IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 8, Issue 1 (Jul. - Aug. 2013), PP 47-49
www.iosrjournals.org

Minimization of Surface Roughness in CNC Turning Using Taguchi Method

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Abstract: *Turning is a process to remove the material from the outer diameter of the rotating cylindrical work piece. The aim of the project is minimization of surface roughness in turning operation by using taguchi method. Taguchi method is used to find the best combination of cutting parameters like speed (N), feed (f), depth of cut (d), tool nose radius (Rn) and shim materials (Sm) are predicted by using L16 orthogonal array. The combination of control levels was predicted for the optimal surface roughness and using (S/N) ratio. A confirmation runs was used to verify the results for the optimal surface roughness.*
Keywords: *Surface Roughness, S/N ratio, Turning, Taguchi Method,*

I. Introduction

Turning is an important process in many manufacturing industries .Turning process the outer diameter is removed from the rotating cylindrical work piece. Surface roughness is the major factor of reducing the machining accuracy. In this process reduce the surface roughness of the product using taguchi method and need not to be going on other process like grinding to improve the surface finish. Taguchi method is used to find the best combinations of cutting parameters like speed (N), feed (f), depth of cut (d), tool nose radius, tool nose radius (R_n) and shim materials (S_m) to get the minimum surface roughness. The L16 orthogonal array is used to find the best combination of cutting parameters.

II. Taguchi Method

Taguchi method is a great tool for design a high quality system based on orthogonal array. This method achieves the integration of design of experiments with the optimization of the process yielding the desired result. In orthogonal array the numbers are arranged in columns and rows. Taguchi method is a measure of performance called signal to noise ratio (S/N) the logarithmic functions optimization.

III. Experimental Setup

A.Materials&Equipments

The material used in this experiment is mild steel bar diameter of the bar is 22mm and length is 50 mm. Sixteen number of samples of same material and same dimensions have been mad. The CNC machine is used to turn the mild steel bar manufactured by Lakshmi machine works Coimbatore. After machining the surface roughness and, surface profile have been measured with the help of a portable surface roughness tester (mitutoyo).

Table 1,cutting parameters and their levels

FACTORS	PARAMETER	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
A	SPEED	1000	2000	3000	4000
B	FEED	0.2	0.4	0.6	0.8
C	DEPTH OF CUT	0.4	0.6	0.8	1.0
D	TOOL NOSE RADIUS	0.2	0.4	0.8	1.2
E	SHIM MATERIAL	CARBIDE	COPPER	ALUMINIUM	GUN METEL

B.Experimental Result & Analysis

The experiments are used to assessment of surface roughness it is influenced by cutting parameters like speed, feed, depth of cut, tool nose radius, shim material. The $L_{16}4^5$ orthogonal array is shown in below

Table 2,orthogonal array and data analysis

SL.NO	SPEED	FEED	DEPTH OF CUT	TOOL NOSE RADIUS	SHIM MATERIAL
1	1000	0.2	0.4	0.2	CARBIDE
2	1000	0.4	0.6	0.4	COPPER
3	1000	0.6	0.8	0.8	ALUMINIUM
4	1000	0.8	1.0	1.2	GUN METEL
5	2000	0.2	0.6	0.8	GUN METEL
6	2000	0.4	0.4	1.2	ALUMINIUM
7	2000	0.6	1.0	0.2	COPPER
8	2000	0.8	0.8	0.4	CARBIDE
9	3000	0.2	0.8	1.2	COPPER
10	3000	0.4	1.0	0.8	CARBIDE
11	3000	0.6	0.4	0.4	GUN METEL
12	3000	0.8	0.6	0.2	ALUMINIUM
13	4000	0.2	1.0	0.4	ALUMINIUM
14	4000	0.4	0.8	0.2	GUN METEL
15	4000	0.6	0.6	1.2	CARBIDE
16	4000	0.8	0.4	0.8	COPPER

Table 3, S/N ratio calculation

SL.NO	SPEED	FEED	DEPTH OF CUT	TOOL NOSE RADIUS	SHIM MATERIAL	R_a mean	ε	σ
1	1000	0.2	0.4	0.2	CARBIDE	3.1261	0.0390	-9.90094
2	1000	0.4	0.6	0.4	COPPER	5.9241	0.2132	-15.4814
3	1000	0.6	0.8	0.8	ALUMINIUM	5.5638	0.2307	-14.9150
4	1000	0.8	1.0	1.2	GUN METEL	3.7621	0.1717	-11.5177
5	2000	0.2	0.6	0.8	GUN METEL	2.4424	0.3542	-7.8467
6	2000	0.4	0.4	1.2	ALUMINIUM	1.4304	0.0339	-3.1143
7	2000	0.6	1.0	0.2	COPPER	5.3184	0.0843	-14.5166
8	2000	0.8	0.8	0.4	CARBIDE	4.4871	0.6023	-13.1169
9	3000	0.2	0.8	1.2	COPPER	0.9728	0.1015	0.1922
10	3000	0.4	1.0	0.8	CARBIDE	2.2377	0.0296	-6.996
11	3000	0.6	0.4	0.4	GUN METEL	4.8565	0.0851	-13.7277
12	3000	0.8	0.6	0.2	ALUMINIUM	5.2955	0.2212	-14.4857
13	4000	0.2	1.0	0.4	ALUMINIUM	0.8284	0.0230	1.6318
14	4000	0.4	0.8	0.2	GUN METEL	4.5176	0.0190	-13.0983
15	4000	0.6	0.6	1.2	CARBIDE	21.545	0.0347	-26.666
16	4000	0.8	0.4	0.8	COPPER	4.7719	0.1607	-13.5787

Sixteen different factor level experiments were performed using the design parameter combinations in the specified orthogonal array table. Sixteen pieces of bars were machined for each of parameter combinations. The completed response table for these data appears in the table presented below

Table 4, response table

S.NO	SPEED	FEED	DOC	TOOL NOSE RADIUS	SHIM MATERIAL
1	-12.9537	-3.9809	-10.0804	-13.0003	-8.7651
2	-9.6486	-9.6725	-10.7151	-10.1735	-10.8468
3	-8.7543	-12.0515	-10.2345	-10.8341	-7.7208
4	-7.5230	-13.1747	-10.4661	-4.8716	-11.5476

Standard deviation was subtracted from each measurement in the sample (sample mean), then the square difference obtained prior were calculated. The sample variance is written as formula:
S/N ratio = $-10 \log_{10} (Y^2+\sigma^2)$

IV. Conclution

In this work the surface roughness is minimized using taguchi method, which is used to find the best combination of cutting parameters of cutting parameters like speed, feed, depth of cut, tool nose radius and shim materials. The L16 orthogonal array and S/N ratio is used to predict the best level of cutting factors for minimizing the surface roughness are speed (4000 rpm), feed (0.2m/min),depth of cut (0.4 mm), tool nose radius (1.2 mm), shim material (Aluminium). The ANOVA analysis is used to find the spindle speed, feed, and depth of cut significant effect on surface roughness and the tool nose radius and shim material is less effect on surface roughness.

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