The effect of cutting speed on dimension accuracy and burr development of high-speed micro drill proses on aluminium

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Abstract. The machining process is a part of the production technology used in almost every manufacturer of industrial products. The world of the industry continues to grow along with technology, emerging machining technology that can produce miniaturization products on of that is a micro-drilling process. This research observed the dimension accuracy and burr development on micro drilling process on Aluminium. The accuracy of the hole dimension and burr development on top and bottom were observed on three different cutting speed. The thickness of aluminium as the workpiece is 0.5mm and drill with a diameter of tungsten carbide drill bit 0.3mm. The results show at the cutting speed of 13.2 m/min, the largest hole diameter was found 0.3117 mm, while the smallest hole diameter is 0.3039 mm measured at a cutting speed of 18.8 m / min. For the top burr height found that the largest number is 0.19 mm and the smallest number at 0.07 mm. While the bottom burr height has the highest value of 0.39 and the lowest at 0.12 mm, it can be concluded that the deviation of hole dimension size and burr height is inversely proportional to cutting speed.

1. Introduction
The machining process is one of the most needed production technologies in almost every product that is produced through the process of casting, rolling, or forming which always requires the final processing by machining. Along with the development of material needs and the quality of machining products, this technology is also constantly developed both in terms of technical (machine capability and cutting tools), the impact of the process on product quality, as well as economic considerations. [1].

One of the fundamental things in the operation of the industry is drilling process which is one of the processes of making holes in a component. When the size of the hole turns small and the smaller the process is called the micro-drill process by using a process that only has a micro-sized hole diameter. This continues to be the focus of the industrial world such as electronics, space, the world of health, chemical reactors, types of filters and much more. The new curing process can be stated as a micro-drill process when it is in size between 1µm - 1 mm in diameter [2].

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2. Micro-drilling

2.1 Micro-drilling Process

Micro drill is the mention of the word in terms of the micro-drilling process, there are two ways in micro drill operation, namely conventional and non-conventional, the conventional techniques refer to the basic process where there is a tool, and the spindle rotation is installed, this can create micro holes. While the non-conventional techniques are relatively new and are extensively used in the modern world, unlike conventional methods, non-conventional involves various methods such as electrical, chemical, mechanical, thermal and a combination of all, non-conventional techniques that are often used in the modern world namely: Laser, EDM, ECM, SACE, Electron Beam and Ultrasonic Vibration. Micro drills are classified into micro holes measuring 1 μm - 1 mm [2]. In this study, researchers will only use conventional techniques.

2.2 Hole Quality

Failure and damage to the product resulting from the machining process are caused by the following factors: error geometry, thermal error, the hardness of the material, engine vibration, spindle rotation, and contour. All of these factors can exacerbate the quality of the results of the drill [3], as shown in Figure 1.

![Figure 1. Hole dimension [2].](image)

2.3 Burr Formation

The formation of burrs is a basic phenomenon of the drilling process; this has an impact on the hole surface at the top and bottom, the formation of burrs can create problems in accuracy and quality [2] (see Figure 2). The formation of burrs is caused by several different factors including the properties of the work material, drill geometry and material [4].

![Figure 2. Classification of Burr types [2].](image)
3. Method and Materials

3.1. Setup of machining
The machining process is carried out in this research by adding a high-speed spindle motor with a speed of 24,000 rpm on a CNC milling machine at SMK 2 Banda Aceh. A modified CNC milling machine can be used normally by adding a high-speed spindle. The mechanism can be seen in Figure 3.

![Figure 3. Setup mechanism.](image)

3.2. Parameter of machining
The machining parameters specified in this study are important variables to determine the results of the machining process, the researcher determines the variable of machining which consists of nine different variables can be seen in Table 1.

| Tools   | Tungsten carbide 0.2 mm drill bits | Brass carbide 0.5 mm thickness |
|---------|-----------------------------------|-------------------------------|
| Plate material | 14.000 | 17.000 | 20.000 |
| Spindel Speed | 14.000 | 17.000 | 20.000 |
| Plate Number | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  |
| Feed rate   | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Reapetation | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |

3.3. Materials
The material that is the object of observation in this study is aluminum material which is obtained in the market in Banda Aceh, with the size cut as specified previously.

3.4. Drilling Tool
In this test the cutting tool used is a tungsten carbide type that has a diameter of 0.3 mm, this tool is generally used for making holes on the circuit board and also for metal materials, this tool is manufactured in Japan by Union Tools company.
3.5. Hole Measurement

The hole and the quality of the product of the machining process are measured using a stereo microscope. The object magnification of this microscope reaches 50X. In this measurement, the microscope has a limitation; it cannot connect to the PC directly without the help of a camera recorder. So, this microscope is equipped with an additional camera as shown in Figure 6 below. This observation aims to see the accuracy of dimensions and burrs formed in the tests.

4. Result and Discussion

4.1. Measurement Data

After stages of the machining process have been done, the aluminum is observed using a stereo microscope to measure the dimensional accuracy as well as the height of the burrs created. The size of each hole is created according to the specified parameters. The measurements can be seen in Table 2. From the chart and tables above shows that the number and accuracy of the machining process holes are very determined from the spindle speed and feed rate. Where the speed has been determined to start from 14,000 rpm, 17,000 rpm and 20,000 rpm and the feed rate is 5 mm / min, 8 mm / min, 10 mm / min. From Figure 5 the machining process recorded as follows, the biggest deviation is 0.03117 mm it was in spindle rotation conditions of 14,000 rpm and feed rate of 8 mm/min while the smallest hole size deviation is at spindle rotation of 20,000 rpm and feed rate of 10 mm / min with a value of 0.03039 mm, this is at a maximum speed and speed with a number.

The results of the holes shown in this study are illustrated in Table 2 and Figure 8, that is the dimensions of the hole graph, this result can show that the dimension value of the hole will increase with increasing feed rate and spindle speed.

| Spindel speed (rpm) | Feed Rate (mm/min) | Diameter rate of the hole (mm) |
|---------------------|--------------------|-------------------------------|
| 14000               | 5                  | 0.3111                        |
| 14000               | 8                  | 0.3117                        |
| 14000               | 10                 | 0.3098                        |
| 17000               | 5                  | 0.3094                        |
| 17000               | 8                  | 0.3076                        |
| 17000               | 10                 | 0.306                          |
| 20000               | 5                  | 0.3088                        |
| 20000               | 8                  | 0.3055                        |
| 20000               | 10                 | 0.3039                        |

Table 2. Results of hole diameter
Figure 5. Hole dimension observation.

Figure 6 shows some sample images from the observation. Randomly selected from several options machining parameters.

![Sample images](image)

**Figure 6.** Observation chart of hole dimension.

### 4.2. Entrance and Exits Burr

*In the machining process with the aluminum that was tested, burrs were formed on each hole produced. There were entry burrs and exit burrs. This greatly affects the quality of the result of the machining, as described in Tables 3 and 4.*

| Spindel speed (rpm) | Feed Rate (mm/min) | Burr high entrance (mm) |
|---------------------|--------------------|-------------------------|
| 14000               | 5                  | 0.19                    |
| 14000               | 8                  | 0.18                    |
| 14000               | 10                 | 0.14                    |
| 17000               | 5                  | 0.16                    |
| 17000               | 8                  | 0.16                    |
| 17000               | 10                 | 0.07                    |
| 20000               | 5                  | 0.18                    |
| 20000               | 8                  | 0.15                    |
| 20000               | 10                 | 0.07                    |
From the results of the burr heights measured in table 3 and figure 10 we can see that the highest number is at 0.19 mm, which is spindle speed of 14,000 rpm and feed rate of 5 mm/min. The lowest burr height is at the spindle rotation of 20,000 rpm, and the feed speed of 10 mm/min is shown in Table 3 which is 0.07.

Table 4. Observation result of exits Burr

| Spindel speed (rpm) | Feed Rate (mm/min) | Burr high exit (mm) |
|---------------------|--------------------|---------------------|
| 14000               | 5                  | 0.39                |
| 14000               | 8                  | 0.28                |
| 14000               | 10                 | 0.13                |
| 17000               | 5                  | 0.41                |
| 17000               | 8                  | 0.3                 |
| 17000               | 10                 | 0.17                |
| 20000               | 5                  | 0.33                |
| 20000               | 8                  | 0.31                |
| 20000               | 10                 | 0.12                |
Table 4 shows the measurements of the exit burr height. The highest number is at 0.41 mm, which is at a spindle rotation of 14,000 rpm and a feed rate of 8 mm/min. The lowest is at 0.12 mm, with a spindle rotation of 20,000 rpm and a feed rate of 10 mm/min, which is the maximum rotation and rate of the specified parameters.

5. Conclusions
The test is carried out on aluminum workpieces measuring at 120 mm wide, 35 mm long, 5 mm thick. There was a total of 9 specimens, with 10 holes in each specimen. Based on the test, it was found that different parameters and tool bits affect the accuracy and quality the holes resulted from the drilling process. This is evident in the testing, from the largest hole deviation with a value of 0.3117 mm at spindle rotation of 14,000 rpm and a feed rate of 8 mm/min, while with the smallest hole deviation is at 0.3039, which occurs at a spindle rotation of 20,000 rpm and a feed rate of 10 mm/min. Based on the results of this study, hole accuracy will increase with increasing spindle rotation and feed speed. The same is true with burr formation; the number of burr heights will be lower as the spindle rotation and the feed rate increase.

6. References
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