International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 6, September-October 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Study on Minimum Quantity Lubricant Conditions to Improve the Surface Roughness in Hard Turning of SKD 61 Alloy Steel

The-Vinh Do

The Research Development Institute of Advanced Industrial Technology,
Thai Nguyen University of Technology, Thai Nguyen City, Viet Nam

ABSTRACT

In this research, Taguchi method was applied to find the optimal values of minimum quantity lubricant (MQL) condition in hard turning of SKD 61 with consideration of reduced surface roughness. The performance characteristics of MQL parameters (cutting fluid type, pressure and fluid flow) were studied by using a L9 array, the signal-to-noise ratios and analysis of variance (ANOVA). In result of the present study, the lubricant and the pressure of MQL condition are the most influential factors which give statistic significant effect on machined surfaces. In addition, the optimal condition of the MQL mode to reduce the roughness was also presented.

***KEYWORDS:** MQL; hard turning; SKD61 alloy steel; Taguchi method; surfac roughness*

How to cite this paper: The-Vinh Do "Study on Minimum Quantity Lubricant Conditions to Improve the Surface Roughness in Hard Turning of SKD 61 Alloy Steel" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-6, October 2021, pp.227-229, URL: www.ijtsrd.com/papers/ijtsrd46369.pdf

IJTSRD46369

INTRODUCTION

Nowadays, hard machining has been widely applied in mechanical processing due to have many advantages. The advantages of hard machining were indicated as geometric accuracy, the improved quality of the finished surface, the reduction of the labor expenditures and also reduction burr formation, better chip disposal, higher stability, simplified tooling[1-3]. However, due to high hardness of the work piece material and high cutting temperature, the tool life is reduced[4]. The application of flood coolant in hard machining has not been satisfied, especially in the matter of environment[5, 6]. MQL is a successful key to hard machining. MQL is an effective, environmentally friendly solution to be applied in metal cutting processes. Machining with MQL is a process in which a small amount lubricant at a flow rate less than 250 ml/h is mixed with compressed air and sprayed on cutting zone [7]. MQL helps in increasing the quality of surface finish, improving tool life, reducing tool wear, decrease cutting temperature and cut down the cost of lubrication[8-12]. The effectiveness of MQL has been demonstrated in many studies and application of turning and milling processes.

In machining with MQL, the lubricant, the air pressure and the fluid flow are mainly parameters. They decide the effectiveness of MQL cutting. Applied lubricants in machining are wealthy as mineral oil, synthetic esters, fatty alcohols...[13]. Even the vegetable oil was also used and proven effective in machining[5, 13]. Several authors optimized MQL parameters and achieved positive results [1, 14]. However, the researches on the effects and optimization of the parameters of MQL including flow rate, air pressure and type of lubricant still remain open.

In the study, the Taguchi method and ANOVA were applied to optimize MQL conditions for surface roughness. The best MQL parameters of hard turning of SKD61, such as cutting fluid type, pressure and fluid flow were found out in order to get the better surface roughness.

EXPERIMENTAL PROCEDURE

In this study, Taguchi method was used to design the experiments. This method has been widely used because it is a simple and robust method to optimize the parameters of process with involving significant reducing in cost and time of processing. With three parameters at three levels, Taguchi's L9 orthogonal array was used to organize the experiments. The purpose of present research is to optimize the parameters of the MQL system to get the better surface roughness which are set to minimum. Therefore, the-smaller-is-the-better type was selected. It is calculated according to the following formula:

$$\frac{S}{N} = -10 Log \frac{1}{n}\left(\sum_{i=1}^{n} y_i^2\right) \quad (1)$$

Where: y_i is the observed data, n is the number of experiments which is repeated.

The turning process was performed by a Maxxturn 45 turning CNC machine and CBN cutting tool. The work pieces are SKD 61 steel block with 55 HRC hardness. The turning parameters were cutting velocity of 60 m/min, feed rate of 0.05 mm/rev and depth of cut of 0.1 mm.

RESULTS AND DISCUSSIONS

The analysis was carried out to determine the effect of MQL parameters (fluid flow *F*, pressure *P* and type of lubricant *L*) on surface roughness. The statistic analysis was performed by using Minitab software version 18. From formula (1), S/N ratio was calculated. Value of S/N ratio and measured result of Ra is shown in the Table 1. Mean of S/N response for surface roughness is shown in the Table 2.

TABLE 1. THE SURFACE ROUGHNESS RESULT AND S/N RATIO

L	F ml/h	P KG/cm^2	Ra µm	S/N
Peanut oil	20	3	1.232	-1.81221
Peanut oil	60	4	1.311	-2.35205
Peanut oil	100	5	1.687	-4.5423
Straight cutting oil	20	4	1.293	-2.23197
Straight cutting oil	60	5	1.65	-4.34968
Straight cutting oil	100	3	1.055	-0.46505
Emulsion	20	5	1.388	-2.84779
Emulsion	60	3	0.901	0.905504
Emulsion	100	4	0.955	0.399933

Table 2 shows the response table for S/N. The ranked highest of each level of MQL parameters is the first level for the type of lubricant, the third level for the fluid flow, and the first level for the pressure. Consequently, the optimal condition of the hard turning process will be (1-3-1). The rank of the pressure is "1" meaning that pressure is the most influential factor on the surface roughness. The second factor affecting surface roughness is the type of lubricant

TABLE 2. MEAN OF S/N RESPONSE FOR SURFACE ROUGHNESS.

Level	L	F	P
1	-0.5141	-2.2973	-0.4573
2	-2.9022	-1.9321	-1.3947
3	-2.3489	-1.5358	-3.9133
Delta	2.3881	0.7615	3.4560
Rank	2	3	1

Figure 1 shows the S/N response graph. From the S/N response analysis, the MQL optimal condition of MQL is the emulsion for lubricant, flow rate of 100 ml/h and the pressure of 3 KG/cm^2.

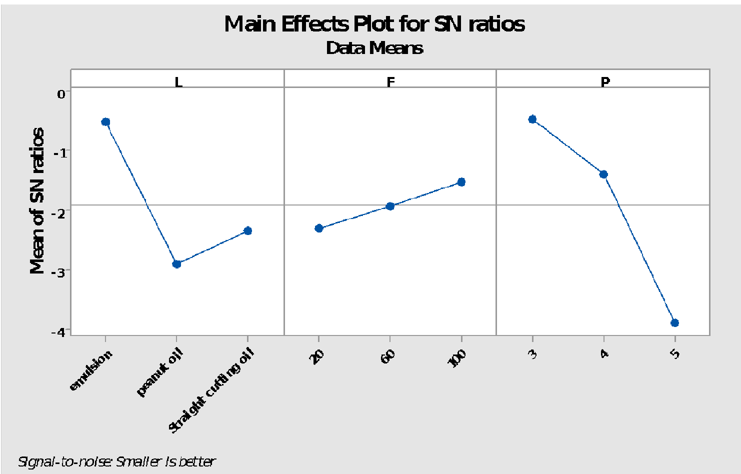

FIGURE 1 EFFECT OF MQL PARAMETERS ON SURFACE ROUGHNESS

TABLE 3 THE ANALYSIS OF VARIANCE FOR SURFACE ROUGHNESS

Source	DF	Adj-SS	Adj-MS	F-Value	P-Value	C%
L	2	0.177171	0.088585	63.90	0.015	28.7
F	2	0.008498	0.004249	3.06	0.246	1,38
P	2	0.428841	0.214420	154.67	0.006	69.47
Error	2	0.002773	0.001386	-	-	
Total	8	0.617282	-	-	-	

Table 3 shows the analysis of variance for surface roughness. Based on analysis of variance, pressure and lubricant are the most significant factors affecting the surface roughness. They contribute 69.47 % and 28.7 % to the total effect, respectively. Their P index less than 0.05 mean that the effect of these factors has statistic significant.

CONCLUSION

In this paper, the Taguchi method and ANOVA were applied to optimize MQL conditions for surface roughness. Some main conclusions are given as the following:

The emulsion lubricant, the 100 ml/h fluid flow and the 3 KG/cm^2 pressure provided the best result for surface roughness in hard turning of SKD 61 with MQL condition.

Lubricant and pressure were two factors most affecting the surface roughness. Lubricant factor contributed 28.7 % and pressure factor contributed 69.47 % of the total effect. The effect of them had statistic significant.

Acknowledgment

The authors wish to thank Thai Nguyen University of Technology. This work was supported by Thai Nguyen University of Technology

References

[1] T.-V. Do and Q.-C. Hsu, "Optimization of minimum quantity lubricant conditions and cutting parameters in hard milling of AISI H13 steel," Applied Sciences, vol. 6, p. 83, 2016.

[2] H. Schulz and T. Moriwaki, "High-speed machining," CIRP annals, vol. 41, pp. 637-643, 1992.

[3] T.-V. Do and N.-A.-V. Le, "Optimization of Surface Roughness and Cutting Force in MQL Hard-Milling of AISI H13 Steel," in Advances in Engineering Research and Application: Proceedings of the International Conference, ICERA 2018, 2019, pp. 448-454.

[4] J. P. Davim, Machining of hard materials: Springer Science & Business Media, 2011.

[5] M. Khan, M. Mithu, and N. R. Dhar, "Effects of minimum quantity lubrication on turning AISI 9310 alloy steel using vegetable oil-based cutting fluid," Journal of materials processing Technology, vol. 209, pp. 5573-5583, 2009.

[6] U. S. Dixit, D. Sarma, and J. P. Davim, Environmentally friendly machining: Springer Science & Business Media, 2012.

[7] N. G. Phafat, R. R. Deshmukh, and S. D. Deshmukh, "Study of Cutting Parameters Effects in MQL-Employed Hard-Milling Process for AISI H13 for Tool Life," in Applied Mechanics and Materials, 2013, pp. 240-245.

[8] T.-V. Do, N.-C. Vu, and Q.-M. Nguyen, "Optimization of cooling conditions and cutting parameters during hard milling of AISI H13 steel by using Taguchi method," in 2018 IEEE International Conference on Advanced Manufacturing (ICAM), 2018, pp. 396-398.

[9] N. Dhar, M. W. Islam, S. Islam, and M. A. H. Mithu, "The influence of minimum quantity of lubrication (MQL) on cutting temperature, chip and dimensional accuracy in turning AISI-1040 steel," Journal of materials processing technology, vol. 171, pp. 93-99, 2006.

[10] N. Dhar, M. Kamruzzaman, and M. Ahmed, "Effect of minimum quantity lubrication (MQL) on tool wear and surface roughness in turning AISI-4340 steel," Journal of materials processing technology, vol. 172, pp. 299-304, 2006.

[11] T. V. Do, Q. M. Nguyen, and M. T. Pham, "Optimization of Cutting Parameters for Improving Surface Roughness during Hard Milling of AISI H13 Steel," in Key Engineering Materials, 2020, pp. 35-39.

[12] T.-V. Do; and T.-D. Phan, "Multi-Objective Optimization of Surface Roughness and MRR in Milling of Hardened SKD 11 Steel under Nanofluid MQL Condition," International Journal of Mechanical Engineering and Robotics Research, vol. 10, pp. 357-362, 2021.

[13] K. Weinert, I. Inasaki, J. Sutherland, and T. Wakabayashi, "Dry machining and minimum quantity lubrication," CIRP annals, vol. 53, pp. 511-537, 2004.

[14] D. Thakur, B. Ramamoorthy, and L. Vijayaraghavan, "Optimization of minimum quantity lubrication parameters in high speed turning of superalloy Inconel 718 for sustainable development," Signal, vol. 20, p. 200, 2009