International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

OPTIMIZATION OF CUTTING PARAMETERS BASED ON TAUGCHI METHOD OF AISI316 USING CNC LATHE MACHINE

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Abstract-The main aim of this research work is focused on the analysis of optimum cutting conditions to get lowest surface roughness in CNC turning of austenitic stainless steel AISI 316 using carbide insert coated with TiN under dry condition. Taguchi method is used for design this experiment and the total 27 experiment performed to find out optimum values of level of different factors in order to minimize surface roughness of austenitic stainless steel AISI 316 in turning. The analysis of variance (ANOVA) is used for calculating the percentage of contribution of each factor in quality of surface roughness. The result show that the maximum effect on surface roughness produce by feed and the minimum effect on surface roughness produce by depth of cut. The surface of workpiece is least effected by cutting speed.

Keywords: Taguchi's Techniques, ANOVA. CNC Turning, Surface roughness.

1. INTRODUCTION

The main aim of this research work to find out the factor affecting the surface roughness. This research work is conducting for optimizing these factors. Now a day's it is great challenge for obtained high quality, good surface finish and high material removal rate for every machining enterprises. The quality of every product is depending on surface smoothness. So in this research work we shall obtain a group of factor on which surface roughness is minimum and surface smoothness maximum. The group of factor is determining with help of Taugchi method in this present work. This research work concerned with the determination of optimal turning parameters for reduced roughness and increased hardness of the machined surfaces while turning of workpiece austenitic stainless steel AISI 316 using carbide insert coated with TiN under dry condition. Yang et al. [1] conducted an experiment to study the optimize the turning operation of S45C steel bars using tungsten carbide cutting tools and reported that cutting speed, feed rate, and depth of cut were the significant cutting parameters for affecting surface roughness. They found out the contribution order of the cutting parameters for surface roughness is feed rate, then depth of cut, and then cutting speed. Zhang et al. [2] have used Taguchi method for surface finish optimization in end milling of Aluminium blocks. The experimental results indicate that in this study the effects of spindle speed and feed rate on surface finish were larger than depth of cut for milling operation. Nalbant et al. [3] conducted an experimental study which was focused on the analysis of optimum cutting conditions to get Lowest surface roughness used Taguchi method to find optimum cutting parameters for surface roughness in turning of AISI 1030 carbon steel bars using TiN coated tools. Three cutting parameters namely, insert radius, feed rate, and depth of cut were optimized. In turning, use of greater insert radius, low feed rate and low depth of cut were used to obtain better surface roughness for the specific test range. Ghani et al. [4] conducted an experimental study which was focused on the analysis of optimum cutting conditions to get lowest surface roughness and cutting force in end milling when machining hardened steel AISI H13 with TiN coated P10 carbide insert tool under semi-finishing and finishing conditions of high speed cutting. Taguchi method was used for experiment study. The milling parameters cutting speed, feed rate, and depth of cut were determine. The result show in end milling, use of high cutting speed, low feed rate and low depth of cut were recommended to obtain better surface roughness and low cutting force. Pranav R. Kshirsagar et al. [5]study in their experimental work the effect of the cutting speed, feed rate and depth of cut on surface roughness of EN8 steel using coated carbide inserts cutting tool on CNC turning machine in dry condition. Taguchi method was used for Design of experiments. The Statistical analysis for Variance (ANOV) based on S/N ratio was used to determine the optimum levels of control factors which affect on surface roughness. The results show that the surface roughness was affected by feed rate only in CNC turning of EN8 steel. Thamizhmani et.al [6] investigated the optimum cutting conditions to get lowest surface roughness of AISI410 by PCBN cutting tool. Results show that surface roughness value was low at high cutting speed with low feed rate. ICiftci [7] investigated the Machining characteristics of austenitic stainless steels (AISI 304 and AISI 316) using CVD multi layer coated carbide tools. The turning tests were conducted at four different cutting speeds with a constant feed rate and depth of cut. The effect of work piece grade, cutting tool coating top layer and cutting speed were conducted on cutting forces and machined surface roughness. Results show that surface finish values decreased with increasing in cutting speed until a minimum value was reached, beyond which they increased. Sujan Debnath et al. [8]. conducted an experimental to study to investigated the effect of various cutting fluid levels and cutting parameters on surface roughness and tool wear of mild steel bar using a TiCN + Al2O3 + TiN coated carbide tool by using Taguchi and orthogonal array in C NC turning process. Llhan Asilturk et al. [9] conducted an experimental to study the modelling of experimental data of surface roughness of Co28Cr6Mo medical alloy machined on a CNC lathe. Three cutting parameters spindle rotational speed, feed rate, and depth of cut were used and tool tip radius based on the Taguchi orthogonal test design and RSM. Supriya Sahu et al. [10] investigated the optimum cutting conditions to get lowest surface roughness in turning and the performance of multi-layer TiN coated tool in machining of hardened steel (AISI 4340 steel) under high speed turning and found the effect of cutting parameters (speed, feed, and depth of cut) on surface roughness using Taguchi method. Feng and Wang [11] conducted an experiment to study for obtained the surface roughness in finish turning operation by developing an empirical model through considering working parameters. R.K.Suresh et.al [12] focused to investigate the effect of cutting parameters on EN-41 B alloy steel using Taguchi technique. An accurate regression model is developed for material removal rate. Result show that feed is the most dominant parameter for MRR. R. B. Mandavia [13] conducted an experiment to study to effect of different input parameters temperature, cutting speed, feed etc. And their effect on surface roughness, hardness, material removal rate, tool wear, tool life. Taguchi method was used for designed this experiment. Based on the study it is observed that depth of cut, speed and feed affected the surface roughness while turning of austenitic stainless steel AISI316 significantly. So more study and investigation is required to investigate the factor affected the surface roughness under various operations.

2. DESIGN OF EXPERIMENTS

This presented work is based on Taguchi method of design of experiments. Taguchi strategy is effective technique for planning process that works reliably and ideally finished the types of conditions .When number of factor in a design is increase then it is very complex for solution .then a special designed method in which the use of orthogonal array to study the whole parameter space with lesser was suggested by Taguchi.

2.1. Smaller the Better

In situations where you need to limit the events of some undesirable item qualities, you would figure the accompanying S/N proportions/N ratio of smaller the better is given below

$$(S/N)_{\text{smaller the better}} = -10*\log(\Sigma(Y2)/n)$$

Where Y = responses for the given factor level combination
And n = number of responses in the factor level combination.

2.2. Larger the Better

Cases of this kind of building issue are mileage (miles per gallon) of a car, quality of solid, resistance of protecting materials, and so forth. The accompanying S/N proportion ought to be utilized and this is given below

$$(S/N)_{\text{larger the better}} = -10*\log(\Sigma(1/Y2)/n)$$

Where Y = responses for the given factor level combination
And n = number of responses in the factor level combination.

2.3. Nominal the better

In case of nominal the better you have a fixed signal value (nominal value), and the variance around this value can be considered the result of noise factors:

$$(S/N)_{\text{nominal the better}} = -10*\log(s2)$$

Where Y = responses for the given factor level combination
And n = number of responses in the factor level combination.

3 .EXPERIMENTAL SETUP

Experimental setup in this research work is consist of workpiece (AISI316), CNC lathe machine, Micrometre, tungsten carbide insert type cutting tool and surface tester.

4. WORKPIECE MATERIAL

The material of workpiece which is requirement is austenitic stainless steel AISI 316.Austenitic stainless steel contains 18% chromium and 8% nickel. Stainless steel AISI 316 is an alloy of iron which containing least 10.5% Chromium. Due to excellent mechanical properties austenite stainless steel AISI 316 are widely used in various areas.

Table- 1: The Chemical Composition of AISI316.

Element	Weight %
C	0.058
S	0.019
Mo	2.086
Cu	0.559
Si	0.349
Cr	16.536
V	0.014
Mn	1.080

Table- 2: Mechanical Properties of AISI 316.

Yield Strength	**290 MPa**
Modulus of elasticity	**193 MPa**
Tensile strength	**580 MPa**
Density	**800 kg/mm^3**
BHN	**217**

4. CUTTING TOOL INSERTS

Tungsten inserts carbide type cutting tool is used for turning of stainless steel AISI316 in current work. The nomenclature of cutting inserts is given below. In this research paper cutting tool insert TNMG160408 is use for turning.

5. CNC LATHE MACHINE

The CNC lathe machine "Midas 8i" is used for turning of stainless steel AISI316 in this present work. This machine is manufacturing by GALAXY MACHINERY PVT. LTD

Table- 3: The Full Specification of Midas 8i CNC Lathe Machine

Capacity	
Turning Diameter	280mm
Max. Turning Length	522mm
Maximum Swing Clearance Diameter of Over Carriage	230mm
Maximum Swing Clearance Diameter over Way Covers	430mm

Chuck	
Chuck Size	210 mm
Bar Capacity	50 mm

Spindle Drive	
Spindle Power	40 rpm – 4000 rpm
Range of Spindle	12 hp-10 hp

Fig.1: Workpiece Material

6. SURFACE TESTER

The surface roughness of workpiece in this research work is measuring by Mitutoyo SJ-201P.The surface roughness of workpiece will trace by a pick-up which attached to the detector SJ-201P.

7. FACTORS AND THEIR LEVEL

The factor and there level used in this research work are given below.
1. Cutting speed in rpm
2. Feed in mm/rev
3. Depth of cut in mm

Table- 4: Factor and level for Experiment

Factor	Unit	Level 1	Level 2	Level 3
Feed	mm/rev	0.05	0.1	015
Depth of Cut	mm	0.4	0.8	1.2
Cutting speed	rpm	500	700	900

Fig. 4: CNC Midas 8i

Fig.2: Cutting Tool Inserts

Fig.5: Workpiece Turning

Fig.3: Workpiece after Machining

Fig.6: Mitutoyo SJ-201P (Surface Tester)

Table -5: Surface Roughness, MRR and S/N ratio

S.N.	Depth of cut (d) mm	Feed (f) mm/rev	Speed (N) rpm	Cutting Speed (V) m/min.	MMR mm^3/sec	Avg. Roughness(Ra) µm	RMS Roughness (Rq) µm	S/N for Ra
1	0.4	0.05	500	50.265	16.7551	0.42	0.51	7.53501419
2	0.4	0.05	700	70.371	23.45714	0.33	0.41	9.6297212
3	0.4	0.05	900	90.477	30.15918	0.29	0.37	10.75204
4	0.4	0.1	500	50.265	33.5102	0.47	0.58	6.55804284
5	0.4	0.1	700	70.371	46.91428	0.40	0.49	7.95880017
6	0.4	0.1	900	90.477	60.31836	0.37	0.45	8.63596552
7	0.4	0.15	500	50.265	50.2653	0.80	1.01	1.93820026
8	0.4	0.15	700	70.371	70.37142	0.81	1.04	1.83029962
9	0.4	0.15	900	90.477	90.47754	0.76	0.99	2.38372815
10	0.8	0.05	500	50.265	33.5102	0.38	0.47	8.40432807
11	0.8	0.05	700	70.371	46.91428	0.32	0.40	9.89700043

12	0.8	0.05	900	90.477	60.31836	0.24	0.30	12.3957752
13	0.8	0.1	500	50.265	67.0204	0.45	0.55	6.93574972
14	0.8	0.1	700	70.371	93.82856	0.40	0.49	7.95880017
15	0.8	0.1	900	90.477	120.63672	0.42	0.51	7.53501419
16	0.8	0.15	500	50.265	100.5306	0.77	0.95	2.2701855
17	0.8	0.15	700	70.371	140.74284	0.79	1.00	2.04745817
18	0.8	0.15	900	90.477	180.95508	0.78	1.00	2.15810795
19	1.2	0.05	500	50.265	50.2653	0.34	0.44	9.37042166
20	1.2	0.05	700	70.371	70.37142	0.33	0.42	9.6297212
21	1.2	0.05	900	90.477	90.47754	0.32	0.41	9.89700043
22	1.2	0.1	500	50.265	100.5306	0.44	0.53	7.13094647
23	1.2	0.1	700	70.371	140.74284	0.42	0.51	7.53501419
24	1.2	0.1	900	90.477	180.95508	0.41	0.50	7.74432287
25	1.2	0.15	500	50.265	150.7959	0.84	1.08	1.51441428
26	1.2	0.15	700	70.371	211.11426	0.82	1.02	1.72372295
27	1.2	0.15	900	90.477	271.43262	0.82	1.03	1.72372295

8. RESULT AND DISCUSSION

Table- 6: Response Table for Signal to Noise Ratio

Level	depth of cut (mm)	feed (mm/rev)	speed (rpm)
1	6.358	9.723	4.740
2	6.622	7.555	6.468
3	6.252	1.954	7.025
Delta	0.370	7.769	1.285
Rank	3	1	2

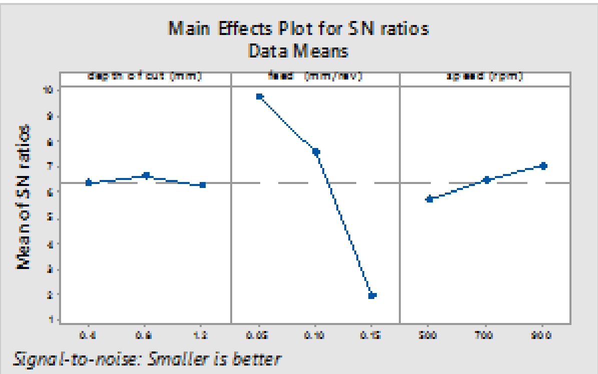

Fig.7: The Main Effect Plot for SN ratios Data Means

From the plot diagram it is clear that when depth of cut is increase then mean of SN ratio is increase at a point but after increasing in depth of cut mean of SN ratio is decrease. When feed is increase then means of SN ratio is decrease. When speed is increase then mean of SN ratio is also increase.

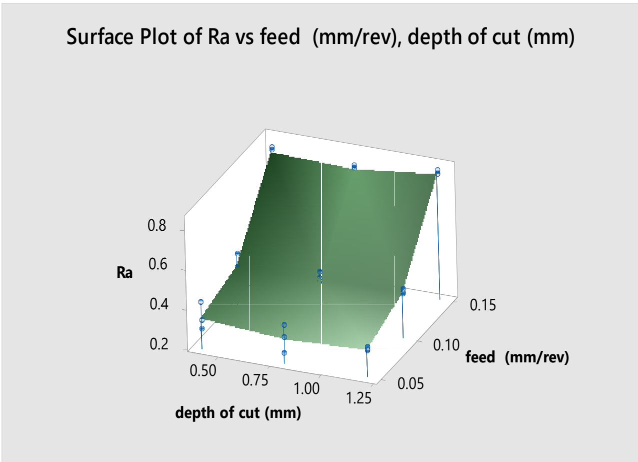

Fig.9: Surface Plot of Ra Vs Feed, and Depth of Cut

This figure shows variation of surface roughness with feed and depth of cut. We can obtain the minimum value of surface roughness with respect to feed and depth of cut.

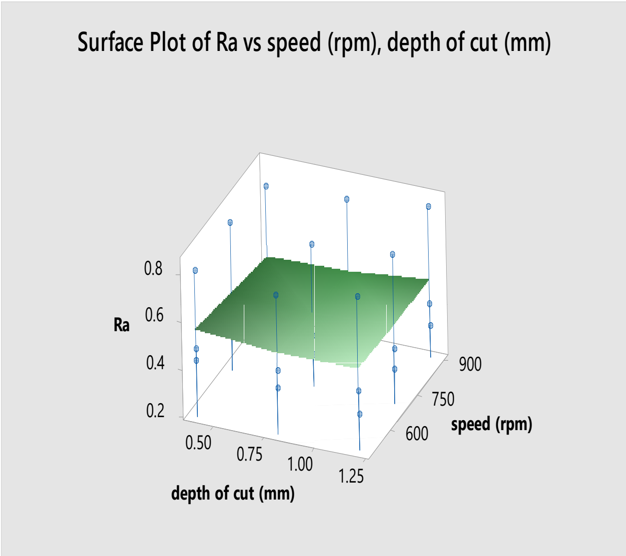

Fig.10: Surface Plot of Ra Vs Speed, and Depth of Cut

This figure shows variation of surface roughness with feed and depth of cut. We can obtain the minimum value of surface roughness with respect to speed and depth of cut.

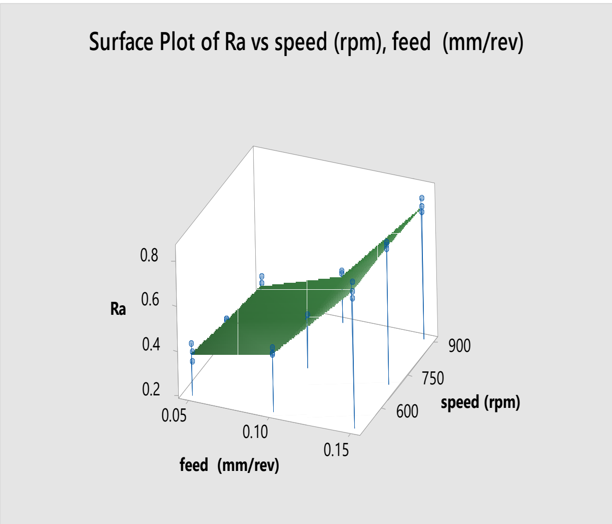

Fig. 11: Surface Plot of Ra vs Speed, and Feed

This figure shows variation of surface roughness with feed and depth of cut. We can obtain the minimum value of surface roughness with respect to speed and feed.

9. REGRESSION EQUATION

It is use for obtained the relationship between depth of cut, speed and fee rate with surface roughness.
Ra =0.1346 + 0.0125depth of cut (mm) + 3.689feed (mm/rev) -0.000139 speed (rpm)

10. ANOVA

Table- 7: Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
depth of cut (mm)	2	0.00201	0.001004	1.16	0.333
feed (mm/rev)	2	1.11454	0.557270	644.21	0.000
speed (rpm)	2	0.01401	0.007004	8.11	0.003
Error	20	0.01727	0.000864		
Total	26	1.14783			

Model Summary

S	R-sq	R-sq(adj)	R-sq(prep)
0.0293888	98.50%	98.04%	97.26%

Analysis of variance shows the contribution of the parameter which effect on surface roughness.

CONCLUSION

- In this research work we investigate the effects of cutting parameters depth of cut, feed and speed on surface roughness of AISI316 stainless steel. Finally we obtained the values of selected machining parameters for affecting surface roughness. The optimum value of depth of cut 0.8 mm; feed is 0.05 mm/rev, and speed 900 rpm. Corresponding to these values of parameters the minimum surface roughness recorded.
- From regression relation the value obtained corresponding to optimum values of parameters was 0.2539 µm. And there was no value in of surface roughness is recorded less than this value during 27 experiments. Hence result was validated.

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