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Research paper

Optimization cutting parameters when grinding X12M steel using Hai Duong grinding wheel

Nguyen Van Thien [1], Hoang Tien Dung [1], Do Duc Trung [1,*], Ngo Cuong [2]

[1] *Faculty of Mechanical Engineering, Hanoi University of Industry, No. 298, Cau Dien Street, Bac Tu Liem District, Hanoi Vietnam*
[2] *College of Economics and Technology, Thai Nguyen University, Thainguyen, Vietnam*
**Corresponding author E-mail: dotrung.th@gmail.com*

Abstract

This paper presents an experimental research to build two regressions they are relationship between surface roughness of workpiece and cutting parameters when grinding grinding X12M steel using Hai Duong grinding wheels. Two types of Hai Duong grinding wheel using in this paper are Cn46.TB1.G. V1.400x40x203x50m/s and Cn46.CV1.G. V1.400x40x203x35m/s. Three cutting parameters are considered in this paper are depth of cut, feed rate and velocity of workpiece. Genetic algorithm had used to find value of cutting parameters for minimum value of surface roughness. This work had get optimization value of cutting parameters for each case of a pair of workpiece – wheel.

Keywords: *Cylindrical Grinding; Surface Roughness; Cutting Parameters; X12M Steel; Optimization; Hai Duong Grinding Wheel.*

1. Introduction

Grinding is a manufacturing process with unsteady process behaviour, whose complex characteristics determine the technological output and quality. The assessment of the grinding process quality usually includes the microgeometric quantities of the component. Study on grinding focus in the large of the range. In which, study on optimization the cutting parameters had done by many authors: Optimization value of depth of cut, velocity of workpiece, grinding wheel speed and numberof passes when grinding AISI 5120 by Al_2O_3 grinding wheel [1], [2]; Optimization value of depth of cut, velocity of workpiece, grinding wheel speed when grinding EN24 steel by Al_2O_3 grinding wheel [3], [4]; Optimization value of grinding wheel speed, depth of cut and feed rate when grinding EN-8 by A10K5V wheel [5]; Optimization value of grinding wheel speed, feed rate, depth of cut, grain size and concentration of cutting fuild when grinding AISI 4140 [6].

X12M steel is representing for high alloy steel. Vietnam have imported this steel from Rusia with large quantity, for technology grinding by Hai Duong grinding wheel, the wheel have manufactured by Hai Duong grinding wheel factory (Vietnam). In this paper, study on optimization cutting parameters when grinding X12M steel using Hai Duong grinding wheels.

2. Grinding experiment

2.1. Workpiece

Workpiece in this work is X12M steel which had heat treated for archived 58÷60HRC in hardness. Shape and dimesion of workpiece of this material is show in Figure 1.

In Table 1 showns the equivalent sign of steel of countries.

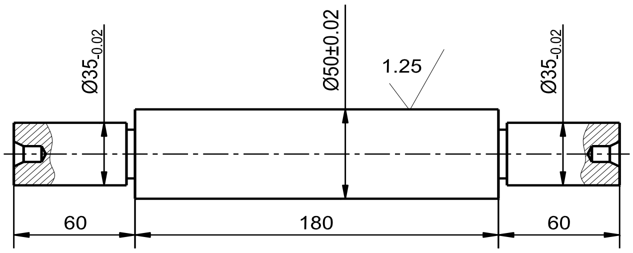

Fig. 1: Experimental Component

Table 1: Equivalent Sign of Steel of Countries

Vietnam	Russia	American	Japan
160 Cr12Mo	X12M	D2	SKD11

2.2. Machine tool and grinding wheel

Grinding experiments were conducted on an 3b153 cylindrical grinding machine (Russia).

Two type of Hai Duong grinding wheel factory's had used in this work which are Cn46.TB$_1$.G. V$_1$.400x40x203x50m/s and Cn46.CV$_1$.G. V$_1$.400x40x203x35m/s.

2.3. Surface roughness tester

The measurements were carried out with a Mitutoyo Surftest SJ-201 stylus type surface texture-measuring instrument. Each ground component was measured three times. The surface roughness response for each test, is the average reading of three consecutive measurements.

2.4. Experimental design

Matrix of D-optimal designs with three input parameters which is used in this work, each parameter have three levels of value, quoted in Table 2.

Table 2: Levels of Input Parameters when Grinding X12M Steel

Levels	Code value	Input parameters		
		t(mm)	f(m/min)	v(m/min)
High level	+1	0.0075	0.6	37.68
Medium level	0	0.005	0.45	31.40
Low level	-1	0.0025	0.3	25.12

Table 3: Matrix of D-Optimal Designs

Run	t	f	v
1	0	-1	-1
2	0	1	-1
3	0	-1	1
4	0	1	1
5	-1	0	-1
6	1	0	-1
7	-1	0	1
8	1	0	1
9	-1	-1	0
10	1	-1	0
11	-1	1	0
12	1	1	0
13	0	0	0

2.5. Experimental conditions

It is important to conduct the experiments under chatterfree conditions and to keep the cutting speed (34 m/s), the depth of dressing (0.01 mm), the feed rate of dressing (1 m/min) and the coolant flow constant (25 litres/min). Experimental investigations require precise process set-up to ensure that the trials are done according to plan. Errors and inaccuracies at this stage could nullify experimental validity.

3. Experimental results and optimization

3.1. Experimental results

Grinding X12M steel by above type of grinding wheels and above condition. Measurement the surface roughness on each component. The result showns on Table 4.

Table 4: Experimental Matrix when Grinding X12M Steel

Run	t	f	v	$R_a(\mu m)$ Cn46.TB$_1$.G. V$_1$400x40x203x50m/s	Cn46.CV$_1$.G. V$_1$400x40x203x35m/s
1	0	-1	-1	0.27	0.40
2	0	1	-1	0.40	0.57
3	0	-1	1	0.36	0.48
4	0	1	1	0.50	0.67
5	-1	0	-1	0.25	0.38
6	1	0	-1	0.40	0.60
7	-1	0	1	0.33	0.44
8	1	0	1	0.48	0.69
9	-1	-1	0	0.22	0.33
10	1	-1	0	0.38	0.52
11	-1	1	0	0.36	0.47
12	1	1	0	0.55	0.73
13	0	0	0	0.40	0.54

From table 4, build the regressions as bellow:

- When grinding X12M steel using Cn46.TB1.G. V1.400x40x203x50m/s grinding wheel, coefficient of determination $R^2 = 0.9944$.

$$R_a = 0.40 + 0.08125 * t + 0.0725 * f + \tag{1}$$

$$0.04375 * v - 0.02 * t^2 - 0.0025 * f^2$$

$$-0.015 * v^2 + 0.0075t * f$$

$$-1.2 * 10^{-17} * t * v + 0.0025 * f * v$$

- When grinding X12M steel using Cn46.CV$_1$.G. V$_1$.400x40x203x35m/s grinding wheel, coefficient of determination $R^2 = 0.9995$.

$$R_a = 0.54 + 0.115 * t + 0.08875 * f \tag{2}$$

$$+0.04125 * v - 0.015 * t^2 - 0.0125 * f^2$$

$$+0.0225 * v^2 + 0.0175 * t * f$$

$$+0.0075 * t * v + 0.005 * f * v$$

From equations (1) to (2) show that, in all of two cases, the influence of depth of cut on surface roughness is bigger than feed rate, velocity of workpiece has influence on surface roughness is smallest.

3.2. Optimization

The surface roughness optimization is based on the developed response surface model and the application of the floating-point genetic algorithm for minimization problems. A selected population of solutions initially evolves from a given number of individuals by employing genetic mechanism. This is performed with an adopted optimization program, developed in Excel [7]; population of appointed size is randomly chosen between the lower and upper values and undergoes a process of evolution in a simulated competitive environment. The latter mechanism consists of tournament selection, linear crossover and non-uniform mutation. Both bit-exchange crossover and bit-flip mutation occur at every cycle, according to assigned probabilities. Optimization has been achieved by determination of three control parameters of the genetic algorithm; the size of the population and the probability values for crossover and mutation, their value are 100, 0.25 and 0.05 respectively, as [8 - 10]. Optimization value of cutting parameters in four cases, quoted in Table 5. The fitness of each individual is evaluated (Fig. 2 to Fig. 3).

Table 5: Optimization Value of Cutting Parameters and Surface Roughness of Workpiece

Workpiece/Grinding wheel	Optimization value of cutting parameters Code value t	f	v	Actually value $t(mm$	$f(m/min$	$v(m/min$	$R_a(\mu m$
X12M/ Cn46.TB$_1$.G.V$_1$400x40x203x50m/s	-0.9999	-0.9991	-0.9999	≈ 0.0025	≈ 0.30	≈ 25.12	0.175
X12M/ Cn46.CV$_1$.G.V$_1$400x40x203x35m/s	-0.9999	-0.9999	-0.6391	≈ 0.0025	≈ 0.30	≈ 27.38	0.317

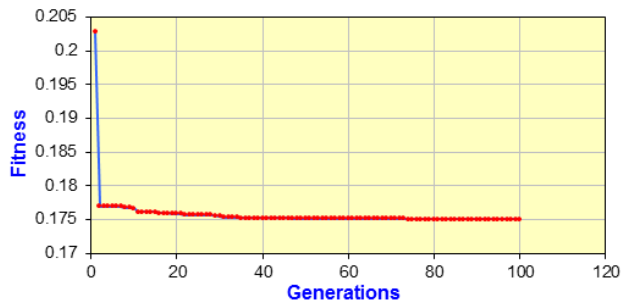

Fig. 2: Genetic Algorithm Graph for Grinding X12M by Cn46.TB$_1$.G. V$_1$400x40x203x50m/s

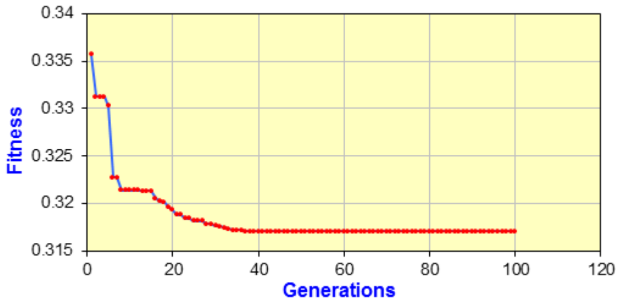

Fig. 3: Genetic Algorithm Graph for Grinding X12M by Cn46.CV_1.G.$V_1$400x40x203x35m/s

4. Conclusions

This paper built the relationship between surface roughness of workpiece and cutting parameters when grinding X12M steel using two types of Hai Duong grinding wheel. Those relationships is basic for controlling and optimization the grinding process. Optimization value of cutting parameters are showed in this paper in each case of a pair of workpiece – wheel.

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