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Influence of the dressing feed rate on the roughness and roundness error of the workpiece surface in the SCM400 steel centerless grinding process

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ABSTRACT: *This paper presents a study on the influence of the dressing feed rate on the roughness and roundness error of the workpiece surface when machining SCM400 steel using the method of plunge centerless grinding. Carrying out grinding with eleven different values of the dressing feed rate (from 50 mm/ min to 550 mm/ min) on the CNC centerless grinding machine. This study has determined the influence of the dressing feed rate on the roughness and roundness error of the workpiece surface. The range of values of the feed rate assuring the small values for the roughness and roundness error of workpieces has been shown in this study. A number of developments for further studies have also been proposed in this study.*
KEY WORDS: *centerless grinding, SCM400 steel, surface roughness, roundness error, dressing feed rate*

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I. INTRODUCTION

In mechanical machining, centerless grinding is a machining method that is many times more productive than centered grinding due to its high machining mode and less time for setting, adjusting and dismantling workpieces [1, 2]. In addition, because the workpiece does not need to be located in the center hole, the amount of machining stock can be reduced because the workpiece is primarily located by the machining surface; It is possible to improve the grinding productivity because the workpiece is attached to the spindle and the regulating wheel, so it has a high rigidity; if a large thickness wheel is used, it is possible to significantly reduce the longitudinal feed rate and machine long workpiece or multiple workpieces simultaneously by the plunge feed.

In the method of centerless grinding, the roughness and roundness error of a workpiece surface are important parameters that determine the quality of an object to be grinded [1- 3]. There have been a number of studies on the roughness and roundness error of workpiece surface in plunge centerless grinding processs published. The influence of dressing method on the roughness of machined surface [2]; the survey of the roughness of machined surface in dressing by electric pulse method [4]; the survey of the roughness of machined surface in dressing by electrolysis method [5]; the influence of some dynamic - geometric parameters of the technological system on the roughness of machined surface [6 - 8]; the influence of cutting speed on the roughness of machined surface [9]; the relationship between the roundness error of a workpiece and the geometric parameters of the technology system [2]; the influence of dressing method on the roundness of workpiece surface [10, 11]; the influence of the accuracy of the wheel on the roundness of workpiece surface [12]; the analysis of vibration and rounding process of workpiece surface [13]; the study on simulation of simultaneous influence of some dynamic and geometric parameters in the grinding process on the roundness error [14]; the influence of feed rate on roughness and roundness error of workpiece [15-18].

In this study, we will investigate the influence of the longitudinal feed rate in grinding wheel dressing on the roughness and roundness error of the workpiece surface when grinding SCM400 steel. From this, the range of dressing feed rate can be determined to ensure the small values for the roughness and roundness error of the workpiece surface.

II. GRINDING EXPERIMENT

2.1. Component

The grinding component is the SCM400 steel, which is often used to machining workpieces working under the conditions of abrasion and heat resistance. After heat treatment, the sample has a hardness of 54 ÷ 56HRC. Before the grinding test, the sample was lathed and pregrinded (Figure 1). The length and diameter of the grinding surface are 80 (mm) and 30 (mm), respectively. The chemical composition of the test sample is shown in Table 1.

Table 1. Chemical composition of SCM400 steel

C	Si	Mn	P	S	Cr	Mo	Ni	Cu
0.41%	0.25%	0.72%	0.03%	0.03%	1.1%	0.23%	0.25%	0.3%

Fig 1. grinding component

2.2. Grinding machine

The tests were conducted on CNC centerless grinding machine with the symbol STC-2410 (Figure 2). Some basic specification of the grinding machine are as follows:

- Maximum diameter of the workpiece in plunge grinding process: 60 (mm)
- Maximum length of the workpiece in plunge grinding process: 150 (mm)
- Grinding wheel speed: 1600 (rev/ min)
- Guide stone speed (stepless adjustment): 9 ÷ 102 (rev/ min)
- Rotation angle of the grinding wheel head in the vertical plane: -20 ÷ 30
- Rotation angle of the grinding wheel head in the horizontal plane: $0 \div 4.5^0$
- The distance from the straight line connecting the center of the grinding wheel and the center of the regulating wheel to the bottom of the workrest: 220 (mm)
- Total capacity: 21.8 (KW).
- Overall dimension: 2250x1800x1600 (mm)

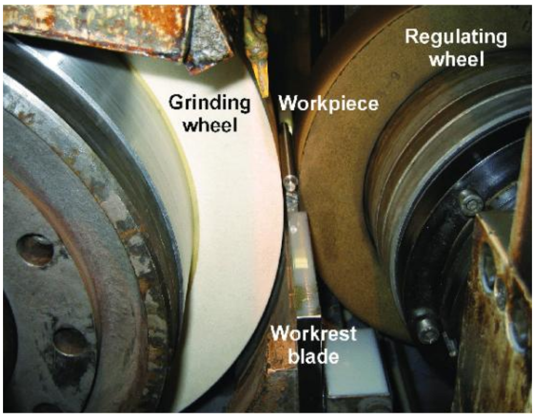

Fig 2. Grinding machine

2.3. Grinding wheel and regulating wheel

The grinding wheel used in this study has the symbol: Cn100 TB_2 G V_1. The outside diameter, thickness and inside diameter of the grinding wheel are 480 (mm), 150 (mm) and 320 (mm), respectively.

The redulating wheel is made of rubber with the outside diameter, thickness and inside diameter of 250 (mm), 150 (mm) and 120 (mm), respectively.

2.4. Measuring devices

The roughness of machined surface is measured by SJ-201 machine (Figure 3). At each value of the dressing feed rate, three steel samples will be grinded, the roughness of each sample will be measured three times, the roughness value for each test will be the average of nine successive measurements.

The roundness error of the workpiece is checked by a 5/10.000 comparative measuring gauge (figure 4). For each test, the roundness error will be calculated using the average of three consecutive measurements.

Fig 3. SJ201 surface roughness tester

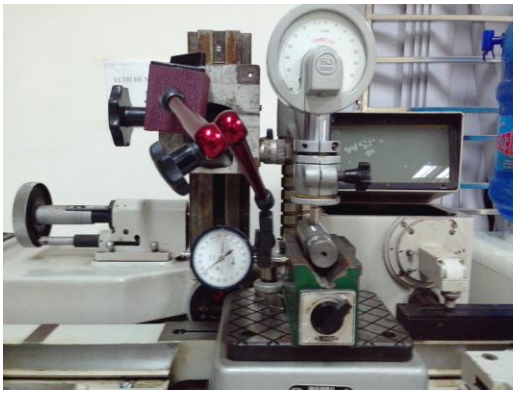

Fig 4. Roundness error measurement system

2.5. Grinding conditions

Grinding process is carried out with the following conditions:
- Grinding wheel speed: 1600 (rev/ min)
- Regulating wheel speed: 36 (rev/min)
- Height of workpiece center: 12 (mm)
- Plunge feed rate: 10 (µm/s)
- Machining stock according the radius: 0.05 (mm)
- Dreasing parameters: depth of dressing 0.005 (mm), dressing feed rate 50 ÷ 550 (mm/ min), grinding wheel speed 40 (m/ s).
- Regulating wheel dressing parameters:
- Regulating wheel dressing parameters: depth of dressing 0.01 (mm)**,** dressing feed rate 30 (mm/min).
- The regulating wheel is rotated in the vertical plane at an angle of 0.5^0 and rotated in the horizontal plane at an angle of 0^0.
- Grinding fluid: emusil (TOTAL firm), concentration of 6.5%, flow of 8 liters/min.

III. RESULTS AND DISCUSSION

Grinding testing was conducted with 11 different values of the longitudinal feed rate in dressing (50mm/ min to 550 (mm/ min)). The roughness and roundness error were measured according to the method described above. The values of roughness and roundness error are shown in Table 2 and graphs in Figures 5 and 6.

Table 2. Roughness and roundness error values

No.	Dressing feed rate (mm/min)	Surface roughness (µm)	Roundness error (µm)
1	50	3.89	4.65
2	100	1.66	5.66
3	150	0.98	5.82
4	200	0.89	5.96
5	250	0.85	6.77
6	300	1.06	6.88
7	350	1.26	6.92
8	400	1.95	12.44
9	450	2.77	13.54
10	500	3.68	14.76
11	550	4.12	15.84

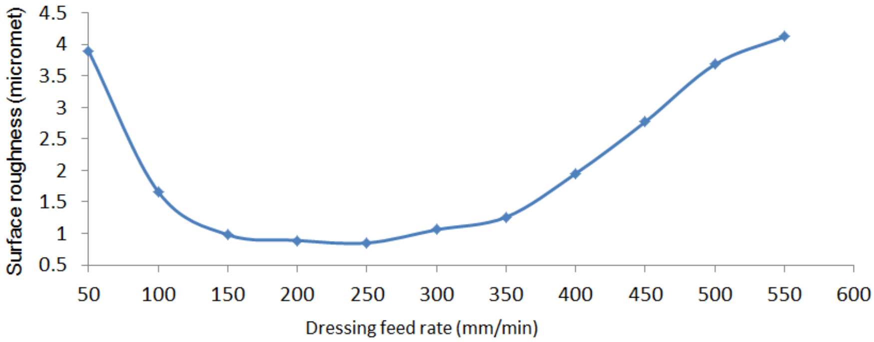

Fig 5. Influence of the dressing feed rate on surface roughness

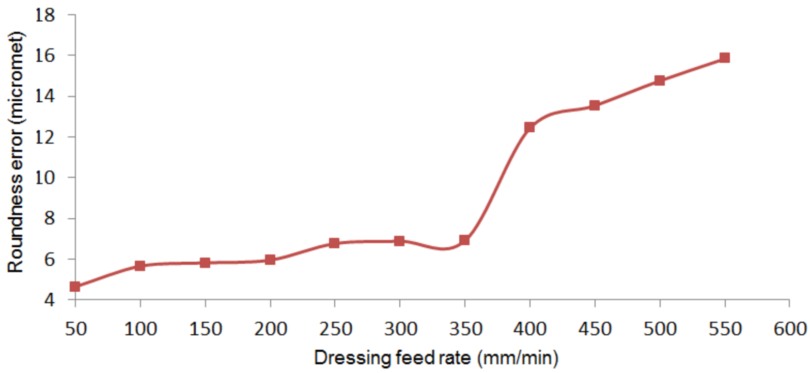

Fig 6. Influence of the dressing feed rate on roundness error

The results on Table 2, Figure 6 show that:
- The dressing feed rate has a great influence on the roughness and roundness error of the workpiece surface.
- When increasing the dressing feed rate, the roundness of the workpiece surface increases. Meanwhile, when increasing the dressing feed rate, the surface roughness may increase or decrease.
- Surface roughness is small and stable when the dressing feed rate is in the range of 150 (mm/ min) to 300 (mm/ min). Whereas, if the feed rate is between 50 (mm/ min) and 250 (mm/ min), the roundness error has a small value.
- If the dressing feed rate is between 150 (mm/ min) and 250 (mm/ min), both roughness and roundness error are small and stable.

IV. CONCLUSION

- The dressing feed rate has an important influence on the roughness and roundness error of the workpiece surface.
- When grinding SCM400 steel, the roughness of the machined surface and the roundness error have the smallest value corresponding to the dressing feed rate in the range of 150 (mm/ min) to 250 (mm/ min).
- The study on the influence of the grinding wheel speed, the plungefeed rate, the height of the workpiece center, as well as determination of the value of these parameters to ensure the small values for roughness and roundness error are the necessary works to be conducted in the following studies.

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