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ANALYSIS OF MACHINING CONDITIONS FOR THE TURNING PROCESS BY USING REGRESSION MODELING AND TAGUCHI

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ABSTRACT

The present study highlights an experimental study carried out to analyze the effect of various machining process parameters on the surface roughness (Ra), surface hardness (Ha) of finish product and tool wear (Tw) of cutting tool. The parameters such as cutting speed (A), feed rate (B), and depth of cut (C) were chosen as operation parameters. The purpose of this paper is to determine the optimum level of machining process parameters for achieving the highest surface finish, highest surface hardness of product and lowest tool wear during operation. By using Taguchi parametric design technique. Taguchi is an important tool for rebusts design which offers a systematic approach to optimize a design for quality characteristic. Taguchi's L8 standard orthogonal array is selected for experimental planning and developed model is tested by ANOVA. And result is confirmed by regression modeling and conducting confirmation experiments.

Keywords: *- Taguchi L8 OA, Regression modeling and taguchi, turning on lathe machine.*

I. INTRODUCTION

A process and product have three qualities characteristic such as higher the better; lower the better and nominal the best. Higher the better is considered in case of tensile strength, compressive strength, toughness, hardness etc.to gets the best result they should be maximum. And lower the better is consider in case of process time, resources, cost, defects, losses, tool wear, surface roughness etc. to get the best result they should be minimum. Good surface finish is necessary to improve corrosion resistance, to reduce friction, wear, and noise and improved product life. Tool wear during process also should be low to get the best product quality and dimension accuracy. The Taguchi method is adopted experimentally to investigate influence of surface roughness, surface hardness and tool wear by cutting parameters such as cutting speed, feed rate and depth of cut.

II. EXPERIMENTAL SET UP & DATA ANALYSIS

Due to widely use in industrial and domestic application, specimens were prepared from low carbon mild steel containing 0.06 % carbon, 0.09% silicon, 0.37 % manganese, 0.063 % phosphorus, 0.065 % sulphur. Having 40 mm diameter and 250 mm length was used. Cutting parameters were taken at two ranges is shown in table I. The parameter which were constant during experiment such as tool geometry and dry turning, Totally 8 experiments with different level of cutting speed, feed rate and depth of cut combination based on Taguchi L8 orthogonal array were performed and surface roughness, surface hardness, and tool wear was measured for all cases.

Table 1. Selected parameters & their level

S. No	Parameter /Lever	L1	L2
1	Cutting speed (A) in m/min	445	555
2	Feed Rate (B) in mm/rev	0.3	0.5
3	Depth of cut (C) in mm	0.5	0.8
4	Tool material	SS	HSS

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Table 2. Taguchi L8 Standard orthogonal Array

Exp./ Parameter	Para.1	Para.2	Para.3	Para.4
1	1	1	1	1
2	1	1	2	2
3	1	2	1	2
4	1	2	2	1
5	2	1	1	2
6	2	1	2	1
7	2	2	1	1
8	2	2	2	2

Table 3. Output Response for Ra, Ha & Tw

Exp. No.	Ra In μm	Ha In HRC	Tw In mm
1	0.535	28	0.19
2	0.623	33	0.35
3	0.412	35	0.30
4	0.915	39	0.49
5	0.399	30	0.28
6	0.823	32	0.37
7	0.450	37	0.41
8	0.762	42	0.50
Mean	0.614	34.50	0.361

Table 4. S/N Ratio for Ra, Ha and Tw

Exp. No.	Ra	Ha	Tw
1	5.432	28.943	14.424
2	4.110	30.370	9.118
3	7.702	30.881	10.457
4	0.771	31.821	6.196
5	7.980	29.542	11.056
6	1.692	30.102	8.635
7	6.935	31.364	7.744
8	2.360	32.464	6.020
Mean	4.622	30.685	9.206

Table 5. Mean response for Ra

Parameter/Level	Level1	Level 2
A	0.621	0.608
B	0.595	0.634
C	0.449	0.780
D	0.680	0.549

Mean 0.614

Table 6. Mean response for Ha

Parameter/Level	Level1	Level 2
A	33.75	35.25
B	30.75	38.25
C	32.50	36.50
D	34.0	35.0

Mean 34.50

Table 7. Mean responses for Tw

Parameter/Level	Level1	Level 2
A	0.332	0.390
B	0.297	0.425
C	0.295	0.427
D	0.365	0.357

Mean 0.361

Table 8. S/N response for Ra

Parameter/Level	Level1	Level 2
A	4.503	4.741
B	4.803	4.442
C	7.012	2.233
D	3.707	5.538

Mean 4.622

Table 9. S/N response for Ha

Parameter/Level	Level1	Level 2
A	30.503	30.868
B	29.739	31.632
C	30.182	31.189
D	30.557	30.814

Mean 30.685

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Table 10. S/N response for Tw

Parameter/Level	Level1	Level 2
A	10.048	8.363
B	10.808	7.604
C	10.920	7.492
D	9.162	9.249

Mean 9.206

III. RESULT & DISCUSSION

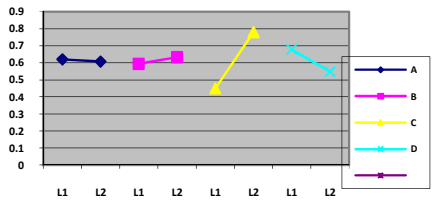
Experimental Optimum situation for minimum surface roughness is obtained on level A2B1C1D2 and Prediction Optimum situation for surface roughness is obtained on level A2B1C1D2. Experimental optimum situation for maximum surface hardness is obtained on level A2B2C2D2 and Prediction optimum situation for surface hardness is obtained on level A2B2C2D2. Experimental optimum situation for minimum tool wear is obtained on level A1B1C1D2 and Prediction optimum situation for minimum tool wear is obtained on level A1B1C1D2.

Regression analysis-The correlation between the cutting parameters and outcome response were obtained by regression analysis.
By using MATLAB software R2011B.

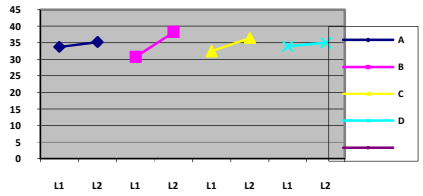
$$Ra = e^{0.8511} * (\text{cutting speed})^{-0.1239} * (\text{feed rate})^{0.0819} * (\text{depth of cut})^{1.1707}$$

$$Ha = e^{2.8718} * (\text{cutting speed})^{0.1898} * (\text{feed rate})^{0.4270} * (\text{depth of cut})^{0.2463}$$

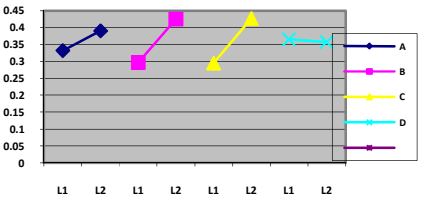
$$Tw = e^{-5.4570} * (\text{cutting speed})^{0.8807} * (\text{feed rate})^{0.7230} * (\text{depth of cut})^{0.8388}$$



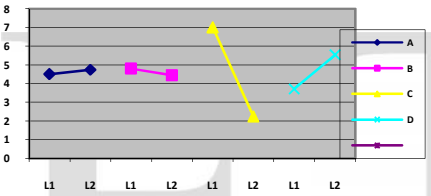
Graph 1. Main effect plot for mean response of Ra



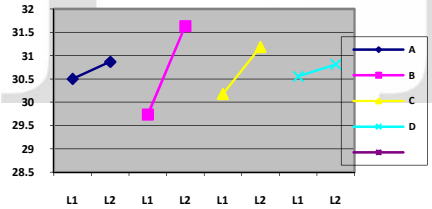
Graph 2. Main effect plot for mean response of Ha



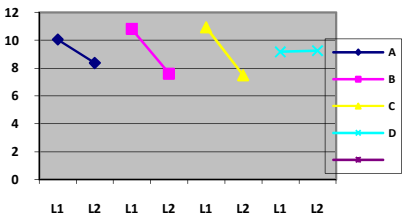
Graph 3. Main effect plot for mean response of Tw



Graph 4. Main effect plot for S/N response of Ra



Graph 5. Main effect plot for S/N response of Ha



Graph 6. Main effect plot for S/N response of Tw

ANALYSIS OF VARIANCE

The main effect of analysis of variance (ANOVA) is to investigate the design parameters and to indicate which parameters are significantly affecting the output

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parameters. In the analysis the sum of square and variance are calculated. F-test value at 95 % confidence level is used to decide the significant factors affecting the process and percentage contribution is calculated.

Table 11. Analysis of variance for Ra

Symbol	DOF	SS	MS	F-value	% C.
A	1	0.112	0.112	0.039	0.201
B	1	0.256	0.256	0.091	0.460
C	1	45.676	45.676	16.249	82.211
D	1	6.704	6.704	2.384	12.066
Error	3	2.811	0.937		5.059
Total	7	55.559			100

Table12. Analysis of variance for Ha

Symbol	DOF	SS	MS	F-value	% C.
A	1	0.264	0.264	1.748	2.712
B	1	7.16	7.16	47.417	73.579
C	1	2.028	2.028	13.430	20.840
D	1	0.128	0.128	0.847	1.315
Error	3	0.151	0.050		1.551
Total	7	9.731			100

Table 13. Analysis of variance for Tw

Symbol	DOF	SS	MS	F-value	% C.
A	1	0.0064	0.0064	1.5609	8.226
B	1	0.0328	0.0328	8.0	42.159
C	1	0.0344	0.0344	8.390	44.215
Error	3	0.0041	0.0013		5.2699
Total	7	0.0778			100

COMPARISON BETWEEN RESULTS

Comparision of results is shown by table below

Parameter	Exp. result	Prediction result	Regression result	Optimum level
Ra	0.399	0.359	0.430	A2B1C1D2
Ha	42	41.5	41.191	A2B2C2D2
Tw	0.19	0.198	0.214	A1B1C1D2

IV. CONCLUSION

This paper has presented an investigation on the optimization and the effect of machining parameters on the surface roughness, surface hardness and tool wear. The optimum level of parameters is determined by using the Taguchi method, the highly effective parameters to surface roughness is depth of cut and highly effective parameter to surface hardness is feed rate and highly effective parameter to tool wear is depth of cut.

SUMMARY

In the present work the relation between surface roughness, surface hardness and tool wear with various machining parameters have been found out.

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