Key Engineering Materials Vols. 471-472 (2011) pp 233-238
Online available since 2011/Feb/21 at www.scientific.net

doi:10.4028/www.scientific.net/KEM.471-472.233

Influence of Cutting Parameters on Surface Roughness for Wet and Dry Turning Process

Muhammad Yusuf[a], Khairol Anuar[b], Napsiah Ismail[c] and Shamsuddin Sulaiman[d]

Department of Mechanical and Manufacturing Engineering

Universiti Putra Malaysia 43400 Serdang, Selangor D.E. Malaysia

[a]m_yusoef@yahoo.com, [b]khairol@eng.upm.edu.my, [c]napsiah@eng.upm.edu.my, [d]suddin@eng.upm.edu.my

Keywords: turning, surface roughness, parameters process, design of experiment

Abstract. This paper presents a study of the quality of a surface roughness model for mild steel with coated carbide cutting tool on turning process. The experiments were carried out under wet and dry cutting conditions. The model is developed based on cutting speed, feed and depth of cut as the parameters of cutting process. This research applies the fractional factorial design of experiment approach to studied the influence of cutting parameters on surface roughness. The measured results were collected and analyzed using commercial software package called Minitab. Analysis of variances is used to examine the influence of turning factors and factor interactions on surface roughness. The result indicated that, there are inherent differences in surface roughness between wet and dry cutting process with the same parameters process model. Analysis of variance was found that feed parameter is the most significant cutting parameter, which influences the surface roughness. The most significant interactions were found between cutting speed and feed parameters for dry turning process. Therefore is a significant effect of using combination of the fluid for cooling the cutting operation.

Introduction

Turning is the primary operation in most of the production processes in the industry. The starting material is generally a workpiece generated by other processes such as casting, forging, extrusion, or drawing.

In turning operation, the quality of surface roughness is an important requirement for many turned workpieces. Thus, the evaluation of machine tool and the choice of optimized cutting parameters becomes very important to control the required surface quality. The quality of machined component refers to studies have been reported recently, the final surface roughness obtained during turning operation may be considered as the sum of two independent effects [2,4]:

- ideal surface roughness, the result of the tool geometry and the feed rate, and
- natural surface roughness, the result of the irregularities in the cutting operation.

The factors contributing to natural surface roughness is the productivity of machine tools and mechanical parts. The occurrence of chatter or vibrations and inaccuracies parts movements of the machine tool can be affect on the surface quality.

Although many factors affect the surface conditions of a machined component, optimize of cutting condition is extremely important task to determine surface quality of manufactured parts. Hence, surface roughness constitutes one of the most critical constraints for the selection of machine tools and cutting parameters in process planning. Majority of machining operations require the cooling and lubricating action of cutting fluids. But, due to ecological and human health problems, manufacturing industry are now being forced to implement strategies to reduce the amount of cutting fluids used in their production line. New approaches for elimination of cutting fluids application in machining processes have been examined and dry machining was presented as the solution.

Surface roughness as affected by the cutting conditions has been investigated by engineers and researchers for many years on different of materials and methods [3, 5, 8, 9, 12]. In this study, analyze the effects of cutting parameters (cutting speed, feed rate and depth of cut) on surface roughness (*Ra*) of mild steel using coated carbide tool. The experiment conducted under wet and dry cutting conditions. The aim of this research is focus on the analysis of optimum cutting conditions to get lowest surface roughness. The other factors can be affected on surface roughness such as vibrations of machine and tool chatter ignored for analysis.

Experiment Setup

The material used for experiment is mild steel of hardness 180 HB. The workpiece received in the form of 38 mm diameter long bar and cut to 150 mm length, it is machined under dry and wet cutting condition. The machine used for turning operation is Harrison conventional lathe machine**,** maximum spindle speed achievable on this machine is 2200 rpm and spindle power 5.5 KW. The Taegutec TNMG 160408 MT TT5100 cutting tool insert coated carbide was used in the experimental with Mitsubishi tool holder MTJNR. The surface roughness was measured using Mahr Surftes. Design of experiment methodology used to determine the effects of cutting parameters on surface roughness in the turning. The factors and factorial levels are summarized in Table 1.

Experiment Result and Discussion

The present experiment results for assessment of surface roughness which was influenced by cutting speed, feed rate, and depth of cut parameters with dry and wet cutting condition according to 2^3 full factorial design as given in Table 2. Based on the results, the surface roughness in wet and dry turning was obtained in the range of 1.04 μm to 3.36 μm and 1.91 μm to 2.65 μm. The minimum values are the good quality of surface roughness, it has obtained during wet and dry turning process with the parameters model (v = 88 mm/min, f = 0.05 mm/rev, a_p = 0.25 mm) and (v = 129 mm/min, f = 0.05 mm/rev, a_p = 0.5 mm). The comparison of the percentage difference in surface roughness between wet and dry process are illustrated in Fig. 1. The highest difference (45.8 %) occurred on the test no. 2 and lowest (9.5 %) on the test no. 7.

Table 1. Factors and factor levels

Level	Factors		
	Cutting speed v (m/min)	Feed f (mm/rev)	Depth of cut a_p (mm)
Low (-1)	88	0.05	0.25
High (+1)	129	0.09	0.5

Table 2. Detail of experiment and results of wet and dry turning

Cutting parameters				Surface roughness (wet) R_a (μm)			Surface roughness (dry) R_a (μm)		
Test No.	v	f	a_p	Observed Response		Average Respons e	Observed Response		Average Respons e
1	−1	−1	−1	1.10	1.14	1.12	1.90	1.92	1.91
2	−1	−1	+1	1.02	1.06	1.04	1.87	1.97	1.92
3	−1	+1	−1	2.95	3.10	3.03	2.40	2.63	2.52
4	−1	+1	+1	3.22	3.50	3.36	2.43	2.58	2.51
5	+1	+1	+1	2.77	3.16	2.97	2.53	2.77	2.65
6	+1	+1	−1	2.35	3.77	3.06	2.58	2.67	2.63
7	+1	−1	−1	1.22	2.02	1.62	1.68	1.90	1.79
8	+1	−1	+1	1.18	1.34	1.26	1.44	1.78	1.61

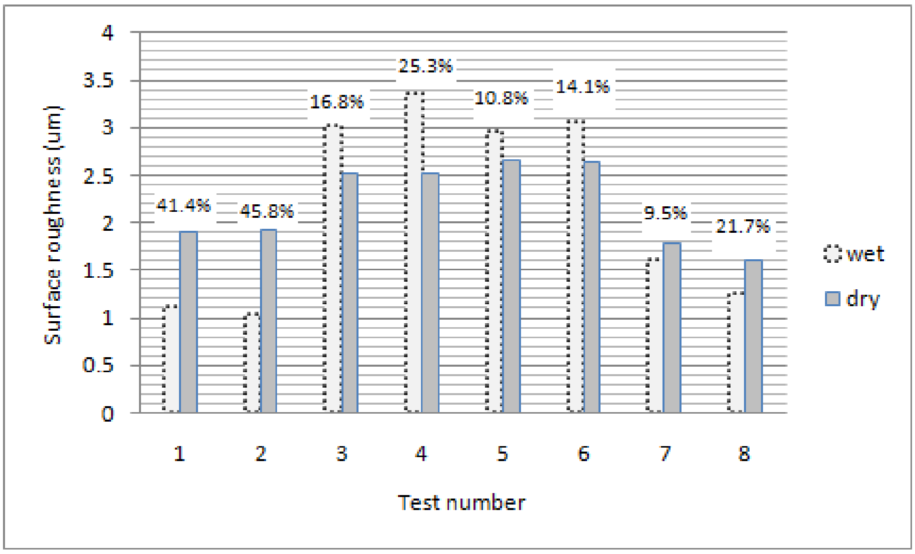

Fig. 1. The differences plots of surface roughness

Furthermore, the results were analyzed in the form of analysis of variance (ANOVA) in Minitab software. Its purpose is to determine which factors and factor interactions are statistically significant in affecting the surface roughness. Based on a 95% confidence interval, cutting speed, feed and depth of cut parameters have a statistically significant influence on surface roughness, since their *p*-values are smaller than 5%. Table 3 shows ANOVA for surface roughness in wet and dry turning processes. From the calculations can be inferred that feed has more influence on surface roughness in wet and dry turning processes, because their *p*-value are smaller than 0.05. In addition, the following two-factor the interactions of *v-f* parameters (cutting speed, feed) in dry turning process produce a statistically significant influence on the surface roughness, because *p*-values is also smaller than 0.05.

Further analysis can be conducted with the aid of the main effects and interaction plots. Fig. 2 gives the main effect plot of cutting speed on surface roughness in wet and dry turning. The surface roughness in wet turning appears to increase with increase of cutting speed, while it decreased with increase of cutting speed in dry turning. The surface roughness is tended increase with increase of feed in wet and dry turning are shown in Fig. 3. Fig. 4 gives the main effect plot of depth of cut on surface roughness, the surface roughness in wet and dry turning has a tendency to reduce with increase of depth of cut.

Table 3. Analysis of variance for surface roughness

Source	Wet					Dry				
	DF	SS	MS	F	P	DF	SS	MS	F	P
v	1	0.0324	0.0324	0.20	0.667	1	0.00766	0.00766	0.40	0.541
f	1	13.5792	13.5792	82.87	0.000	1	2.34856	2.34856	124.04	0.000
a_p	1	0.0100	0.0100	0.06	0.810	1	0.00601	0.00601	0.32	0.587
v * f	1	0.2916	0.2916	1.78	0.215	1	0.11731	0.11731	6.20	0.034
v * a_p	1	0.1260	0.1260	0.77	0.403	1	0.00601	0.00601	0.32	0.587
f * a_p	1	0.1156	0.1156	0.71	0.423	1	0.00856	0.00856	0.45	0.518
Error	9	1.4747	0.1639			9	0.17041	0.01893		
Total	15	15.6296				15	2.66449			

In order to determine the interaction effects of cutting process parameters on R_a, the three-dimensional surface plots were generated considering two parameters at a time. These interaction effects are depicted in Fig. 5, 6 and 7. From these figures, it is observed that the interaction effects of cutting parameters on R_a in both turning processes wet and dry are almost similar. It can be observed from Fig. 5 and 6 that, the surface roughness sharply increases with the increase of feed parameters. On the other hand, the surface roughness slightly increases with increase of depth of cut with constant cutting speed. The minimal surface roughness results with combination of low feed rate and high depth of cut, as depicted in Fig. 7.

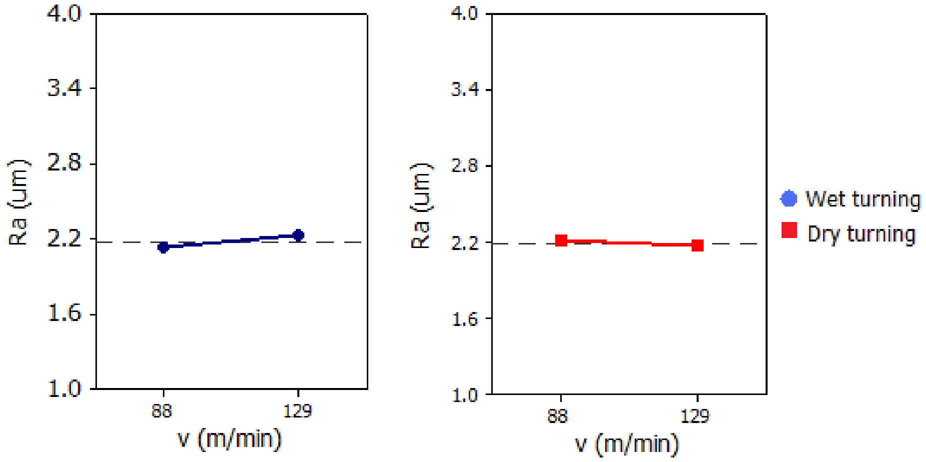

Fig. 2. The main effect plots of cutting speed on surface roughness

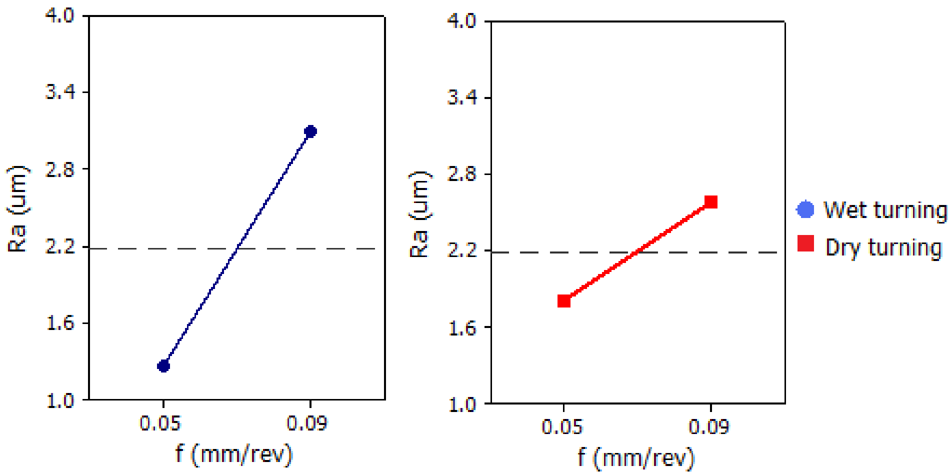

Fig. 3. The main effect plots of feed on surface roughness

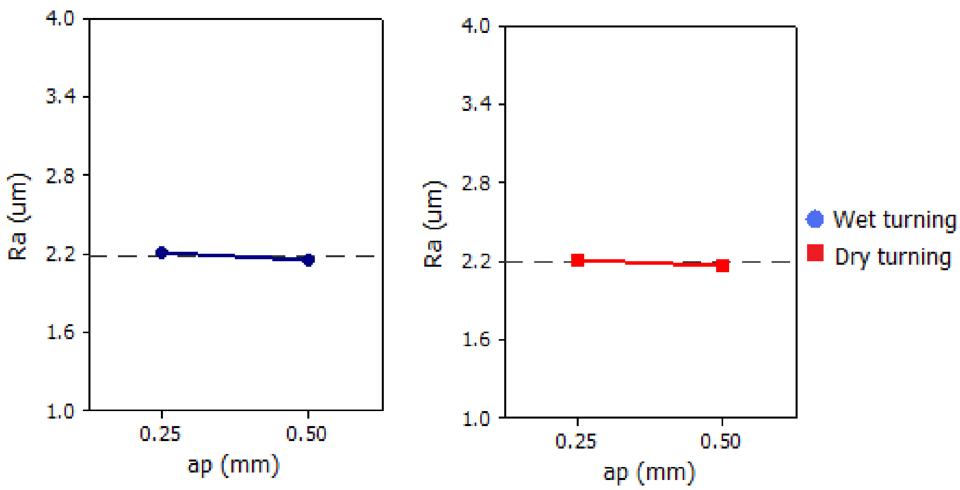

Fig. 4. The main effect plots of depth of cut on surface roughness

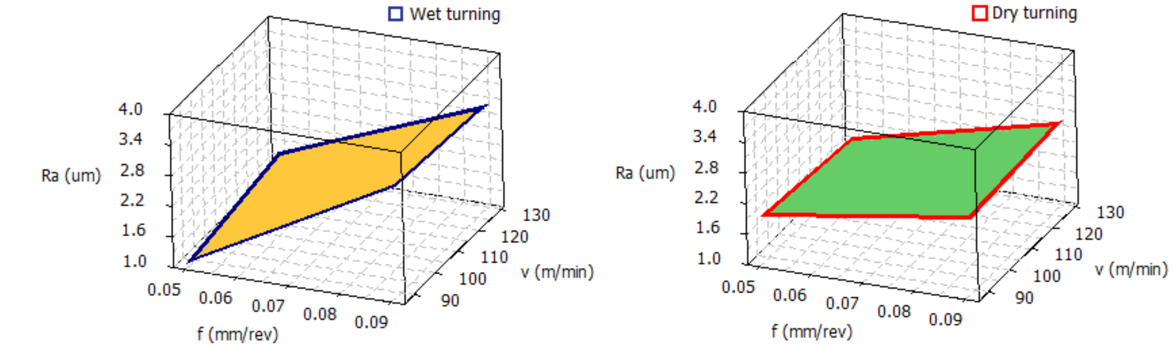

Fig. 5. Interaction effect of cutting speed and feed on surface roughness

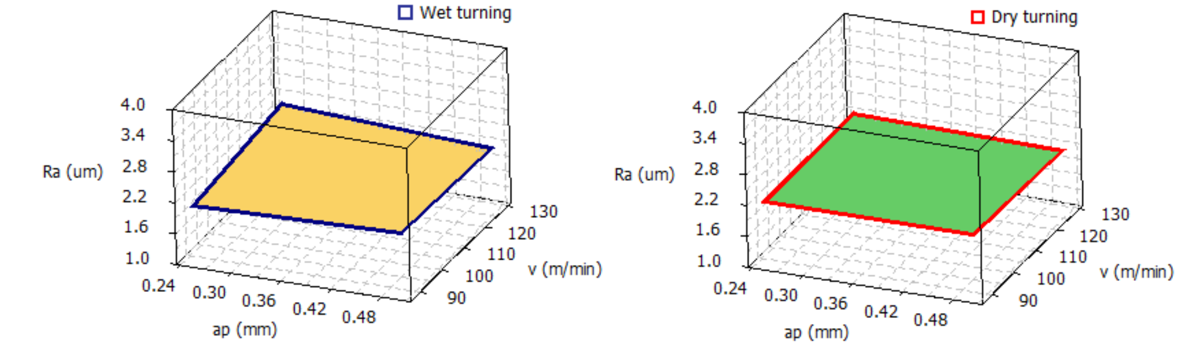

Fig. 6. Interaction effect of cutting speed and depth of cut on surface roughness

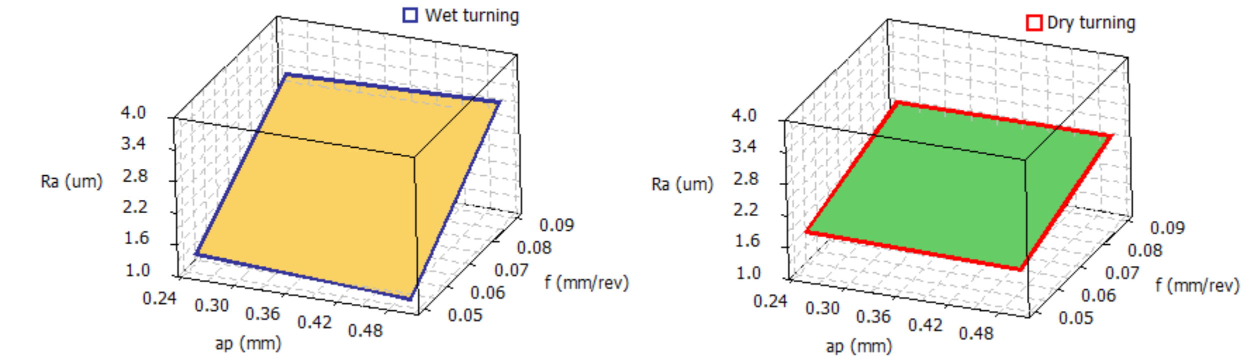

Fig. 7. Interaction effect of feed and depth of cut on surface roughness

Summary

In this paper, the influence of cutting process parameters on surface roughness for mild steel with coated carbide cutting tool during wet and dry turning process have been measured. Based on the results, it was found that cutting process parameters (cutting speed, feed and depth of cut) has influences on surface roughness in wet and dry cutting condition. The following conclusion can be drawn:

- The minimum values of surface roughness are the good quality, it obtained during wet and dry turning process with the parameters model (v = 88 mm/min, f = 0.05 mm/rev, a_p = 0.25 mm) and (v = 129 mm/min, f = 0.05 mm/rev, a_p = 0.5 mm).
- There are inherent differences in surface roughness between wet and dry cutting process with the same parameters of process, the highest difference (45.8%) occurred on the test no. 2 and lowest (9.5 %) on the test no. 7.

- From the ANOVA, it was found that feed parameter is the most significant cutting parameter, which influences the surface roughness. Most significant interactions were found between cutting speed and feed parameters for dry turning process.

Further research will investigate the quality of surface roughness in wet and dry turning based on the above models with different materials.

Acknowledgements

The authors thank Mr. Tajul Ariffin, Mr. Ahmad Shaifudin, Mr. Mohd Saiful Azuar and Mr. Muhammad Wildan Ilyas from the Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia Universiti Putra Malaysia for their assistance.

References

[1] M. Anthony Xavior and M. Adithan: Journal of Materials Processing Technology Vol. 209 (2009), p. 900 – 909.

[2] G. Boothroyd and W. A. Knight, in: *Fundamentals of machining and machine tools*. 2nd Edition, Marcel Dekker, New York (1989).

[3] C.H. Che-Haron and A. Jawaid: Journal of Materials Processing Technology Vol. 166 (2005), p. 188–192.

[4] A. S. David and S. A. John, in: *Metal cutting theory and practice*. Taylor & Francis Group (2006).

[5] D.A. Fadare, W.F. Sales, E.O. Ezugwu, J. Bonney and A.O. Oni: Journal of Applied Scienes Research Vol. 5(7) (2009, p. 757-764.

[6] B. Fnides, M. A. Yallese, T. Mabrouki and J. F. Rigal: ISSN 1392 - 1207. Mechanika Vol. 3 (2009), p. 68 – 73.

[7] D. I. Lalwani, N. K. Mehta, and P. K. Jain: Journal of Materials Processing Technology Vol. 206 (2009), p. 167–179.

[8] J. Paulo Davim, V. N. Gaitonde and S. R. Karnik: Journal Of Materials Processing Technology Vol. 205 (2008), p. 16 – 23.

[9] Raviraj Shetty, R. Pai, V. Kamath and S. S. Rao: ARPN Journal of Engineering and Applied Sciences Vol. 3 (2008), p. 59 - 67.

[10] Yusuf Sahin and A. Riza Motorcu: Materials and Design Vol. 26 (2005), p. 321 – 326.

[11] S. Thamizhmanii, S. Saparudin and S. Hasan: Jounal of Achievements in Materials and Manufacturing Engineering Vol. 20 (2007), p. 503 - 506.

[12] Tugrul Ozel, Tsu-Kong Hsu and Erol Zeren: Int J Adv Manuf Technol Vol. 25 (2005), p. 262–269

[13] R. H. Myers and D. C. Montgomery, in: *Response Surface Methodology*. 2^{nd} edition, John Wiley & Sons, 2002.

Composite Science and Technology
doi:10.4028/www.scientific.net/KEM.471-472

Influence of Cutting Parameters on Surface Roughness for Wet and Dry Turning Process
doi:10.4028/www.scientific.net/KEM.471-472.233