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# THE GRINDABILITY OF SEGMENTED GRINDING WHEELS PRODUCED BY VIETNAM IN ROUGH MACHINING ALUMINUM MATERIAL

*У статті розглянуто нещодавно розроблені у В'єтнамі сегментовані шліфувальні круги, з опорою на основи переривчастої механічної обробки, з метою підвищення шліфуючої здатності зерен. Явище «засалювання» шліфувального круга, яке виникає при наліпанні шліфованої стружки в міжзеренному просторі, при використанні таких кругів зменшується, особливо при обробці алюмінію. Досліджувались круги з різним співвідношенням переривчастих ділянок та робочої поверхні круга. Випробування кругів проводилися для алюмінієвого сплаву, а також закаленої та незакаленої сталі при різних режимах обробки. При цьому виявлено, що механізми механічної обробки дещо відрізняються.*

*Ключові слова:шліфування, переривчаста обробка, сегментований шліфувальний круг*

*В статье рассматриваются сегментированные шлифовальные круги, разработанные недавно во Вьетнаме с опорой на основы прерывистой механической обработки, с целью повышения шлифующей способности зерен. Явление «засаливания» шлифовального круга, возникающее при налипании шлифованной стружки в межзеренном пространстве, при использовании таких кругов уменьшается, особенно при обработке алюминия. Исследовались круги с различным соотношением прерывистых участков и рабочей поверхности круга. Испытания кругов проводились для алюминиевого сплава, а также закаленной и незакаленной стали при различных режимах обработки, при этом выявлены некоторые отличия в механизме механической обработки.*

*Ключевые слова: шлифование, прерывистая обработка, сегментированный шлифовальный круг*

*Recently developed in Vietnam segmented grinding wheels is base on the fundamental of discontinuous machining is used to enhance the grindability of abrasive grains. The phenomenon of grinding chips adhesive to space between grains, that make the wheels became "dull", was reduce, special machining aluminum. In this paper, the evalution of segmented grinding wheel is based on the cutting performance. $\eta$ is defined as a ratio between the discontinued regions and the. of the grinding wheel's working surface. There were five newly developed grinding wheels with (10.91%, 16.37%, 18.19%, 20.01% and 21.83% respectively) and one conventional $\eta$ different $\eta$ = 0%) were used to grind unhardened steel, hardened steel and aluminum. The results showed $\eta$ grinding wheel (that segmented grinding wheels obtained a smoother surface in compared with conventional $\eta$ = 20,01% for machining unhardened steel and at $\eta$ = 18,19% machining aluminum material. On the other hand, segmented wheels with a less number of abrasive grains, show a higher efficiency for obtaining the smoother surface roughness than conventional wheels in the same working conditions. However, the mechanism of machining hardened and aluminum materials is a little bit different.*

*Keywords: grinding, discontinuous machining, segmented grinding wheel*

## 1. Introduction

Nowadays, the fabricate industry is using numbers of new materials with the difference in hardness, from hard ones such as thermal steel, alloy steel, carbide

alloy or ceramic material to soft ones like aluminum alloy, magnesium alloy and so on. All of them need the fine final machining in order to reach desired surface quality and dimension. The grinding process and grinding wheels are using as an effective way to reach the precision and surface roughness as expected. [1, 2].

Improving the fine final machining process can help in the job of enhanced products' reliability as the whole system. In this situation, as soon as machining conditions should not be taken out from properties of the material, we cannot ignore the impact of the grinding process to the material in real. In addition, we have to take notice of characteristic of treated surface of material, before and after machining process [3]. This paper mention the grinding process with Aluminum Alloy, C45 and C45 harden steel using segment grinding wheel. Surface quality got from the process is compared with the process using normal continuous grinding wheel. Effects by process variables are also researched.

## 2. Segment grinding wheels

In this experiment, a formal grinding wheel and 5 segmented grinding wheel have been used. Wheels have the same diameter, width, adhesive, dressing condition, grain size, grain density and stiffness and producer (Hai Duong grinding wheel producer). The formal griding wheel have continuous working surface (segmented rate $\eta$ = 0%) while other wheels are slotted equally in order to make different segment rate.

Table 1 – General parameter of grinding wheel

| |
|---|
| 1. Wheel's serial: Cn46 MV2 350x40x127-35m/s |
| 2. Outside diameter: 350 (mm) |
| 3. Inside diameter: 127 (mm) |
| 4. Wheel's width: 40 (mm) |
| 5. Wheel's velocity: 35 (m/s) |
| 6. Abrasive particle: Cn46 GV6 MV2 |
| 7. Adhesive: ceramic |

Table 2 – Segmented grinding wheel's parameters

| No | Number of tracksz | Angle between two slotted continually $\alpha$ (degree) | Segment rate $\eta$(%) |
|---|---|---|---|
| 1 | 12 | 30 | 10.91 |
| 2 | 18 | 20 | 16.37 |
| 3 | 20 | 18 | 18.19 |
| 4 | 22 | 16.36 | 20.01 |
| 5 | 24 | 15 | 21.83 |


Figure 1 – Geometry parameter of segmented griding wheel
with angle β slot's width w and slot's depth b

The griding process is performed by flat grinding machines OKAMATO made in Japan with the specifications of the grinding machine are listed in Table 3. Fig.1is the photographed of the wheel on the machine

Table 3 – Specifications of the grinding machine

| **Parameter** | **Length (mm)** | **Width (mm)** | **Height (mm)** |
|---|---|---|---|
| 1. Machine dimension | 4.280 | 1.850 | 2.190 |
| 2. Pallet dimension | 2.150 | 800 | |
| 3. Working space | 1.200 | 520 | 350 |
| 4. Capacity of main spindle motor: 11KW | | | |

Figure 2 –The wheel on the machine

Workpiece material used for the experiment is C45 with 2 type materials, harden steel with the hardness of 42-43HRC (5 patterns) and 5 patterns unhardened, 5 patterns aluminium alloy produced by Van Xuan Co., axbxc size = 100x35x40mm. Figure 2 is a screenshot of the workpiece used in the experiment

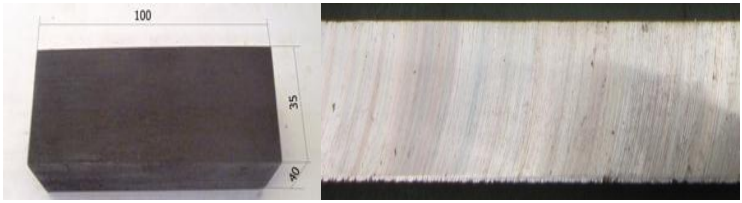


Figure 3 – C45 steel with 100x35x40mm dimension, the hardness 42-43 HRC and unhardened 82 HB , and aluminium A6061

The chemical composition of aluminum alloy A6061 is shown in Table 4.

Table 4 – Composition of chemical elements in aluminum alloy A6061

| element | Cu | Fe | Si | Mg | Zn | Cr | Al |
|---|---|---|---|---|---|---|---|
| Content% | 0.15 ~ 0.40 | 0.7 | 0.40 ~ 0.80 | 0.8 | 0.25 | 0.04 ~ 0.35 | The rest |

For all experiments, cutting velocity *v* and feed rate *s* are fixed at the value of *v = 32m / s, s = 12m/min*, while cutting depth *t* be changed to 0.015 mm; 0.025 mm and 0.05 mmrespectively. Each machining process is perform with 10 double cruises. The depth of the layer of removal material after 10 double cruisesis measured by an electronic caliper from Mitsubishi.

## 3. Results and Discussions

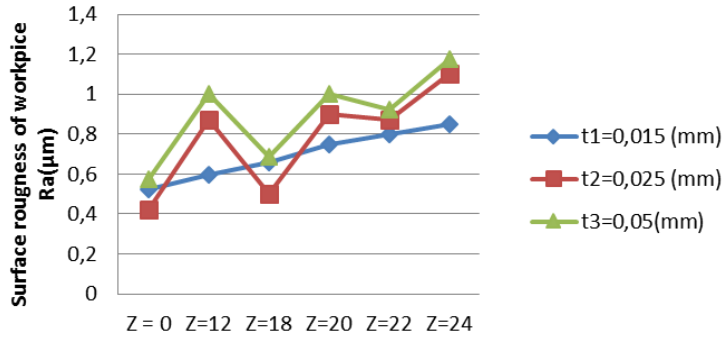


Figure 4 – The relationship between surface roughness Ra workpiece when changing t machining aluminum

When the cutting depth change respectively from 0.015mm; 0.02mm; 0.025mm, the feed rate is f = 12m/min, the process with Aluminum Alloy did not follow the rule. Theoretically, increasing the cutting depth will decrease the surface

quality [4, 5, 6]. When the cutting depth is $t_2$ = 0,025mm surface quality is better than when the cutting depth is $t_1$ = 0,015mm, even with t= 0,03mm, and z=18. In the process with continuous grinding wheel, grits on wheel's surface tend to close together, lead to the decreasing of efficiency in grinding process and surface quality.

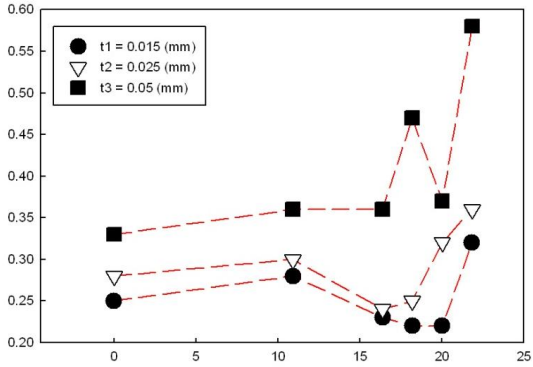


Figure 5 – The relationship between surface roughness Ra of the workpiece when changing t machining steel C45 hardened

With segmented grinding wheels, not all of them always better than traditional grinding wheel. But when the segment ratio increase, the surface roughness reach a peak at the segment ratio change from $\eta$ = 18,19% to $\eta$ = 20,1% (as in figure 5). At this point of $\eta$, the surface roughness is lowest even when compared with traditional grinding wheel

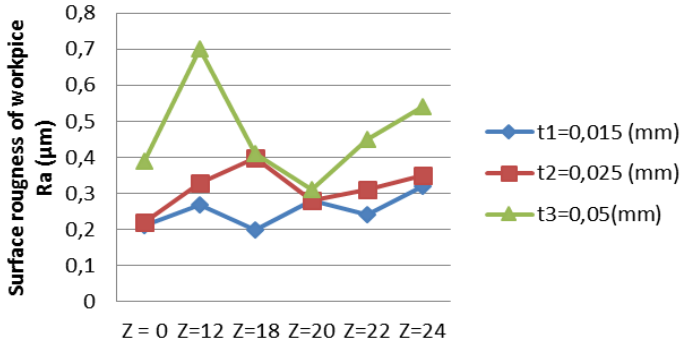


Figure 6 – The relationship between surface roughness Ra of the workpiece when changing t machining steel C45un hardened

When cutting depth enhanced in the process with C45 harden and normal C45, surface quality reach a highest point at Z=20, surface quality still remain even when increasing cutting depth. This is one of pros of segment wheels.

Characteristics of harden materials grinding process are lower residual stress, lower grinding power, short shavings while soft materials come with slide material layer, scratch, higher energy, long shavings. So that as long as the cutting depth and the contact length is big, the surface quality is low.

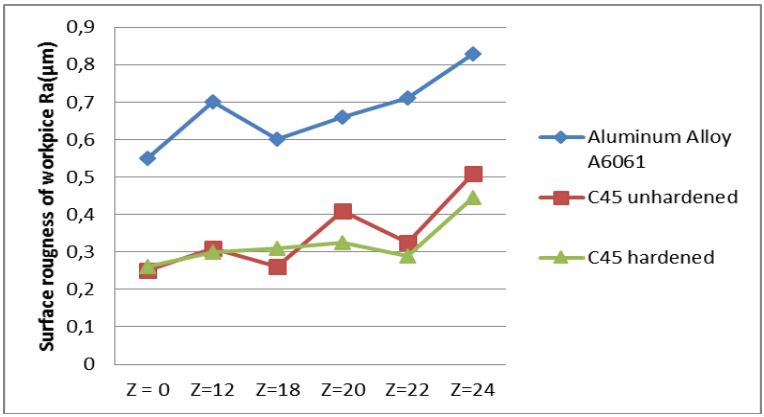


Figure 7 – The relationship between surface roughness Ra of the workpiece with 3 type of workpices when machining t=0,02mm; $S_3$= 12m/ph; v=30m/s

Surface roughness measured when machining with the z=18 segment wheel as the segment ratio of η = 16,37% show that the segment help arranging abrasive grit in the right way to avoid the same moving trajectory of the grit, give us higher surface quality compared with traditional grinding wheel at process variables of t=0,02mm; $f_3$= 12m/ph; v=30m/s. This thing give a pros to the z=18 segment wheel

**4. Conclusion**.

This paper mention the grinding process with Aluminum Alloy, C45 unhardened and C45 harden steel using segment grinding wheel. The result show that:

1. The segment wheel with segment ratio of $\eta$ = 16,37% show the best cutting ability compared with traditional grinding wheel. When increasing the cutting depth with the Z=20 process, the surface quality is still remain with 3 types of material

2. When machining harden material as C45 harden steel, crushed shavings created and combine with the segment space on working surface of the wheel help

shaving easier to move out from the machining space, coolant entered to the machining area through this way too, help increase the cutting ability of grinding wheel

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