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Optimization of Surface Roughness in cylindrical grinding

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Abstract - *Cylindrical grinding is one of the important metal cutting processes used extensively in the finishing operations. In cylindrical grinding, there are two types of output quality characteristics Surface finish and surface roundness. I have to do minimize the surface roughness in cylindrical grinding. There are three process parameters which I have taken such as wheel speed, work speed and depth of cut. I used Taguchi method, smaller the signal to noise ratio, minimum the surface roughness (Ra). A mathematical model is developed using regression analysis to compare the experimental surface roughness and predicted surface roughness. ANOVA is calculated to determine the contribution factor of wheel speed, work speed and depth of cut on surface roughness.*

Key Words: *Cylindrical grinding, surface roughness (Ra), surface roundness, Design of experiments (DOE), Taguchi method, S/N ratio.*

1. INTRODUCTION

Cylindrical grinding is an essential process for final machining of components requiring smooth surfaces and precise tolerances. As compared with other machining processes, grinding operation that should be utilized under optimal conditions. It is widely used in industry, grinding remains perhaps the least understood of all machining processes. There are three different process parameters like wheel speed, work speed, and depth of cut.

The major operating input parameters that influence the output responses surface roughness and surface roundness. The surface quality produced in cylindrical grinding is influenced by various parameters given as follows

(i) Wheel parameters: abrasives, grain size, grade, structure, binder.

(ii) Process parameters: wheel speed, depth of cut, work speed.

The empirical conditions having restricted range of validity are conventionally used in practice because grinding process involves many uncontrollable parameters. So the ground surface quality with these conditions is not reliable or acceptable in any specific situation. To achieve the required surface quality in a specific situation, process parameters can be determined through a series of experimental runs. But, that may be a time-consuming and expensive method and also it cannot determine the exact optimum because of restricted experiment.

Taguchi can conveniently optimize the grinding parameters with several experimental runs well designed.

2. TAGUCHI METHOD

Taguchi method is the process of engineering optimization in a three step approach namely system design, parameter design and tolerance design. In the system design, a basic functional prototype design will be produced by applying scientific and engineering knowledge. In parameter design, independent process parameter values will be optimized and where as in tolerance design, tolerances will be determined and analyzed for optimal values set by parameter design. Taguchi method is a powerful design of experiments (DOE) tool for optimization of engineering processes, in which the concept of S/N ratio is used for the improvement of quality through variability reduction and improvement of measurement(M.Janardhan et.al)2011.

3. EXPERIMENTAL DATA

The experiment was planned using Taguchi's orthogonal array in the design of experiments, which help in reducing the number of experiments. The L27 orthogonal array (M. janardhan et.al) 2012.

Table3.1 Parameters and Their Levels for Experiment

level	Wheel Speed (N)(RPM)	Work Speed (V)(m/min	Depth of cut (d)(µm)
1	1250	7.5	5
2	1650	10	10
3	2050	12.5	15

Table3.2 Experimental values

Trial no.	Wheel Speed (N) (RPM)	Work Speed (V)(m/ min)	Depth of cut (d) (µm)	Surface Roughness (Ra) (µm)	S/N Ratio (Ra)
1	1250	7.50	5	1.034	0.294
2	1250	7.50	10	1.440	3.167
3	1250	7.50	15	1.624	4.211
4	1250	10	5	1.34	2.437
5	1250	10	10	1.591	4.033
6	1250	10	15	1.721	4.715
7	1250	12.5	5	1.38	2.797
8	1250	12.5	10	1.679	4.501
9	1250	12.5	15	1.940	5.756
10	1650	7.5	5	1.180	1.437
11	1650	7.5	10	1.56	3.862
12	1650	7.5	15	1.684	4.526
13	1650	10	5	1.490	3.463
14	1650	10	10	1.641	4.302
15	1650	10	15	1.716	
16	1650	12.5	5	1.501	3.527
17	1650	12.5	10	1.697	4.59
18	1650	12.5	15	1.826	5.23
19	2050	7.5	5	1.361	2.67
20	2050	7.5	10	1.582	3.98
21	2050	7.5	15	1.703	4.62
22	2050	10	5	1.460	3.287
23	2050	10	10	1.632	4.254
24	2050	10	15	1.805	5.129
25	2050	12.5	5	1.513	3.596
26	2050	12.5	10	1.734	4.781
27	2050	12.5	15	2.072	6.327

Lower is better S/N =-10 log [1/n (Σyi2)]

Table (3.3) Mean Response Table for Surface Roughness

Parameter	L1	L2	L3
Wheel speed	**1.52**	1.58	1.65
Table speed	**1.46**	1.59	1.70
Depth of cut	**1.36**	1.61	1.78

Table (3.4) S/N Ratio Table for Surface Roughness

Parameter	L1	L2	L3
Wheel speed	**3.54**	3.95	3.89
Table speed	**3.19**	4.03	4.01
Depth of cut	**2.61**	4.16	5.02

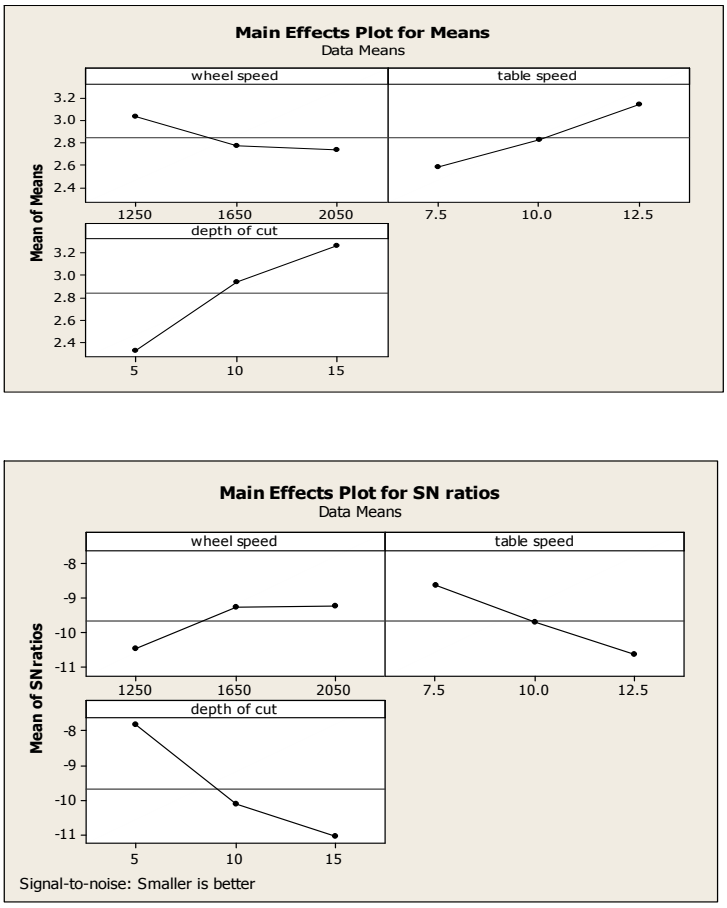


Figure 1: Effect of Process Parameter on Surface Roughness

Table -3.5 Analysis of Variance for Surface Roughness, minitab-16 software.

source	DOF	SS	Mean SS	F-Ratio	p-value
Wheel speed	2	0.05652	0.02826	4.84	0.019
Table speed	2	0.38608	0.19304	33.04	0.000
Depth of cut	2	0.95909	0.47955	82.09	0.000
error	20	0.11684	0.00584		
total	26	1.51854			

4. Development Mathematical Modeling

Regression analysis is performed to find out the relationship between factors and surface roughness. In conducting regression analysis, it is assumed that factors and the response are linearly related to each other. A multiple regression technique was used to formulate the wheel speed, work speed and depth of cut to the surface roughness. The response function representing the surface roughness can be expressed as: Surface roughness = f (wheel speed, work speed, depth of cut). This equation can also be written as:

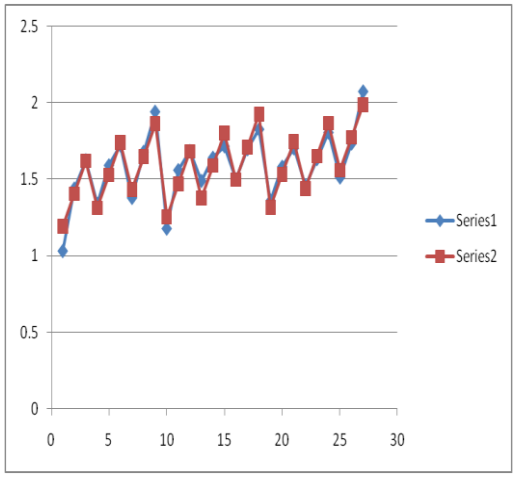
$$Ra = 0.425 + 0.000155\ x1 + 0.0483\ x2 + 0.0426\ x3$$

Table-4.1 the coefficient of regression model

Predictor	Coeff.	Std. Error	Beta	T	Sig.
constant	0.4252	0.1002		4.24	0.000
Welding speed	0.00015458	0.00004081		3.79	0.001
Table speed	0.048311	0.006529		7.40	0.000
Depth of cut	0.042578	0.003265		13.04	0.000

Table-4.2 comparison between experimental and predicted surface roughness.

Serial No.	Experimental surface roughness	Predicted surface roughness	%Error
1	1.034	1.194	-15.4739
2	1.440	1.407	2.291667
3	1.624	1.62	0.246305
4	1.34	1.31475	1.884328
5	1.591	1.52775	3.975487
6	1.721	1.74075	-1.14759
7	1.38	1.4355	-4.02174
8	1.679	1.6485	1.816557
9	1.940	1.8615	4.046392
10	1.180	1.256	-6.44068
11	1.56	1.469	5.833333
12	1.684	1.682	0.118765
13	1.490	1.37675	7.600671
14	1.641	1.58975	3.123096
15	1.716	1.80275	-5.05536
16	1.501	1.4975	0.233178
17	1.697	1.7105	-0.79552
18	1.826	1.9235	-5.33954
19	1.361	1.318	3.159442
20	1.582	1.531	3.223767
21	1.703	1.744	-2.40752
22	1.460	1.43875	1.455479
23	1.632	1.65175	-1.21017
24	1.805	1.86475	-3.31025
25	1.513	1.5595	-3.07336
26	1.734	1.7725	-2.2203
27	2.072	1.9855	4.17471



Series -1 experimental values
Series-2 predicted values

Comparision between experimental and predicted surface roughness.

5. Response Graphs for Means

5.1 Level [1] for wheel speed W1 = 1.52 Ra indicated as the optimum situation in terms of Surface Roughness values.

5.2 Level [1] for table speed T1 = 1.46 Ra indicated as the optimum situation in terms of Surface Roughness values.

5.3 Level [1] for depth of cut D1 = 1.36 Ra indicated as the optimum situation in terms of Surface Roughness values.

5.4From ANNOVA analysis the contribution factor of depth of cut is 82.09%, Table speed is 33% and wheel speed is 4% seen from table (3.5)

6. CONCLUSIONS AND SCOPE OF FUTURE WORK

For main effects depth of cut and table speed have significant effect on the surface roughness. Whereas wheel speed have decreasing effect on the surface roughness. This is consistent with the conclusions from the study of other investigators.

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