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Optimization the Cutting Parameters when Grinding SKD11 Steel using CBN Grinding Wheel

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ABSTRACT: *In this paper presents the study on optimizing the cutting parameters to ensure the surface roughness with the smallest value when grinding SKD11 steel using CBN grinding wheel. The cutting parameters mentioned in this study include workpiece velocity, feed rate and the depth of cut. Experiment on grinding SKD11 basing on the Box-Behnken test plan with CBN grinding wheel HY-180x13x31.75-100#, to develop the relationship between surface roughness of workpiece and cutting parameters. Minitab 16 statistical software was used to perform optimization problem solving. The results have determined the optimal values of workpiece velocity, feed rate and depth of cut with values of 6.9 (m/min), 3 (mm/stroke) and 0.012 (mm) respectively, and then the surface of the workpiece has a minimum roughness of 0.44 (μm). Later on, the development direction for further research is also mentioned in this paper.*

Key words: *SKD11 steel grinding, CBN grinding wheel, surface roughness, optimization*

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I. INTRODUCTION

In mechanical processing, grinding method is often chosen for machining surfaces that require high accuracy and surface gloss [1, 2]. The study of optimizing the cutting parameters when grinding to process the surface workpiece of a small surface roughness has been conducted by many studies.

M. Janardhan and A. Gopala Krishna [3] optimally studied two parameters of the grinding process including surface roughness and material removal rate (MRR) when grinding EN24 steel by aluminum oxide grinding wheel WA 60K5V. In this study, the outside diameter x the thickness x the inside diameter of wheel are 250mm x 25mm x 76.2mm. The cutting parameters that they took into consideration in their study included the wheel velocity, the workpiece velocity and the depth of cut. Consequently, they found the optimum value of the parameters as follows: wheel velocity of 16.36 (m/s), workpiece velocity of 7.5 (m/min) and the depth of cut of 5 (μm), while the roughness surface of the smallest value $R_a = 1.034\,(\mu m)$. Pawan Kumar et al. [4] used aluminum oxide grinding wheel A60L5V with outside diameter x thickness x inside diameter of 350mm x 40mm x 127mm to study and determine the optimal value of parameters including wheel velocity, workpiece velocity and depth of cut when grinding EN40 steel basing on the surface roughness criteria of the workpiece. Their research determined that the optimal values of wheel velocity, workpiece velocity and depth of cut were 15.57 (m/s), 15 (m/min) and 11.94 (μm) respectively, then the surface roughness of workpiece reached its minimum value $R_a = 1.2\,(\mu m)$. M. Aravind et al. [5] combined the Taguchi method and the response surface methodology to study the optimum value of the parameters including grain size of wheel, depth of cut and feed rate when grinding AISI 1035 steel. Particularly, the grain size of the grinding wheel was surveyed in three different types: 36, 46 and 60. They came to the conclusion, the optimal value of the parameters including the grain size, depth of cut and feed rate were 54, 0.05 (mm) and 0.2 (mm) respectively. Rajesh Rai P and Vijaykumar H [6] used Taguchi method to optimally study the grinding process. In this study, they changed the value of the input parameters including the grain size of wheel (46, 54 and 60), feed rate and the depth of cut when grinding AISI 410 steel. Basing on this, they determined the optimum value of the grain size, feed rate and the depth of cut were 54, 0.5 (mm) and 0.06 (mm) respectively.

Basing on some researches mentioned above, the study determined the value of cutting parameters to process small surface roughness that has been done by many studies. Nevertheless, in those studies, the value of the cut-off parameters found was only suitable for each specific case, difficult to apply to the processing of different materials with different wheels. In order to apply the research results to the actual production, it is necessary to conduct experimental research, optimize the grinding process according to specific conditions.

In this study, the optimal study of SKD11 steel grinding process with CBN grinding wheel to determine the value of the cutting parameters ensures the machining surface having smallest roughness.

II. EXPERIMENTAL DESIGN

2.1. Experimental machine

The experiments were conducted on a Toyoda surface grinder (Fig. 1).

Figure 1. Experimental machine - tool

2.2. Components

Experiment on SKD11 steel grinding process, this is the steel representing the high alloy steel group, widely used to manufacture machine parts requiring high precision and high surface gloss by grinding technology. The equivalent symbols of these steels for some countries are presented in Table 1. The dimensions of workpiece are 50 (mm) in length, 40 (mm) in width and 10 in thickness (mm).

Table 1: Equivalent symbols of SKD11 steel of some countries [7]

Japan	Russia	America
SKD11	X12M	D2

2.3. Grinding wheel

The grinding wheel used in this study is a CBN wheel (Korea), HY-180x13x31.75-100#. The outside diameter, the thickness, the inside diameter of the wheel are 180 mm, 13 mm, 31.75 mm respectively.

2.4. Measuring equipment

The surface roughness was measured with TESA RUGOSURF 10 roughness gauge. For each test workpiece, surface roughness was measured at least three times, surface roughness value at each experimental site was the average value of successive measurements.

2.5. Design of experiment

Experimental plans including the number of experiments and the sequence of experiments was formulated in the form of Box-Behnken plans. This was a type of empirical plan commonly used in research to optimize machining processes [8].

Box-Behnken testing plan with three input parameters including workpiece velocity, feed rate and depth of cut. During the experiment, each parameter received three levels of coding values, the actual value of each parameter at the coding levels as shown in Table 2. Experimental matrix of 15 experiments is shown in Table 3.

Table 2: Design factors and their levels

Parameter	Code	Value at the coding level		
		-1	0	1
v (m/min)	x_1	5	10	15
f (mm/stroke)	x_3	3	4	5
t (mm)	x_2	0.01	0.015	0.02

Table 3: Experimental design matrix

TT	Cutting mode						R_a (µm)
	Actual value			Coding value			
	v (m/min)	f (mm/stroke)	t (mm)	x_1	x_2	x_3	
1	5	3	0.015	-1	-1	0	0.46
2	15	3	0.015	1	-1	0	0.75
3	5	5	0.015	-1	1	0	0.82
4	15	5	0.015	1	1	0	0.68
5	5	4	0.010	-1	0	-1	0.59
6	15	4	0.010	1	0	-1	0.66
7	5	4	0.020	-1	0	1	0.82
8	15	4	0.020	1	0	1	0.80
9	10	3	0.010	0	-1	-1	0.55
10	10	5	0.010	0	1	-1	0.65
11	10	3	0.020	0	-1	1	0.62
12	10	5	0.020	0	1	1	0.66
13	10	4	0.015	0	0	0	0.54
14	10	4	0.015	0	0	0	0.52
15	10	4	0.015	0	0	0	0.55

2.6. Grinding conditions

Beside the workpiece velocity, feed rate and the depth of cut that would be adjusted for each experiment orderly shown in Table 3, the testing process was carried out with the value of other parameters as follows: the wheel velocity (26 m/s), the depth of dressing (0.01 mm), the feed rate of dressing (150 mm/min), coolant with emulsion 10% oil and flow (4.6 liters/min).

III. THE RELATIONSHIP BETWEEN SURFACE ROUGHNESS AND CUTTING PARAMETERS

Experiments were conducted as planned in Table 3, with the values of the input parameters as in Table 2. The surface roughness after measurement also included in Table 3. Minitab statistical software was used to analysis of experimental results, from which the regression equation was developed, showing the relationship between surface roughness and cutting parameters in the coding form of parameters such as equation (1). This regression equation has a coefficient of determination $R^2 = 0.9167$, very close to the value of 1. It confirmed that the regression equation (1) has a very high compatibility with the experimental data. This equation is the basis for choosing the value of the cutting parameters in order to process the surface roughness of the part with specific requirements.

$$R_a = 0.53667 + 0.02500 * x_1 + 0.05374 * x_2 + 0.05625 * x_3 + 0.11917 * x_1^2 \\ +0.02167 * x_2^2 + 0.06167 * x_3^2 - 0.10750 * x_1 * x_2 - 0.02250 * x_1 * x_3 - 0.01500 * x_2 * x_3 \quad (1)$$

Optimization

Proceeding to solve the problem of optimizing the grinding process to determine the value of the cutting parameters, to process the surface of the part with the least roughness. The optimization problem is written in the coding form of the input parameters as follows:

$$\begin{cases} R_a = f(x_1, x_2, x_3) \rightarrow min \\ -1 \leq x_1, x_2, x_3 \leq 1 \\ R_a > 0 \end{cases} \quad (2)$$

Use Minitab 16 statistical software to solve optimization problems in formula (2). The result is shown in Fig. 2.

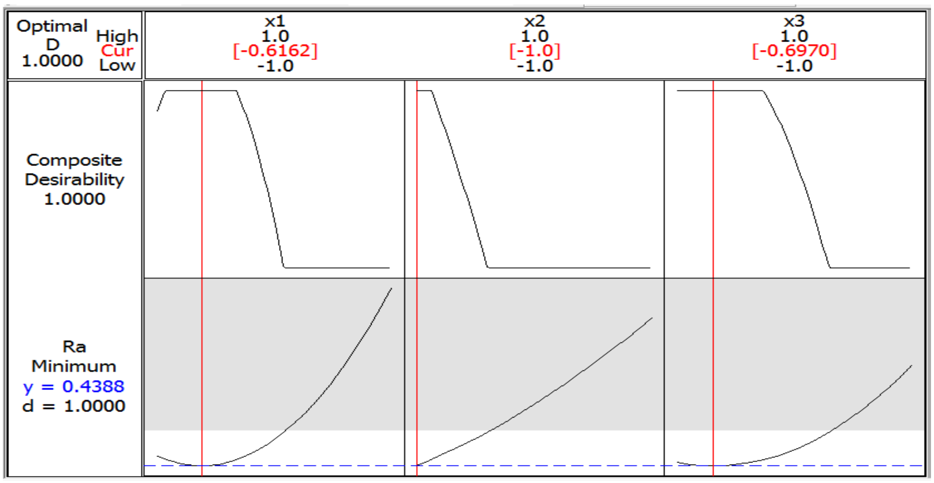

Figure 2. Optimization graph

Basing on the results in Fig. 2, the real numerical optimization of the cutting parameters including the workpiece velocity, feed rate and the depth of cut was determined to be 6.9 (m/min), 3 (mm/stroke) and 0.012 (mm), then roughness the surface of the smallest valuable part with an approximate value of 0.44 μm.

IV. CONCLUSION

An optimal study of the cutting parameters to process the surface of the smallest roughness workpiece when grinding SKD11 steel with CBN grinding wheel, has been carried out in this study. The study leads to determination of the optimum value of the parameters of dressing, cooling lubrication technology, etc. when using pairs of grinding wheel – material of workpiece used in this study will be carried out in later studies.

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REFERENCES

[1]. Stephen Malkin and Changsheng Guo, Grinding technology: Theory and Applications of Machining with Abrasives – Sencond edition, Industrial press, New York (2008).
[2]. Marinescu Loan D., Eckart Uhlmann and Brian Rowe W., Handbook of machining with grinding wheels, CRC Press Taylor & Francis Group (2006).
[3]. M. Janardhan and A. Gopala Krishna, Multi – Objective optimization of cutting parameters for surface roughness and metal removal rate in surface grinding using response surface methodology, International Journal of Advances in Engineering & Technology, Vol. 3, Issue 1, pp. 270-283 (2012).
[4]. Pawan Kumar, Anish Kumar, Balinder Singh, Optimization of Process Parameters in Surface Grinding Using Response Surface Methodology, InternatIonal Journal of research In MechanIcal engIneerIng & technology, Vol. 3, Issue 2, pp. 245-252 (2013).
[5]. M. Aravind, Dr. S. Periyasamy, Optimization of Surface Grinding Process Parameters By Taguchi Method And Response Surface Methodology, International Journal of Engineering Research & Technology, Vol. 3 Issue 5, pp.1721-1727 (2014).
[6]. Rajesh Rai P, Vijaykumar H K, Optimization of Process Parameters in Surface Grinding For AISI 410 by Taguchi Technique, AIP Conference Proceedings 2080, 050001 (2019); https://doi.org/10.1063/1.5092929
[7]. Tran Van Dich, Ngo Tri Phuc, World steel handbook, Science and Technics Publishing House, Ha Noi (2006).
[8]. Raymond H. Myers, Douglas C. Montgomery, and Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization Using Designed Experiments, John Wiley & Sons, Inc., 3rd Edition (2009).

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