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EFFECT OF LONGITUDINAL FEEDS ON FLAT GRINDING PROCESSES ON VIBRATION AND SURFACE ROUGHNESS IN OCR12VM MATERIAL

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ABSTRAK

Proses gerinda adalah pemesinan untuk mencapai permukaan akhir yang berkualitas tinggi dan akurasi dimensi yang tinggi. Ada dua proses dasar, yaitu proses roughing dan finishing. Proses roughing menghasilkan gaya potong dinamis yang lebih tinggi daripada proses finishing dan menghasilkan getaran yang lebih tinggi sehingga mengurangi kualitas permukaan dan juga cenderung menurunkan akurasi dimensi serta memperpendek umur batu gerinda. Di sisi lain, proses roughing diterapkan untuk mengurangi waktu pemesinan dan oleh karena itu meningkatkan produktivitas. Penelitian ini dilakukan untuk mempelajari pengaruh pemakanan longitudinal terhadap getaran dan kekasaran permukaan baja perkakas yang dikeraskan OCR12VM (setara dengan JIS SKD 11) yang dikerjakan dengan proses penggerindaan datar. Pemakanan longitudinal divariasikan dari 100 mm/s hingga 250 mm/s dengan kenaikan 50 mm/s. Masing-masing variasi dikerjakan dengan kedalaman potong masing-masing 0,01 mm, 0,02 mm dan 0,03 mm. Parameter pemesinan konstan ditetapkan sebagai berikut: n= 3000 rpm, pengumpanan melintang= 0,04 mm/langkah. Dimensi grit 80 Aluminium oxide grinding wheel= 200 mm x 25 mm. Hasil penelitian menunjukkan bahwa kekasaran permukaan berbanding lurus dengan tingkat getaran RMS. Pengaruh pemakanan longitudinal bahwa bertambahnya kecepatan mengakibatkan kekasaran permukaan yang lebih tinggi. Garis tren data kekasaran permukaan memiliki fungsi kuadrat terhadap pemakanan longitudinal. Kesamaan seperti yang disebutkan sebelumnya, tingkat getaran meningkat juga secara kuadrat dengan meningkatnya pemakanan longitudinal. Dengan demikian, terlihat jelas bahwa kekasaran permukaan erat kaitannya dengan tingkat getaran selama proses gerinda. Berdasarkan hasil tersebut, tingkat kekasaran permukaan dapat diprediksi dengan mengukur tingkat getaran selama proses gerinda, tanpa melakukan pengukuran kekasaran permukaan.

Kata kunci: Gerinda Datar, pemakanan longitudinal, getaran, kekasaran permukaan, *RMS*

ABSTRACT

The grinding process is machining to achieve a high-quality surface finish and high dimensional accuracy. There are two basic processes, the roughing and finishing process. The roughing process generates higher dynamic cutting forces than the finishing process. It leads to a higher vibration that reduces the ground surface quality, tends to lower dimensional accuracy, and shortens the grinding wheel *life. On the other hand, the roughing process is applied to reduce machining time, increasing productivity. We conducted this research to study the effect of longitudinal feed on vibration and the surface roughness of hardened tool steel OCR12VM (equivalent to JIS SKD 11), machined by the surface grinding process. The longitudinal feed was varied from 100 mm/s up to 250 mm/s with a 50 mm/s increment. Each variation was machined with a depth of cut of 0.01 mm, 0.02 mm and 0.03 mm, respectively. The constant machining parameter was set: n= 3000 rpm, transversal feeding= 0.04 mm/stroke. The dimension of the grit 80 Aluminium oxide grinding wheel= Ø 200 mm x 25 mm. The result of the research showed that the surface roughness of the ground surface was linearly proportional to the RMS vibration level. The longitudinal feed effects that increased feed resulted from higher surface roughness. The surface roughness data trend line has a square function to the longitudinal feed. The similarity, as previously mentioned, is that the vibrations level also increases quadratically with increasing the longitudinal feed. Thus, it is evident that the surface roughness of the ground surface is closely related to the vibration level during the grinding process. Based on this result, it can predict the roughness of the ground surface by measuring the vibration level during the grinding process without measuring the surface roughness.*

Keywords: *Surface grinding, longitudinal feed, vibration, surface roughness, RMS*

1. INTRODUCTION

The use of grinding machines is the final part of various machining processes. Therefore, it is necessary to avoid vibration. The vibrations that occur in the machining process are very dangerous and undesirable. This happens because there is a vibrator/excitation source that propagates through all the components/parts of the machine in question. There are two grinding processes, namely, the coarsening process and the refining process. In the roughing process, vibration can damage and shorten the life of the tool/machine. While in the process of refinement (finishing), it will reduce the accuracy of the dimensions, shape, and smoothness of the surface of the workpiece [1][2].

The workpiece to be used in the research experiment is OCR12VM steel (equivalent to JIS SKD 11), which has been hardened. It is a tool of steel material that has easy-to-harden properties and high wear resistance. The application of its use in life such as stamping tools, woodcutters, molding tools, knives, and roller equipment.

Research on Chatter as in S55C material using WA60JmV type grinding stone. The result was the chatter grew very quickly when the conditions of cutting depth, grinding width and grinding speed were large and the speed of the workpiece was low. Then increasing the stiffness and damping in the mechanic system could reduce the growth rate/formation of chatter [3]. The growth of grinding stone chatter on flat grinders, with 4140 hardened steel material, dimension 100 mm x 50 mm x 50 mm. It used a grinding stone with dimensions of 150 x 20 mm and a grinding type of 38A60KVBE. The spindle rotation speed was 2000 rpm (33.3 Hz). The result was that the growth of the chatter was relatively decreasing along with increasing the speed of the grinding wheel (wheel speed), whereas for the depth of cutting and the speed of the workpiece (workpiece speed) the greater would increase the growth of the chatter [4].

Researched dynamic simulations as models of flat grinders for time. Where the quality of the workpiece in the grinding process was influenced by static and dynamic conditions in a mechanical system, dynamic compliance caused vibrations that made the surface quality of the workpiece decrease. This study used a low carbon steel material (Fe510-EN 10027) with dimensions of 260 mm x 210 mm x 40 mm, type 7A36IBJ15 grinding stone with a dimension of 400 x 57. By varying the depth of cut, the feeding speed and the rotation of the grinding wheel [5].

From these research data, it is necessary to research an experimental study of the effect of longitudinal feeds on the flat grinding process on vibrations and surface roughness in OCR12VM hardened tool steel material so that it can be determined the relationship of process variables to the response, the magnitude of the vibration amplitude, the level of surface roughness that can be achieved and the relationship of vibration response to the surface roughness of the hardened tool steel OCR12VM material.

2. METHODOLOGY

The abrasive machining process is a process of abrasion of material using hard abrasive powder particles. The process of abrasive machining is divided into two, namely the bonding and non-abrasive machining process [6]. In the abrasive bounded process, the abrasive particles are bonded together with a certain gluing, while in the non-bonded abrasive process, the abrasive particles are not glued together. Examples of abrasive machining processes are grinding (surface, cylindrical, internal), polishing, water jet cutting, and abrasive jet cutting [7].

The machining process is often unable to produce workpieces with the expected level of roughness or dimensional accuracy. Many factors cause it, for example, materials that are worked too hard or too brittle, like ball and roller bearings, pistons, crankshafts, gears, cutting tools and molds. One process that is commonly used to produce workpieces with certain characteristics above is the grinding process. The grinding process is included in the bonded abrasive machining process, which is often used for the finishing process. This process is the process of removing material using a chisel in the form of a grinding wheel/disk, which is made from a mixture of abrasive powder and a binder with a particular composition and structure [8].

Grinding wheels mounted on the main shaft rotate with a certain peripheral speed depending on the diameter of the grinding wheel and its rotation. The peripheral speed at the edge of the grinding wheel can be calculated by the following formula:

$$v_s = \frac{\pi\, d_s\, n_s}{60\ 000}\ \ \mathrm{m/s} \tag{1}$$

With:

- v_s : peripheral speed of abrasive; (m/s)
- d_s : diameter abrasive; (mm)
- n_s : rotary abrasive; (r/min)

The material used in this research experiment was hardened OCR12VM tool steel with dimensions of 300 mm x 60 mm x 20 mm, with A80PV grinding wheel type (dimensions 200 mm x 25 mm x 32 mm). The constant variable was the spindle grinding wheel at 3000 rpm and cross feed 0.04 mm/step. Whereas the process variables was:

- ✓ Feeding speed (mm/s): 100, 150, 200, dan 250.
- ✓ Depth of Cut (mm): 0.01, 0.02, dan 0.03.

And the response variable was:

- ✓ Vibrations (grms)
- ✓ Surface Roughness (μm)

The equipment used was the surftest MT-301, Grinding machine KGS818AH, accelerometer, ADC Pico tech, computer, and power supply.

The experiment was to prepare a grinding wheel (A80PV) that had been done dressing, then prepare the OCR12VM workpiece that had been leveled and cleaned beforehand. Vibration measurements were made during the cutting test, namely by assembling and installing two accelerometers on the workpiece in the direction of the x-axis (channel B) and the direction of the z-axis (channel A), connecting it to the power supply and ADC, then connected to the computer. Set the machining process variables, such as cutting depth and feeding speed, that have been determined. Then the cutting test was conducted on each combination of process variables to obtain cutting data in the form of vibration stored on a computer. And from the data obtained time domain which then, by using the FFT formula was changed to the frequency domain. Then the RMS level is calculated, with the formula for nonsinusoidal vibrations or random vibrations like Figure 1 as follows: [9]

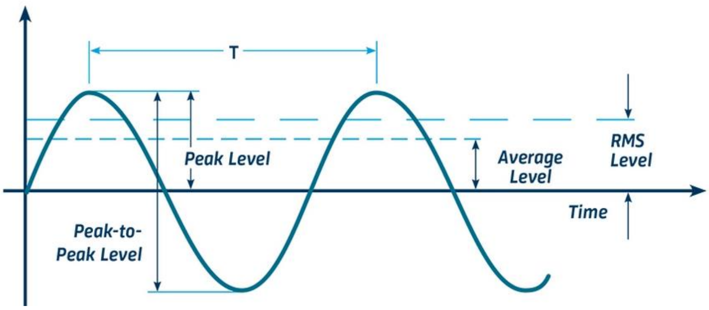

Figure 1. The relationship vibration amplitude nonsinusoidal (random)

$$\text{RMS level} = \sqrt{\frac{1}{T}\int_0^T a^2(t)dt} \tag{2}$$

$$\text{Average level} = \frac{1}{T}\int_0^T |a|dt \tag{3}$$

Determination of the peak level of the amplitude comes from the maximum value of vibration (a), and peak to a peak level of the amplitude can be calculated by adding up the maximum and minimum values in a period of vibration (T) [10][11].

For surface roughness measurement, it was conducted after the workpiece had been ground. The workpiece was cleaned, then measured the value, and the level of roughness was with the surftest. The cutting test scheme will be conducted in the flat grinding process, as shown in Figure 2 below.

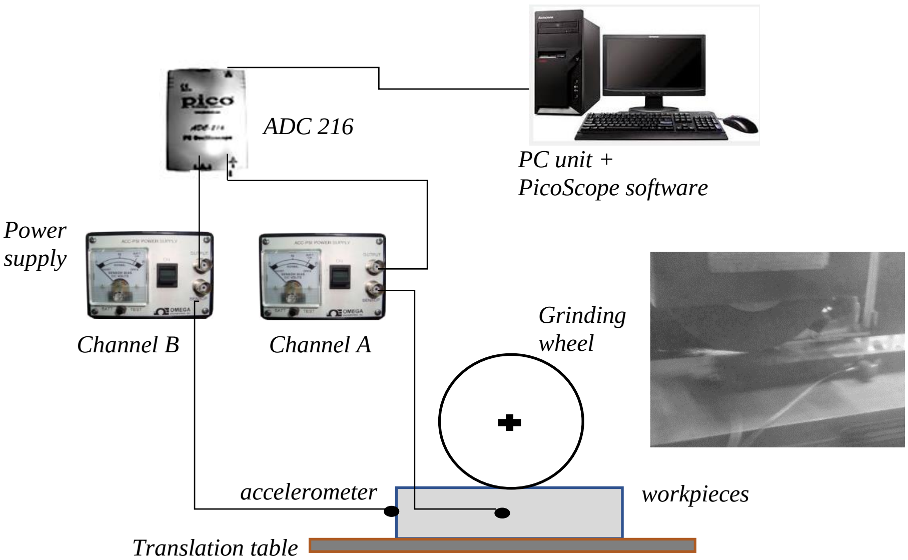

Figure 2. Grinding test measurement scheme

The results of the surface roughness data are converted into grade numbers, as shown in Table 1 [8], so that the relationship between the depth of cut and feeding speed can be analyzed.

Table 1. Roughness Grade Numbers and Standard Sample Length

Ra (μm)	Roughness Number	Sample length (mm)	Description
50 25	N12 N11	8	Very rough
12,5 6,3	N10 N9	2,5	Rough
3,2 1,6 0,8 0,4	N8 N7 N6 N5	0,8	Normal
0,2 0,1 0,05	N4 N3 N2	0,25	Fine
0,025	N1	0,08	Very smooth

3. RESULT AND DISCUSSION

The test data that had been conducted on the OCR12VM hardened tool steel flat grinding process using 80 grit grinding wheel against vibration and surface roughness was as presented in Table 2 and Table 3 below.

Table 2. RMS Amplitude Calculation Results

Sample	Feeding Speed	Depth of Cut	Amplitude rms	
			x-axis (B)	z-axis (A)
	mm/s	mm	grms	grms
1	100	0.01	0.3480	0.4491
2		0.02	0.9794	1.0881
3		0.03	1.2331	1.2965
4	150	0.01	0.6098	0.7364
5		0.02	1.3259	1.4275
6		0.03	1.7282	2.0449
7	200	0.01	1.0899	1.2245
8		0.02	2.3011	2.6319
9		0.03	3.0754	3.4503
10	250	0.01	3.1185	3.4335
11		0.02	5.2839	4.9872
12		0.03	6.9084	7.7456

Note: 1g= 9,81 m/s^2

The calculation in Table 2 is obtained from the time domain, which is changed in the frequency domain with FFT (Fast Fourier Transforms), which then calculated the vibration amplitude RMS value in units of gravity rms. Whereas Table 2, is obtained from the measurement of surface roughness perpendicular to the grinding direction.

Table 3. Surface Roughness Measurement Results

Sample	Feeding Speed mm/s	Depth Of Cut mm	Surface roughness Direct µm
1	100	0.01	0.15
2		0.02	0.19
3		0.03	0.23
4	150	0.01	0.18
5		0.02	0.23
6		0.03	0.27
7	200	0.01	0.22
8		0.02	0.28
9		0.03	0.32
10	250	0.01	0.35
11		0.02	0.40
12		0.03	0.47

Note: Measurement direction perpendicular to the feeding

So, from the two data tables, it can be graphed like Figure 3 below.

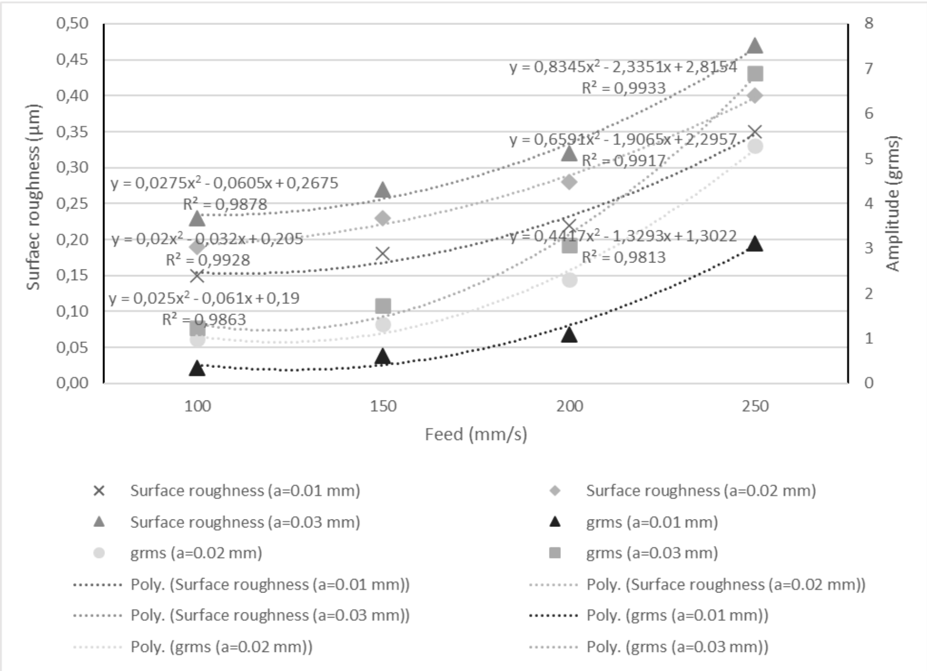

Figure 3. The relationship of feeding speed and depth of cut to the vibration and surface roughness of the OCR12VM hardened tool steel material

In Figure 3, it could be seen that the relationship between feeding speed and cutting depth to vibration and surface roughness of OCR12VM hardened tool steel was a quadratic polynomial function, the effect of process variables on response, for surface roughness was 99% and for vibration was 98% could be explained by the equation.

The greater the feed speed and depth of cut, the greater the surface roughness value of OCR12VM hardened tool steel material. Conversely, if the feed speed increases while the depth of the cut decreases, there will be a decrease in surface roughness.

At large feeding speeds, creating the contact between the grinding wheel and the workpiece increases so that the force required is also greater and can cause greater surface roughness of the OCR12VM hardened tool steel material. Likewise, with the greater depth of cut, the surface roughness of the workpiece will be even greater. This is due to the large contact between the chisel (grinding wheel) and the surface of the workpiece, creating a large cutting force[12].

Conversely, if the contact tool, in this case, is a grinding wheel with a workpiece, occurs very slowly, then the surface roughness results obtained will be smoother. The level of surface roughness that can be achieved by using a flat grinder is from N3 to N5. Where for the level of surface roughness, N3 and N4 are smooth and N5 is the normal category. Based on the relationship between cutting depth and feeding speed to the level of surface roughness of the OCR12VM hardened tool steel material that can be achieved, it can be seen in Table 4 below.

Table 4. Surface roughness level

Depth of cut (mm)	Feeding Speed (mm/s)	Surface roughness level
0.01	100	N3/N4
	150	N3/N4
	200	N4
0.02		N4
0.03	250	N4/N5

4. CONCLUSION

Surface roughness (Ra) was directly proportional to the vibration grms on flat grinding. Feeding speed and depth of cut affected the surface roughness of the OCR12VM hardened tool steel material in the form of a quadratic relationship of 99%. Feeding speed and depth of cut affected the vibration rms of OCR12VM hardened tool steel material in the form of a quadratic relationship of 98%. And addition to feeding speed and depth of cut would increase vibration and surface roughness.

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