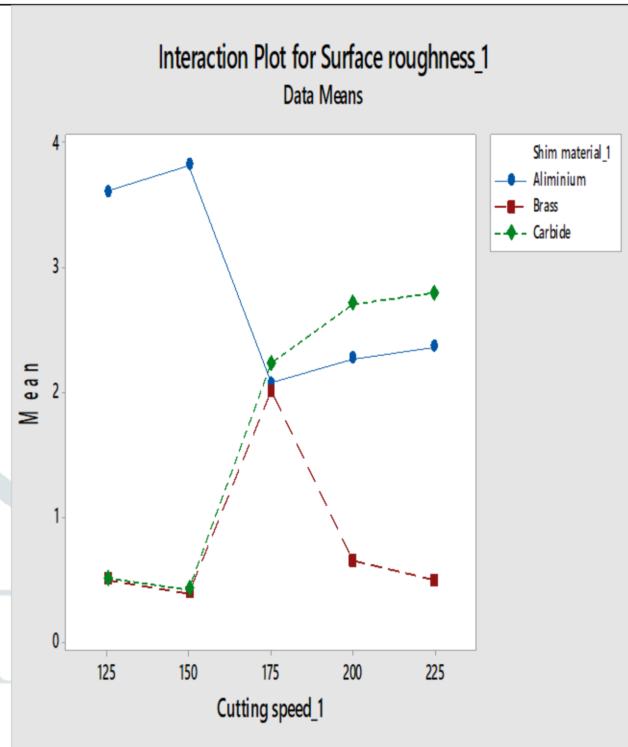
For Depth of cut 0.2



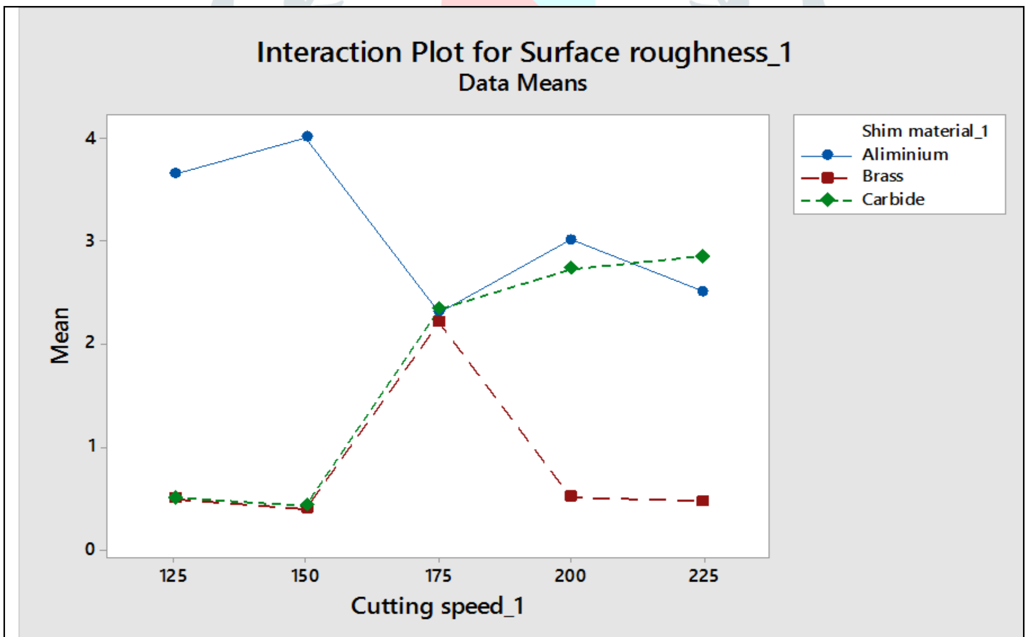
For Depth of cut 0.3



For Depth of 0.4



For Depth of 0.5



3.1 Anova Method

Analysis of Variance (ANOVA) is performed using Design Expert 10.0.3 software for each response to check significance of factors on each response. ANOVA for material removal rate is as shown in Table 4 and ANOVA for mean surface roughness is as shown in Table 5. These tables also show the Degrees of Freedom (DOF), sum of squares, mean squares, F-values and P-value. ANOVA analysis is done with 95% confidence level.

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Shim material	2	25.994	26.99%	25.994	12.9972	17.70	0.000
Cutting speed	4	1.684	1.75%	1.684	0.4209	0.57	0.683
Depth of cut	4	21.615	22.45%	21.615	5.4036	7.36	0.000
Error	0	0.00	0.00%	0.00	0.7344		

IV. CONCLUSIONS

This research depicts and shows investigation on effect and optimization of process parameters on surface roughness with the help of ANOVA coupled with regression analysis method. For surface roughness, control factors cutting speed, depth of cut and shim material have 66.1%, 9.63% and 26.23% contribution respectively.. In general for MRR cutting speed is most significant factor whereas for surface roughness cutting speed is most significant parameters respectively. Surface roughness is obtain good and its value is less when cutting speed is in between 185 to 210mm/min and along with that brass shim is used as damper .Also the tool vibrations less when brass shim is used as damper For low speed brass shim and and carbide shim shows almost similar result so both shim came used.

References

1. M. Siddhpura, R. Paurobally, “A review of chatter vibration research in turning”, School of Mechanical & Chemical Engineering, The University of Western Australia, 27 May 2012

2. E. Budak , E. Ozlu “Analytical Modeling of Chatter Stability in Turning and Boring Operations: A Multi-Dimensional Approach”,Faculty of Engineering and Natural Sciences, Turkey, vol-56, 2007

3. O. Gutnichenko, V. Bushlya, J.M. Zhou, J.-E. Stahl, “Tool wear and vibrations generated when turning high-chromium white cast iron with pCBN tools” Lund University, Sweden, Page 285 – 289, 2016

4. M.S. Fofana, “Nonlinear regenerative chatter in turning”, Worcester Polytechnic Institute, Worcester, MA 01609-2280, USA

5 Ranganath M.S.*, Vipin, Kuldeep, Rayyan, Manab, Gaurav Department of Mechanical Engineering, Delhi Technological University, Delhi, India

6 T.Pothal, “Dynamics of 2-dof regenerative chatter during turning”, Indian Institute of Technology, Guwahati 781039, july 2005, India

7 Gutnichenko, V. Bushlya, J.M. Zhou, J.-E. Stahl, “Tool wear and vibrations generated when turning high-chromium white cast iron with pCBN tools” Lund University, Sweden, Page 285 – 289, 2016

8 Altintas, M. Weck, “Chatter Stability of Metal Cutting and Grinding”, Manufacturing Automation Laboratory, Canada, 2004.