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Optimization of Machining Parameters in Hard Turning of SKD61 Steel by Using Taguchi Method

The-Vinh Do, Huong-Lam Duong, Thanh-Dat Phan

Thai Nguyen University of Technology, Thai Nguyen City, Vietnam

ABSTRACT

This research focuses on building a mathematical model of cutting parameters including cutting speed, feed rate, and depth of cut in turning SKD61 steel. Taguchi method was applied to create experimental index. Signal to noise ratios and analysis of variance analyzed the significance of each value. The result showed that the feed rate parameter has the most effect on the roughness of the cutting piece, following by the cutting speed and the depth of cut respectively. The built model was success to predict the surface roughness with R_sq of 90.85%.

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

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INTRODUCTION

Surface roughness is an essential evaluation value in machining. Surface roughness has a substantial effect on the properties of the machined part such as wear resistance, heat generation and transfer, fatigue strength, etc. In the cutting process, the selection of machining parameters has a great influence on the surface roughness. Therefore, a lot of research has focused on finding the optimal cutting mode to improve the machining roughness.

Abhishek Aswal et al. conducted optimization of cutting parameters in turning Aluminum-2014 Alloy to improve roughness[1]. The authors concluded that cutting speed is the most influential factor on roughness. A model and optimization process of surface roughness was conducted by M. H. El-Axir et al [2]. The conclusion is that feed rate and rotational speed are the two factors that have the largest role in affecting surface roghness. In a study by M. Nalbant et al., the authors used Taguchi method to optimize cutting parameters to reduce surface roughness in turning of AISI 1030 steel[3]. the insert radius and feed rate are the two main factors affecting surface roughness. In a study on turning hardened steel P20, Anh-Toan Hoang et al. optimized the turning parameter to determine the effect of the parameters on the surface roughness[4]. The conclusion shows that cooling condition and feed rate are factors that have a prominent influence on roughness. In [5], The-Vinh Do and Quoc Manh Nguyen conducted a study on the influence of factors on roughness in turning hardening SKD 61. The authors concluded that the cooling condition and feed rate are the two most influential factors on roughness. Feed rate is one of the factors that have the greatest influence on roughness in metal cutting, which has been recognized in many studies[6-9].

Taguchi is a powerful yet simple optimization method[1, 10-14]. Taguchi method is widely used in experimental studies because of its efficiency and economy. In this study, Taguchi method was applied to optimize the cutting parameter in SKD 61 steel turning. The effects of cutting parameters on

roughness were determined to find the most influential factor.

EXPERIMENTAL PROCEDURE

SKD61 work-pieces with the hardness of 55 HRC were used in turning with CBN insert. Each work-piece block has the dimension of 100 mm lengthwise and 20 mm diameter. The chemical compound is shown in the Table 1.

The experiments were performed on a Maxxturn 45 turning CNC machine as shown in Figure 1

TABLE 1: SKD61 STEEL COMPOSITION

C	Si	Mn	Cr	Mo	V	Ni
0.32 - 0.42	0.80 - 1.20	0.20 - 0.50	4.75 - 5.50	1.10 - 1.75	0.80 - 1.20	0 - 0.30

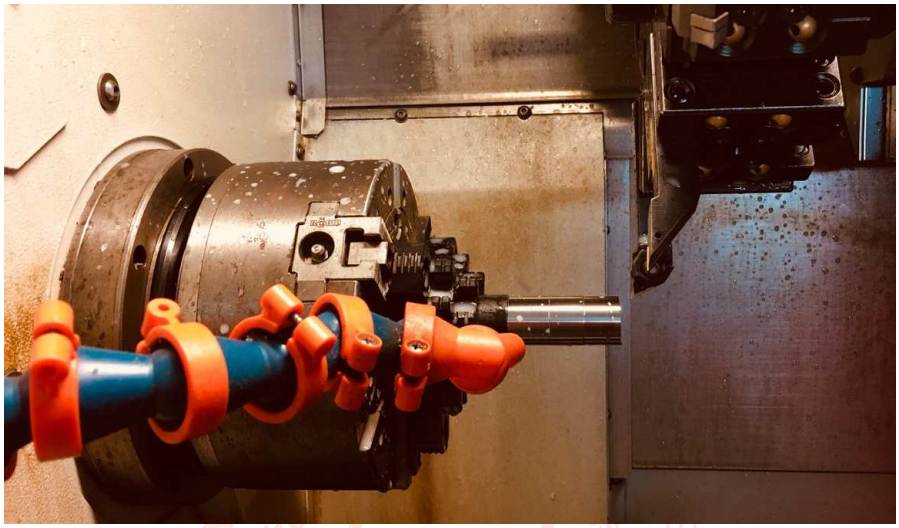

FIGURE 1: EXPERIMENTAL SETUP

TABLE 2: TABLE OF EXPERIMENT RESULTS

v (m/min)	d (mm)	f (mm/rev)	Ra (μm)	S/N
40	0.1	0.05	0.876	1.14992
40	0.2	0.10	1.155	-1.25164
40	0.3	0.15	1.389	-2.85404
50	0.1	0.10	1.002	-0.01735
50	0.2	0.15	1.548	-3.79542
50	0.3	0.05	0.903	0.88624
60	0.1	0.15	1.207	-1.63415
60	0.2	0.05	0.762	2.36090
60	0.3	0.10	1.097	-0.80413

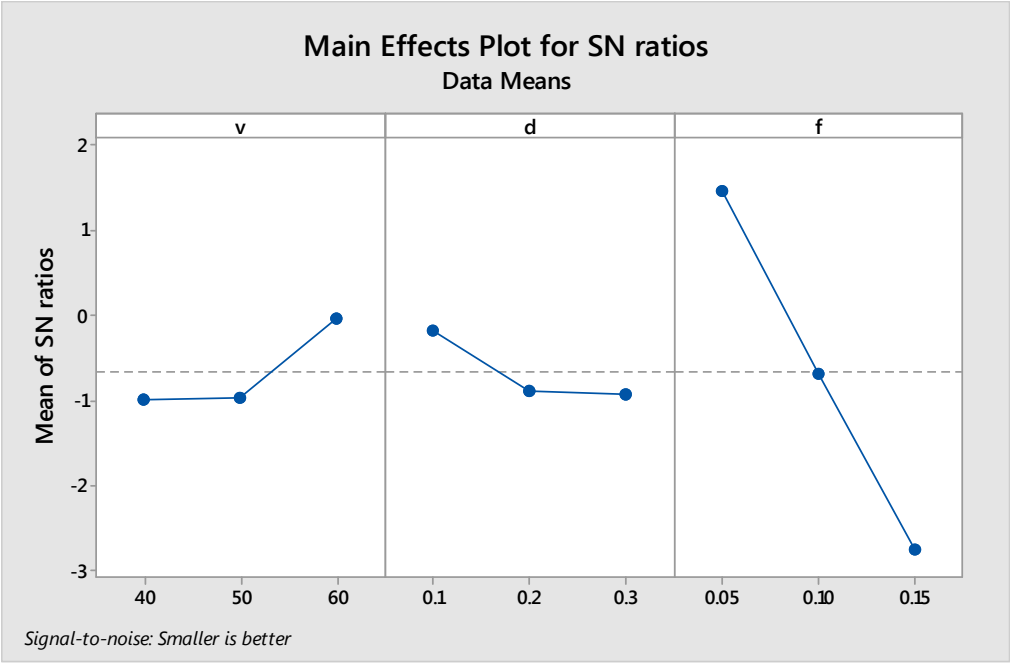

FIGURE 2: S/N RATIO PLOT

RESULTS AND DISCUSSIONS

The L9 Taguchi Orthogonal method was used to select the machining parameters for each and all experiments. The surface values Ra were recorded and calculated to find the signal to noise ratio as in Table 2.

The linear regression equation model was built by using Minitab software:

Ra = 0.764 - 0.00590 v + 0.507 d + 5.343 f(1)

The signal to noise ratio is designed for the smaller the better since minimizing the surface roughness is the target. Figure 2 shows that optimal cutting conditions for minimizing roughness are cutting speed of 60 m/min, depth of cut of 0.1mm and feed-rate of 0.05 mm/rev.

TABLE 3: S/N RATIO RANKING

Level	v	d	f
1	-0.98526	-0.16719	1.46569
2	-0.97551	-0.89539	-0.69104
3	-0.02579	-0.92398	-2.76120
Delta	0.95946	0.75678	4.22689
Rank	2	3	1

Accordingly, the ranks of the machining parameters are presented on Table 3. The feed-rate has the most effect to the Ra, follow up with the cutting speed and the depth of cut.

As shown in Table 4, the analysis of variance showed more detail about the built model. The accuracy of the model is evaluated by the value R-sq which is 90.85%.

TABLE 4: ANALYSIS OF VARIANCE TABLE

Source	DF	Adj-SS	Adj-MS	F-Value	P-Value
Regression	3	0.46456	0.154852	16.54	0.005
v	1	0.02089	0.020886	2.23	0.196
d	1	0.01540	0.015403	1.65	0.256
f	1	0.42827	0.428268	45.74	0.001
Error	5	0.04682	0.009363		
Total	8	0.51137			
R-sq = 90.85%					

CONCLUSION

The research succeed to build a linear regression model to predict the surface roughness in turning with SKD61 steel. The evaluated parameters during experiments included feed-rate, cutting speed and depth of cut. The signal to noise ratio based on the smaller the better method indicated that the feed-rate had the most effect to the surface roughness Ra in this research experiment. Optimal cutting conditions to minimize roughness are cutting speed of 60 m/min, depth of cut of 0.1mm and feed-rate of 0.05 mm/rev. The feed-rate has the most effect to the Ra, follow up with the cutting speed and the depth of cut.

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