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Improvement of Surface Integrity in Hard Turning With Sensitivity Analysis of Cutting Parameter

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This paper presents study of effects of cutting parameters such as cutting speed, feed rate and depth of cut on the surface roughness in hard turning. Taguchi Method and linear regression model of design parameters were utilized to identify the controlling process parameters that can monitor the surface roughness in the hard turning operation. In the process optimization, experimental planning was performed using the orthogonal array and concept of the signal-to-noise ratio. Cutting parameters such as speed, feed rate, and depth of cut were selected as process parameters and the ANOVA analysis showed that feed rate and cutting speed had more effect on the roughness variation that depth of cut.

Keywords : Surface Roughness, Hard Turning, Cutting Parameter, Design of Experiment, Taguchi Method

1. INTRODUCTION

Due to the increasing demand for the better for the better quality, manufacturing engineers are facing with a difficult problem of increasing productivity without compromising quality.. In machining process, surface characteristics of the machined parts have been recognized as a important factors of the quality control in production. Fine surface nor only provides customer satisfaction for product appearance, but also assures the functionality and reliability of the product. One of the important quality factors is surface roughness, which plays an important role in all areas of tribology

Generally, surface roughness in turning is influenced by many cutting parameters such as feed, cutting speed, depth of cut, cutting angle, shape of tool, and tool wear etc. However, it is well known that actual surface roughness depends on process geometry and relative motion between tool and workpiece. The relative motion is influenced by the tool wear and process characteristics.

This paper presents study of effects of cutting parameters such as cutting speed, feed rate and depth of cut on the surface roughness in hard turning. Taguchi Method and linear regression model of design parameters were utilized to identify the controlling process parameters that can monitor the surface roughness in the hard turning. Prediction of optimal machining conditions for good surface finish using Taguchi Method is also conducted.

2. Design of Experiment

The design of experiment was conducted to identify primary and secondary causes for surface roughness deterioration in hard turning. The experiment showed that cutting speed, feed, and depth of cut were the important cutting parameters to influence surface roughness formation.

The number and levels of control parameters were shown in Table 1.

Table 1 Cutting Parameters and their levels

Parameter	Level 1	Level 2	Level 3
(A) Cutting speed [m/min]	50	90	130
(B) Feed rate [mm/rev]	0.1	0.15	0.2
(C) Depth of Cut [mm]	0.05	0.1	0.2

To study the effect of the cutting speed on the surface roughness variation, cutting speed was varied from low speed to high (50m/min ~ 250m/min).

The chosen array in the experiment was L9, which has 9 rows corresponding to the number of tests with 4 columns at three levels, as shown in Table 2.

Table 2 L9 Orthogonal Array (Inner Array: Control Factor)

Run	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

9 testes were conducted for the design of experiment and roughness was selected for the better quality. For the variance of the analysis, each test was repeated three times.

The cutting tests were conducted in Hwacheon CNC turning center. The workpiece material used in the tests was heated treated SKD11 and its hardness was about HRC 62~63. The diameter of the workpiece was 67mm and the length was

150mm. The tool used in the tests was CNGA12040-TN (NTK)-type ceramic insert. Fresh inserts were used in each cutting test. Surface roughness along longitudinal direction were measured 3 times and roughness at three points of the machined workpiece along radial direction was measured directly using Perthometer M1(Mahr) while the workpiece was installed in the machining tool.

3. Results and Discussion

The analysis of data variance with arithmetic average roughness and maximum height roughness was made with the objective of analyzing the influence of cutting velocity, feed, and depth of cut.

Table 3 Arithmetical Average Roughness [um]

Run	A	B	C	D	U0	U1	U2
1	1	1	1	1	0.73	0.81	0.74
2	1	2	2	2	1.15	1.23	1.19
3	1	3	3	3	1.32	1.68	1.72
4	2	1	2	3	0.90	0.97	0.89
5	2	2	3	1	1.33	1.37	1.36
6	2	4	1	2	1.88	1.93	1.97
7	3	1	3	2	0.93	0.95	0.98
8	3	2	1	3	1.18	1.19	1.18
9	3	3	2	1	1.94	1.89	1.87

Table 3 shows the experimental results for surface roughness Ra and S/N response graphs for surface roughness shown in Fig. 1

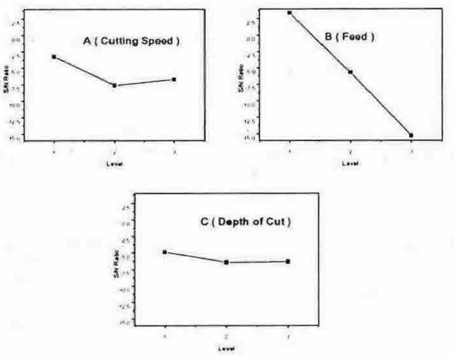

Fig. 1 S/N Ratio of Ra

ANOVA analysis showed that feed rate was the most significant cutting parameter to affect surface roughness similar to the conventional turning. In the S/N ratio and ANOVA analyses, the optimal cutting parameters for surface roughness were the cutting speed at level 1, the feed at level 1, and the depth of cut at level 1. But depth of cut did not affect surface roughness than other two parameters did.

Besides the influence of other design parameters, the influence of the cutting speed was specially analyzed. Fig. 2 shows the result of surface roughness versus cutting speed. The figure showed that as cutting speed varied from 90m/min to 220m/min, surface roughness was improved. In the lower cutting speed (below 90m/min) and higher cutting speed (over 220m/min) different results were observed. The results showed that optimal cutting speed for improving surface roughness exists.

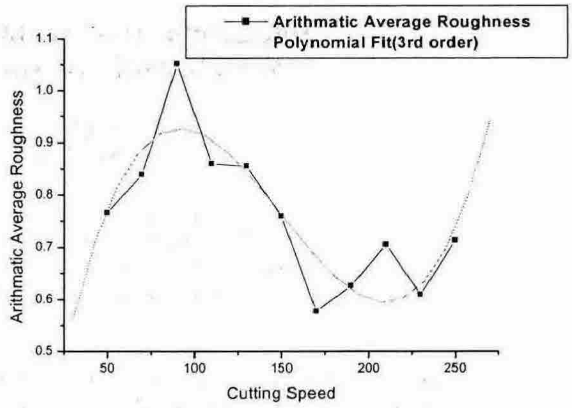

Fig. 2 Roughness VS Cutting Speed

4. Conclusions

From the research, the following conclusions were made for the relationship between cutting parameters and surface roughness.

- The feed had greater influence on the surface roughness than other two parameters in hard turning
- The depth of cut had no significant influence on the surface roughness in hard turning.
- The optimal cutting speed for improving surface roughness was about 200 m/min in hard turning.

5. REFERENCES

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