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The Effect of Wear Endmill Two Flutes on AISI 1045 Machining with CNC Milling

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Abstract--This study describes the tool life of the cutting tool Endmill 2 flute in the machining process. This study aims to analyze the effect of Rake angle Endmill to the perforation process by using CNC milling machine. The machining parameters used Vc= 75 m/min and 50 m/min. Type of Endmill used in this study Endmill cutter 2 flute. The material used in the perforation process is steel AISI 1045. The perforation is done by giving the initial diameter 6 mm before the perforation process with Endmill. The perforation process with Endmill is done by varying the Rake angle of endmill 2º, and 3º. This is done to determine the extent of the incision Endmill strength in the manufacturing of the hole. Measurement wear is performed on the Endmill by measuring the extent of damage occurring to the Endmill after the machining process. From this research it was found that with Rake angle 2º wear which happened smaller, while at Rake angle 3º Endmill wear value tends to be bigger.

Keywords: Endmill, Tool life, CNC Milling, Rake angle.

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1 INTRODUCTION

Producing good product quality is influenced by several factors including material, machine used, cooling used in machining process of cutting condition and cutting tool used [1]. It is important at this point how production machine tools produce more accurate products with shorter processing times and lower costs [2]. In addition to addressing issues of global development carried out an investigation of the machining process environmentally friendly and cost reduction [3].

How to achieve better results will develop new endmills with different tool angles than current cutouts and those with higher efficiency [4] [5]. Parameter characteristics of cutting tools have a very vital role in producing a good product, the tool life of cutting tools can be ascertained from the amount of wear of cutting tools with variations of the geometric angle of cutting tools [2]. The process of cutting the metal often occurs wear on the cutting tool used, this is caused during the machining process of cutting tools interact directly with the material [6]. Cutting temperature contraction and pressure conditions on the surface of the workpiece and cutting tool wear and tear of tools and mechanisms affecting wear [6]. Please note the cutting speed is directly related to the temperature conditions that are in the machine [7]. In addition, the number of eyes (flute) is very influential on the machining process, the role of involvement of the number of flute cutting tools in milling operations is important because it not only affects the cutting strength but also the material surface[8].

The cost of replacing the cutting tool is a major part of the total cost of machining[9], to reduce the cost of replacement cutting tool that is by reducing the wear on the endmill. In research about the use of tools and tools life endmill with different cooling conditions. Where in milling operations the use of fluids can cause damaging effects [10]. Apart from that the use of coolant in fact often cause damage prematurely so that the tool life of the tool becomes short [11]. In terms of production costs with an overhaul of the effects of the coolant can certainly make the cost of production increases. Produce products with high accuracy it should be noted about the life of the tool cut (tool life). If toollife of the cutting tool is ignored in a machining process will certainly adversely affect the quality of the product, the cost of machining process and the machine used. Improve the quality of life of cutting tools can be done by examining the effects of rake angle endmill.

2 LITERATURE

2.1 Tool life

Tool life is the time limit of the chisel's ability to be able to cut effectively and well. As the use of cutting tools and the growing wear rate of cutting tools that are in line with the chiseled user time of the machining process the use of cutting tools for cutting effectively has been exhausted. The wear and tear on the tool used will have an impact on the possible failure of the cutting tool in the machining process. There are three possible ways in which cutting tools can fail in machining such as:

- Fracture failure. The way this failure occurs when the cutting force on the cutting tool becomes excessive, causing it to fail suddenly by the brittle fracture.
- Temperature failure. This failure occurs when the cutting temperature is too high in the cutting tool material, causing the material on the cutting tool to

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soften causing plastic deformation and loss of edge sharpness.

- Gradual wear. The gradual use of the tip of the eye leads to the loss of the cutting tool shape, the reduction of cutting efficiency, the acceleration of the wearing of the appliance being very worn, and the failure of the cutting tool in a manner similar to the temperature failure.

Fracture and temperature failure resulted in early loss of cutting tool sharpness. Both modes of failure are therefore undesirable. Of the three possible tool failures, gradual use is preferred because it leads to the longest use of tools with longer-term economic benefits associated with their use [12].

2.2 Tool Wear

Gradual wear occurs in two major locations on the cutting tool, in the area of fist and the main part of the tool. Thus, two types of wear can be distinguished, namely crater wear which occurs in the field of growling, while the wear of the edge (Flank wear) occurs in the main field of the cutting tool. Crater wear consists of a cavity in the face of the Rake tool that forms and grows from the movement of the chip that glide to the surface. High stresses and temperatures characterize the interplanetary contact of Tool and Chip contributing to wear and tear. Crater wear consists of a cavity in the face of the Rake tool that forms and grows from the movement of the chip that glide to the surface. High stresses and temperatures characterize the interplanetary contact of Tool and Chip contributing to wear and tear. Wear of the crater can be measured either with depth or area. Flank wear occurs on the Relief face of the cutting tool, this results from friction between the workpiece surface and the Relief face adjacent to the edge cutting. Flank wear is measured with a wide wear band, FW. This wear arm is sometimes called Flank wear land.

As a result of the high level of productivity, which is very important in high-speed CNC machine used was noticed tool wear of a Endmill [13]. The criteria recommended by ISO 3685: 1993 to determine the effective tool life for carbides [13], high-speed steels (HSS) and ceramics are:

Tabel 1. Recommended for Flank wear size VB_B on material cutting [13].

Tool Material		Comented Carbides	Carbides Coated	Ceramics	
Operation	(mm)			AL_2O_3	Si_3N_4
Roughing	VB_B	0.3-0.5	0.3-0.5	0.25-0.3	0.25-0.5
Finising	VB_B	0.1-0.25	0.1-0.25	0.1-0.2	0.1-0.2

2.3 Cutting Parameters CNC Milling.

The cutting speed is determined at the outer diameter of the milling cutter. It can be converted into spindle rotation speeds by using the following equation [12]:

$$N = \frac{v.1000}{\pi.D} \qquad (1)$$

feeding *f* in milling usually as slicing per piece of tooth; Called the load chip it represents the size of the chip formed by each cutting angle. It can be converted to the level of food by paying attention to the spindle speed and the number of teeth on the cutter as follows:

$$f_r = N n_t\, f \qquad (2)$$

Where *fr* = rate of feeding, mm/min (in/min); *N* = spindle speed, rev/min; n_t = number of teeth in cutting tool (eye of eye); And *f* = chip load in mm/tooth (in/gear). For the fr value used is the value of the feeding rate according to the Endmill catalog used ie the value fr = 520 mm / min.

Tolerance

For this value is made an international standard (IT). the value of IT is set with ISO 286. the amount of tolerance is adjusted to the size of the size, both hole and shaft are seen in the following equation [14] :

$$IT10 = 64.i \quad Where$$

$$i = 0{,}45\sqrt[3]{D + 0{,}001D\ (\mu m)} \qquad (3)$$

If we are going to make the product / work item, either in large or small quantities, to reach the right size, according to the one shown in the picture, it is not easy because of many factors that affect it.

3 RESEARCH METODE.

3.1 Research Design.

The study examined the wear rate of the endmill 2 flute Ø 8 mm cutter on the perforation process on the AISI 1045 plate. While the material used Endmill is carbide. Before the perforation process with the Endmill first done the initial punch with drill Ø6 mm. The wear rate analysis is performed by varying the Rake angle Endmill ie 2^0, and 3^0, Cutting speed used is 75 m/min and 50 m/min, the wear measurements are performed on the Endmill by measuring the extent of damage occurring to the Endmill after the machining process, and the measurements are also performed on each hole produced by the Endmill.

3.2 Tool and Materials

The equipment used in this research is CNC Milling VMC 850, drill Ø 6 mm, vernier caliper, digital microscope, while supporting tools used are hacksaw, Universal Cutter and tool grinder KW1500768, hardness testing machine. While the material used in this research is AISI 1045 and Endmill cutter 2 flute diamter 8 mm.

Figure 1. Endmill cutter 2 flute carbide

in this study variation of axial rake angle will be required, while for rake angle geometry variation is shown by the following figure.

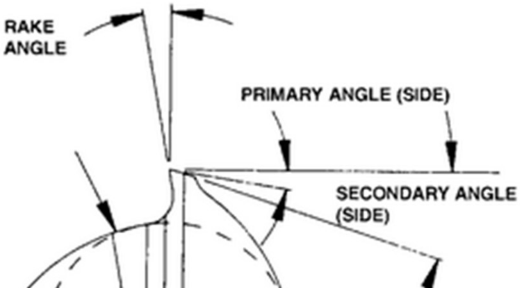

Figure 2. Rake angle geometry Endmill cutting tool

The material to be used is AISI 1045 steel used as material in this research, as for material type which is considered to have hardness value that accompanies with AISI 1045's crest value is S45C, ST-60, DIN C45, CK45, CF45, CQ45 [15].

Figure 3.2 is a picture of the size of the hole to be made, and the distance between holes. The number of holes that can be made in one AISI 1045 plate is 48 holes while the hole diameter is 8 mm.

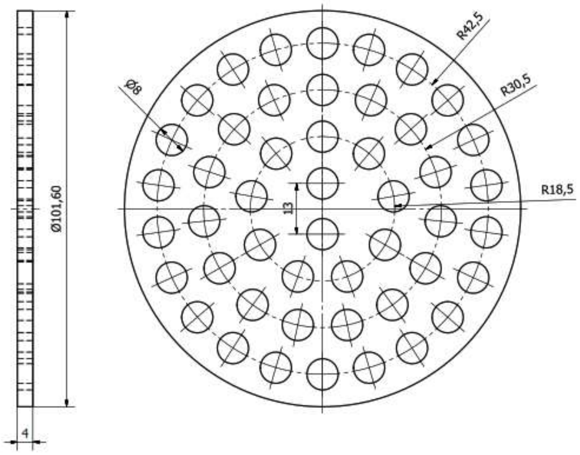

Figure 3. Design of the ST-60 perforation.

3.3 Data Retrieval.

The design of this study is intended as a way to obtain data in the form of research variables, endmill cutting tools used, and the type of material used. The research variables used:

1. Initial hole size
   In the process of this study there is initial hole sizes to be performed before perforation using endmill ie each initial hole with Ø6 mm.
2. Geometry of Endmill Angle.
   The endmill slice angle used will be varied as for the following endmill angle.

Here is a standard table of angle specifications of the endmill tool used:

Table 2. Specification endmill 2 flute

Endmill geomety	
Rake angle	2^0 and 3^0
Diameter endmill	8 mm
Length	60 mm

To get different result on machining result, it will be seen how far angle Rake angle influence, Rake angle change that will be used in this research is 2^0, and 3^0

As for the machine parameters used in this study are as follows:

Table 3. Machine parameters

Cutting Parameters			
Cutting Speed	V	m/min	75 and 50
Feed	f	mm/rev	0.09 and 0.13
Width of Cut	a	mm	1

4 RESULTS AND DISCUSSION

4.1 Result

4.11 Machinery Parameters

The cutting parameters used in this study can be calculated using the equations found in equations (1) and (2) The equation used to calculate the cutting speed is equation (1). The cutting speed is determined at the outer diameter of the Endmill. Then the rotation speed can be calculated as follows:

For the value of V that can be used is Vc = 50-100 m / min, and in this study the cutting speed used Vc = 75 m/min and 50 m/min, while the endmill diameter is D = 8 mm, then:

$$N = \frac{V.1000}{\pi.D} = \frac{75.1000}{3.14.8} = \frac{75000}{25.12} = 2986\,rpm \qquad (5)$$

$$N = \frac{V.1000}{\pi.D} = \frac{50.1000}{3.14.8} = \frac{50000}{25.12} = 1990\,rpm$$

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Furthermore, to know the rate of feeding of cutting Endmill cuttings in the process of feeding can be calculated by equation 2:
Where is the known feed used is fr = 520 mm / min (fr value is explained on the above machine parameters)

$$f = \frac{520}{2986.2} = 0.09\ rev/min \qquad (6)$$

$$f = \frac{520}{1990.2} = 0.13\ rev/min$$

4.12 Hole Tolerance

To determine the tolerance of hole accuracy that has been made it can be calculated based on equation 2.3 in accordance with the standard of tolerance at ISO 286:

$$IT10 = 64\ (0.3645) = 23.328\ \mu m = 0.023mm = \pm 0.02\ mm \quad (7)$$

4.13 Relation of rake angle variation with endmill wear.

Measurement of the endmill wear shown in this discussion, ie the average wear rate of the endmill flute, in which the machining treatment is carried out with the initial hole variation (feed thickness) of each different angle variation, to wear with the initial hole diameter of 6 mm, in this case increased wear and tear are presented in tables and graphs of data wear every holes process. While the value of flank wear (VB_B) recommendation used is 0.500 mm.

In the subsequent process for the preparation of a hole with a 6 mm diameter opening hole at a varied angle, the data contained in the table and graph is the conclusion of increasing the endmill wear value of every 6 holes, in this test the same treatment in the previous test is the variation of rake angle to the 6 mm diameter initial hole, the measurement of the average yield of 2 flutes occurring at the angle variation of the incision to the diameter of the 6 mm diameter opening hole can be seen in Table 4 and Figure 4, as follows:

Table 4 wear Endmill with rake angle 2^0

No.	Time (min)	Tool wear (VB) (75 m/min)	Tool wear (VB) (50 m/min)
1	0.07	0.010	0.012
2	0.40	0.065	0.021
3	0.80	0.113	0.087
4	1.20	0.136	0.128
5	1.60	0.152	0.143
6	2.00	0.170	0.163
7	2.40	0.212	0.182
8	2.80	0.274	0.243
9	3.20	0.328	0.298
10	3.60	0.388	0.359
11	4.00	0.450	0.421
12	4.33	0.503	0.475
13	4.53		0.502

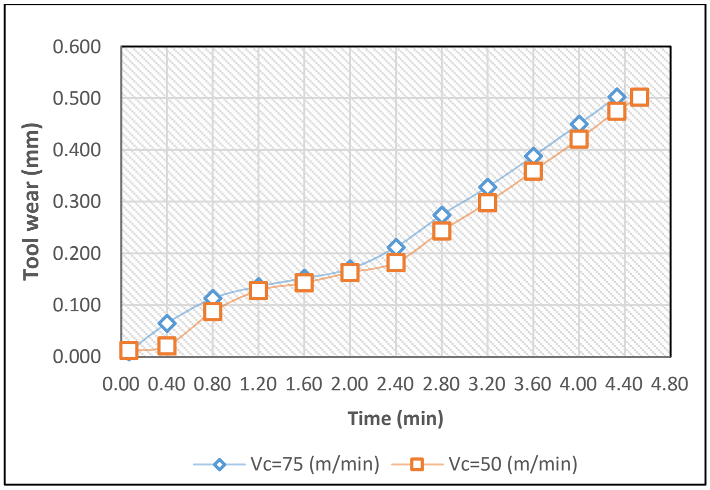

Figure 4 graphs the wear with a rake angle 2^0

Figure 4 draws the resulting graph from the chisel wears with different sizing velocities to the 6 mm diameter starting hole. It appears that with a 2 degree rake angle that with Cutting speed Vc=75 m/min faster wear life wear than Endmill with Cutting speed Vc = 50 m/min, the above graph shows that with cutting speed 50 m/min experiencing wear after the process of making a hole with time of 4.53 minutes and the resulting wear value is 0.502 mm. while at Cuuting speed 75 m/min wear occurs faster, where Endmill experience wear after piercing process with time 4:33 minutes and value of wear resulted is 0.502 mm.

The next discussion is the tables and graphs of wear with the process of making a hole with rake angle 3, as follows.

Table 5. Wear Endmill with rake angle 3^0

No.	Time (min)	Tool wear (VB) (75 m/min)	Tool wear (VB) (50 m/min)
1	0.07	0.072	0.055
2	0.40	0.132	0.091
3	0.80	0.195	0.161
4	1.20	0.250	0.229
5	1.60	0.320	0.271
6	2.00	0.396	0.363
7	2.40	0.445	0.428
8	2.80	0.501	0.482
9	3.00	0.534	0.506

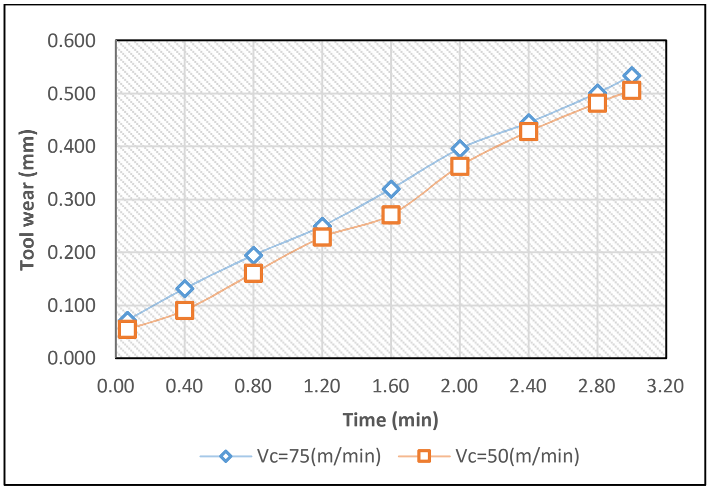

Figure 5. graphs the wear with a rake angle 3^0

In Figure 5 it appears that the same event occurred as in previous experiments, where wear is faster at Cutting speed Vc = 75 m/min than Cutting speed 50 m/min. seen on the graph that wear and tear on Cutting speed 75 m/min happened faster, where the happened at perforation process with time 2,80 minutes and value of keusan which resulted 0.501, while for cutting speed 50 m/min of keuasan happened at perforation process with time 3.00 minutes and with the wear value occurring is 0.506.

4.2 Discussion

According to the ISO standard, the allowable cutting limit is VB$_B$ = 0.500 mm [13]. The tool life of Endmill can be seen on the graph of the initial hole and any Rake angle changes (figures 4 and 5). In addition to the cutting speed noted in the wear and tear of Rake angle changes can also lead to differences in wear and tear in this study. In several studies related to the change of geometry to explain their impact Endmill Tool life of a cutting tool [16] [2] [17]. But too big Rake angle will form the edge of the sharpness of the tool that easily worn or broken [2]. As mentioned in this study, the greater the Rake angle the greater the wear and tear that occurs in the tool [2].

In the results obtained above found that with different Cutting speed and different rake angle Endmill geometry can result in different gains. with lower Cutting speed and smaller rake angle can minimize the occurrence of wear on the Endmill in the perforation process.

The wear results that occur in the Endmill in this study can be seen in the figure below.


(a) (b)

Figure 6. Microscope digital image Endmill wear (a) Relief face (b) Rake angle face

Conclusion

In addition to the influence of Cutting speed, the change in rake angle geometry also greatly affects the wear and tear of the endmill used in the machining process, from this study obtained the longest tool life in the piercing process with Cutting speed 50 m/min and rake angle 2^0, where the value Wear produced 0.501 with 4.33 minutes

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