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Investigate the Effect of Cutting Parameters on Surface Roughness When Milling X12m Steel

Do Thi Kim Lien[1,*], Nguyen Dinh Man[2], Phùng Trần Đính[3]
[1] Faculty of Mechanical Engineering, Viet Hung Industrial University, Vietnam
[2] Faculty of Mechanical Engineering, Thainguyen University of Technology, Vietnam
[3] Faculty of Mechanical Engineering, Viet Hung Industrial University, Vietnam

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ABSTRACT

In this paper, an experimental study on the effect of cutting parameters on surface roughness was conducted when milling X12M steel. The cutting tool used in this study is a face milling cutter. The material that is used to make the insert is the hard alloy T15K6. The cutting parameters covered in this study include the cutting speed, the feed rate and depth of cut. The experiments are performed in the form of a rotating center composite design. The analysis shows that for both Ra and Rz: (1) the feed rate has the greatest influence on the surface roughness while the depth of cut, the cutting speed has a negligible effect on the surface roughness. (2) only the interaction between the feed rate and the depth of the cut has a significant effect on both Ra and Rz while the interaction between the cutting speed and the feed rate, the interaction between the cutting speed and the depth of cut have a negligible effect on surface roughness. A regression equation showing the relationship between Ra, Rz, and cutting parameters has also been built in this study.

Keywords : X12M steel, surface milling, face milling cutter, surface roughness

I. INTRODUCTION

The milling method is increasingly used to process products in the mechanical industry. In terms of machining productivity, milling is one of the methods for the highest productivity. In addition, with the development of milling machines, milling cutters in recent years, the quality of machining surfaces during milling has also been significantly improved. Therefore, in some cases, milling is also chosen as the final machining method.

In order to process a part surface with a small roughness, one of the most common methods in machine fabrication is to select and control the values of the cutting parameters. To do this, first of all, it is necessary to determine the extent and the rules of influence of cutting parameters on surface roughness. Then, there will be the basis to select and control the value of parameters of cutting parameters. This work has been performed by many authors while studying milling of different materials.

D. D. Trung researched when milling AISI 1045 steel [1]. Hasan Gökkaya [2] studied the AA2014 alloy milling. Muhammmad Yasir et al. [3] studied the AISI 316L SS steel milling. Luis Wilfredo Hernández-González et al. [4] conducted steel milling AISI 304. Huu-That Nguyen et al. [5] performed steel milling SKD61. Pathak et al. [6] studied the milling process of two alloys, Al-1Fe-1V-1Si and Al-2Fe-1V-1Si. Erol Kilickap et al. [7] experimented to investigate the effect of cutting parameters on surface roughness when milling Ti-6242S alloy. Okokpujie Imhade et al. [8] experimented with milling 6061 aluminum alloy under the condition of Minimum Quantity Lubrication (MQL). Nguyen Thanh Binh et al. [9] studied the steel milling SKD61. Pham Thi Hoa et al. [10] studied the effect of cutting parameters on surface roughness when milling A6061 aluminum alloy, etc. In this paper, an experimental study will be conducted to determine the influence of cutting parameters on surface roughness when milling X12M steel.

II. MILLING EXPERIMENT

2.1. Experimental system

The experiments were performed on the DUSONG DNME 448. Two-insert face milling cutters were used in this study.

The experimental material is X12M steel which is popular in the machine-building industry, has good machinability, is often used to manufacture parts subjected to static loads, sometimes is also used to manufacture parts that withstand impact in the working process, parts with wear-resistant surfaces, such as axes and gears.

Surface roughness was measured with the SJ201 roughness tester (Mitutoyo - Japan). For each experimental sample, at least 5 measurements were carried out. The roughness value at each experiment (Ra and Rz) is the average value of successive measurements.

2.2. Design the experiment

The center composite design matrix was used to design the experiments in this study with 3 parameters on cutting parameters including cutting speed, the feed rate, and depth of cut. The central composite design is formed by a design combination of 2k (k is the number of input parameters) 2k along axis test points and a number of experimental points at the center [11, 12]. The values of the cutting parameters at the coding levels are shown in Table 1. Experimental matrixes are presented in Table 2.

Table 1. Value of parameters at the levels

Input parameters	symbol	Values at levels				
		-1.68	-1	0	1	-1.68
Cutting speed (m/min)	v	120	146.35	185	223.65	250
Feed rate (mm/tooth)	f	0.08	0.1	0.13	0.16	0.18
Depth of cut (mm)	t	0.2	0.281	0.4	0.519	0.6

Table 2. Matrix of experiments and results

No.	Code value			Real value			Ra (μm)	Rz (μm)
	v	f	t	v (m/min)	f (mm/tooth)	t (mm)		
1	0	0	-1.68	185	0.13	0.2	0.99	2.98
2	0	0	1.68	185	0.13	0.6	0.13	0.77
3	-1	1	-1	146.35	0.16	0.281	0.78	4.16
4	1	1	-1	223.65	0.16	0.281	0.86	4.34
5	0	0	0	185	0.13	0.4	0.57	2.09

6	1	1	1	223.65	0.16	0.519	0.15	0.88
7	-1.68	0	0	120	0.13	0.4	0.16	0.98
8	1.68	0	0	250	0.13	0.4	0.26	1.71
9	0	1.68	0	185	0.18	0.4	1.48	6.83
10	0	0	0	185	0.13	0.4	0.29	1.69
11	0	0	0	185	0.13	0.4	0.37	1.55
12	0	0	0	185	0.13	0.4	0.34	1.69
13	0	0	0	185	0.13	0.4	0.41	2.19
14	-1	-1	1	146.35	0.10	0.519	0.65	3.51
15	1	-1	1	223.65	0.10	0.519	0.40	2.44
16	-1	1	1	146.35	0.16	0.519	0.27	1.75
17	-1	-1	-1	146.35	0.10	0.281	0.26	1.45
18	1	-1	-1	223.65	0.10	0.281	0.47	2.35
19	0	0	0	185	0.13	0.4	0.26	1.30
20	0	-1.68	0	185	0.08	0.4	0.18	1.49

III. ANALYSIS OF RESULTS AND DISCUSSION

3.1. The influence of parameters on Ra

Surface roughness values at each experiment were given in Table 2. Analyze the experimental results in Table 2. The ANOVA analysis results for Ra are presented respectively in Table 3. The influence level of the Cutting parameters on Ra is shown in Fig 1. Interaction between parameters on a Fig 2

Table 3. Results of ANOVA analysis for Ra

	df	SS	MS	F
Regression	9	1.6462	0.1829	3.2379
Residual	10	0.5649	0.0565	
Total	19	2.2111		
	Coefficients	Standard Error	t Stat	P-value
Intercept	0.3753	0.0969	3.8715	0.0031
v	0.0055	0.0643	0.0858	0.9333
f	0.1802	0.0643	2.8013	0.0188
t	-0.1725	0.0643	-2.6810	0.0231
v*v	-0.0711	0.0627	-1.1346	0.2830
f*f	0.1475	0.0627	2.3523	0.0405
t*t	0.0524	0.0627	0.8352	0.4231
v*f	-0.0012	0.0840	-0.0138	0.9893
v*t	-0.0820	0.0840	-0.9762	0.3520
f*t	-0.1915	0.0840	-2.2786	0.0459

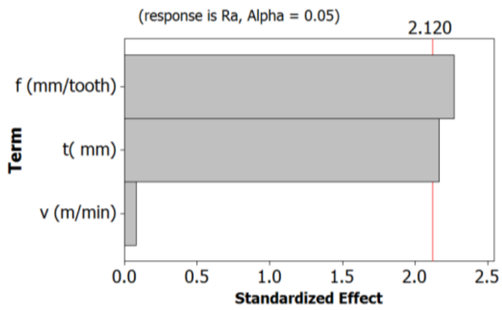

Fig. 1. Main effect on Ra

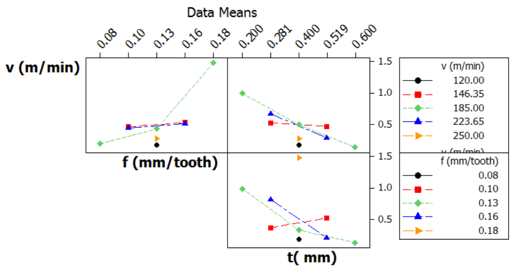

Fig. 2 Interaction influence between parameters on Ra

Observing table 3 shows:

The feed rate has the greatest influence on the roughness Ra while the influence of the depth of the cutting, the cutting speed having a negligible effect on the surface roughness. This problem will also be more obvious when observing figure 1. As the feed rate increases, the surface roughness goes up. The surface roughness will decrease if the depth of cut increases.

Only the interaction between the feed rate and the depth of cut has a significant effect on Ra. The interaction between the cutting speed with the feed rate and between the cutting speed with the depth of cutting has a negligible effect on Ra. The diagrams in Figure 2 also partly support this observation.

3.2. The influence of the parameters on Rz

ANOVA analysis results for Rz are presented respectively in Table 4. The impact level of cutting parameters on Rz is presented in Figure 3. The interaction effect between parameters on Rz is presented in figure 4

Table 4. Results of ANOVA analysis for Rz

	df	*SS*	*MS*	*F*	*Significance F*
Regression	9	32.8112	3.6457	4.6751	0.0122
Residual	10	7.7981	0.7798		
Total	19	40.6094			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	1.7501	0.3601	4.8596	0.0007	0.9477
v	0.0266	0.2391	0.1111	0.9138	-0.5061
f	0.7595	0.2391	3.1772	0.0099	0.2269
t	-0.5449	0.2391	-2.2793	0.0458	-1.0775
v*v	-0.1228	0.2330	-0.5269	0.6097	-0.6419
f*f	0.8763	0.2330	3.7611	0.0037	0.3572
t*t	0.0663	0.2330	0.2848	0.7816	-0.4528
v*f	-0.0646	0.3122	-0.2068	0.8403	-0.7602
v*t	-0.3773	0.3122	-1.2085	0.2547	-1.0730
f*t	-1.0026	0.3122	-3.2114	0.0093	-1.6983

Observing table 4 shows:

Cutting speed has a negligible influence on Rz. The depth of cut and the Feed rate both have a significant influence on the Rz. In which, the influence of the Feed rate on Rz is greater than the influence of the cutting depth. The value of surface roughness will decrease if the value of the Feed rate decreases and the value of the cutting depth increases. Observing figure 3 will also find this comment completely appropriate.

- The interaction between the cutting speed with the Feed rate, and the interaction between the cutting speed and the depth of cutting have a negligible effect on Rz. Meanwhile, the interaction between the Feed rate and the depth of cut has a significant effect on Rz. The graph of the interaction effect between cutting parameters to Rz presented in Figure 4 will also make this statement clearer.

IV. CONCLUSION

In this study, the level and rule of the influence of cutting speed, Feed rate, and cutting depth on surface roughness (Ra and Rz) when milling X12M steel was experimented with and discussed. The results will guide the adjustment of the value of cutting parameters during the machining process to ensure that surface roughness is of small value.

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