OPTIMIZATION OF CUTTING PARAMETERS TO MINIMIZE SURFACE ROUGHNESS OF C45 STEEL IN TURNING PROCESS ON S530 X 1000 LATHE USING TAGUCHI METHOD

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Abstract:

This paper presents the results of experimental work carried out in the process of turning on the S530 X 1000 Lathe with 2 research objects are C45 Steel. This study aims to optimize the cutting parameters of the research object in order to minimize surface roughness using the Taguchi method. In this study, the orthogonal array used $L_9(3^3)$ array with 3 levels and 3 factors. The factors used are derived from cutting parameters such as spindle speed, feed rate, and depth of cut. In this study, using cutting parameters on Dural objects such as the following: spindle speed 120, 280 and 440 rpm, feed rates 0.05, 0.10, 0.21 mm / rev, and depth of cut 0.5, 0.75, and 1 mm. In this study, using cutting parameters on C45 Steel objects as follows: spindle speed 90, 185 and 270 rpm, feed rates 0.06, 0.13, 0.17 mm / rev, and depth of cut 0.5, 0.75, and 1 mm. The use of Signal to Noise Ratio (S / N Ratio) uses a "smaller is better" approach to find optimal experimental results in minimizing surface roughness. The researcher will test a number of experiments, an analysis will be carried out on each experiment that has been tested and then one of the optimal experiments will be chosen to minimize surface roughness.

Keywords: Optimize, Taguchi method, Surface roughness, Signal to Noise Ratio, ANOVA.

1. Introduction

The quality of the products can be seen from a number of aspects, one of which is surface roughness. According to Ribeiro et al. (2017), the value of the machined surface is measured by the surface roughness of the machined component, which is the most important quality characteristic. Nonetheless, the application of optimization techniques could be an interesting solution for reducing the number of variations of experimental experiments. Each combination of cutting parameters can result in different surface roughness and tool life. Nonetheless, it is very difficult to define the best combination that gives lower surface roughness and total tool life for many different parameters to monitor with multiple levels for each one. For the manufacturing industry, surface quality, tool life, and production costs are the most important features in a certain combination of machining parameters.

In this study, the experiment using the Taguchi method to minimize surface roughness for C45 Steel in the turning process. The machines used are in the manufacturing building, Telkom University. Taguchi Method using several cutting parameters from S530 x 1000 lathe which parameters will be carried out experiments to optimize the cutting parameters in minimizing surface roughness.

2. Literature Review and Methodology

2.1 Surface Roughness

Based on Groover (2010), the surface roughness expected from different manufacturing processes is indicated in Figure II.3. The manufacturing process defines the surface finish and the quality of the product. Many systems are able to produce stronger surfaces than others. In addition, processing costs rise with better surface finishing. This is due to additional operations and more time to get ever better surfaces. The processes used for superior finishing include finishing, finishing, polishing, and superfinishing.

2.2 Taguchi Method

The Taguchi method was later developed by Genichi Taguchi in Japan to improve the application of total offline quality control. This method deals with finding the best value of a control factor to make a problem less sensitive to variations in uncontrolled factors. This kind of problem is called Taguchi robust design problem (Negrete et al., 2015).

2.3 Orthogonal Array

In Taguchi's methodology, the main role of the orthogonal array is to allow engineers to evaluate the design of the product in terms of robustness. Orthogonal means balanced in the design of the experiments. The versatility and willingness to delegate a number of variables to orthogonal arrays is a key feature of orthogonal array use. In addition, the reproducibility or repeatability of conclusions drawn from small-scale trials in research and development based on process design (Negrete et al., 2015).

2.2 Signal to Noise Ratio

According to Singh et al. (2016), the Signal-to-noise ratio (summarized SNR or S / N) is a metric that contrasts a target signal with a background noise level in science and engineering. A strength metric used to recognize control factors (signal factors) that minimize product or system variance by reducing the effects of uncontrollable factors (noise factors, such as voltage fluctuations, fatigue, temperature, humidity) is used in Taguchi designs.

2.3 Analysis of Variance (ANOVA)

ANOVA in the Taguchi method is used as a statistical method for interpreting experimental data. Analysis of variance is a calculation technique with quantitative methods to estimate the contribution of each factor to each response that has been measured which helps the process of identifying the contribution of factors so that the estimated accuracy of the model can be determined. The classification of experimental results is carried out statistically according to the source of variation. ANOVA for orthogonal matrices is based on the calculation of the number of squares for each column (Asfar et al., 2018).

3. Processing Stage

3.1 Performance Characteristic Identification

After experimenting with parameters, finally found cutting parameters that produce a relatively smooth surface and can be measured by a Roughness Tester. The following are the cutting parameters selected in table 3.1.

Table 3.1 Cutting Parameters and Levels

Cutting Parameters (Factors)	Levels		
	Level 1	Level 2	Level 3
Spindle Speed (n)	855	1350	2000
Feed Rate (f)	0.13	0.17	0.21
Depth of Cut (a_p)	0.4	0.3	0.5

3.2 Orthogonal Array Determination

It is important to determine the level to evaluate several factors by the number of tests. In this study, 3 level arrays with 3 parameter variables have been chosen to get the Taguchi array with L_9. To determine the Orthogonal Array needed, three factors with three levels are needed, so an array with L_9 is generated. After the orthogonal array is generated, the numbers of the three parameters (spindle speed, feed rate, and depth of cut) are filled into the table according to their level that shown in Table 3.2.

Table 3.2 Taguchi's Orthogonal Array L_9 Design

Number of Experiment	Cutting Speed	Depth of Cut	Feed Rate
1	855	0.13	0.4
2	855	0.17	0.3
3	855	0.21	0.5
4	1000	0.13	0.4
5	1000	0.17	0.3
6	1000	0.21	0.5
7	1200	0.13	0.4
8	1200	0.17	0.3
9	1200	0.21	0.5

3.3 Surface Roughness Measurement

After selecting the parameters and determining the orthogonal array, then the surface roughness measurements of 9 parts are carried out using Mitutoyo SJ-410 Series. The result is shown in Table 3.3.

Table 3.3 Surface Roughness Measurement Result

Spindle Speed	Feed Rate	Depth of Cut	Ra
855	0.13	0.4	2.474
855	0.17	0.3	2.957
855	0.21	0.5	2.404
1000	0.13	0.4	1.462
1000	0.17	0.3	1.342
1000	0.21	0.5	1.548
1200	0.13	0.4	0.86
1200	0.17	0.3	1.102
1200	0.21	0.5	1.463

4. Experimental Result Anlaysis

4.1 Signal to Noise Ratio

In Table 4.1, Signal to Noise Ratio has been calculated with surface roughness (Ra) as response data on all three factors and levels. can be seen in the table, generated analysis numbers with 9 pieces of data because the orthogonal array is L_9. which can be seen in the relationship of parameters with surface roughness.

Table 4.1 Orthogonal Array with Factors

Spindle Speed	Feed Rate	Depth of Cut	Ra	SNRA1
855	0.13	0.4	2.474	-7.868
855	0.17	0.3	2.957	-9.417
855	0.21	0.5	2.404	-7.6187
1350	0.13	0.3	1.462	-3.2989
1350	0.17	0.5	1.342	-2.5551
1350	0.21	0.4	1.548	-3.7954
2000	0.13	0.5	0.860	1.3100
2000	0.17	0.4	1.102	-0.8436
2000	0.21	0.3	1.463	-3.3049

In the Figure 4.1, it is known that the largest influence of spindle speed parameter is at 2000 rpm with level 3, then the optimum feed rate is at 0.13 mm/rev with level 1, and at depth of cut, the optimal result is at 0.5 mm with level 3.

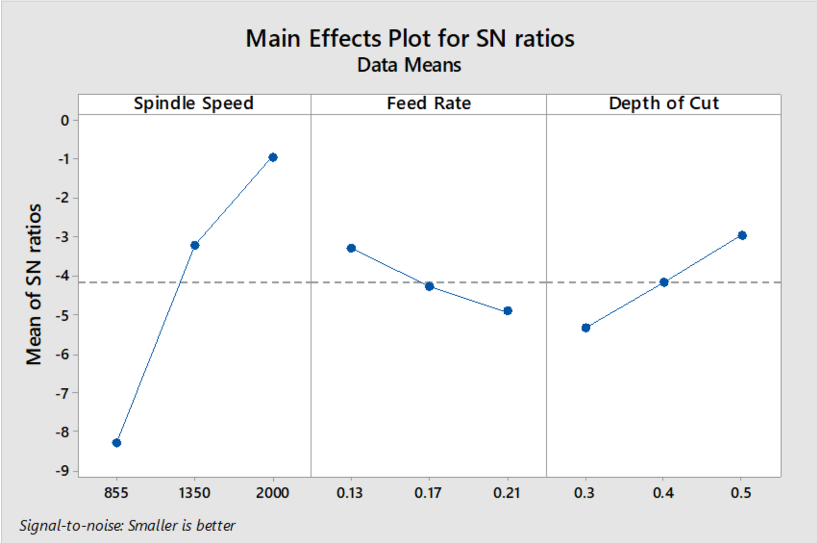

Figure 4.1 Main Effects Plot for SN Ratios

4.2 Analysis of Variance (ANOVA)

After a one-way ANOVA test ran, data shown in Table 4.2 that degree of freedom (DF) is 2 with a contribution is 4.06%, sequence sum of squares (Seq SS) is 4.002, adjusted mean squares (Adj MS) is 2.001, then F-Value is 0.13 and P-Value is 0.883.

Table 4.2 ANOVA One-way Test SNRA1 Versus Feed Rate

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Feed Rate	2	4.002	4.06%	4.002	2.001	0.13	0.883
Error	6	94.447	95.94%	94.447	15.741		
Total	8	98.449	100.00%				

After a one-way ANOVA test ran, data shown in Table 4.3 that degree of freedom (DF) is 2 with a contribution is 8.67%, sequence sum of squares (Seq SS) is 8.538, adjusted mean squares measure (Adj MS) is 4.269, then F-Value is 0.28 and P-Value is 0.762.

Table 4.3 ANOVA One-way Test SNRA1 Versus Depth of Cut

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Depth of Cut	2	8.538	8.67%	8.538	4.269	0.28	0.762
Error	6	89.910	91.33%	89.910	14.985		
Total	8	98.449	100.00%				

5. Conclusion

1. Based on Signal to Noise Ratio results, it shown that the spindle speed parameter with a P-Value of 0.049 is smaller than the significance value 0.05 then the variable is not normally distributed. Then the feed rate and depth of cut parameters obtained a P-Value of 0.057 which is greater than the significance value 0.05 so it can be said that the feed rate and depth of cut variables are normally distributed.
2. Based on Analysis of Variance results, the optimal condition of cutting parameters is spindle speed of 2000 rpm of level 3, the feed rate of 0.13 mm/rev of level 1, and depth of cut of 0.5 mm of level 3.

6. Refference

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