DAFTAR PUSTAKA

Alaitz Gonzalez. 2007. ***Machine Tool Utilisation Phase: Costs and Environmental Impacts with a Life Cycle View Master of Science Thesis Stockholm***,*Presented At Industrial Ecology Royal Institute Of Technology.*

Aqapiou, John S dan Stephenson, David A. 2006. ***Metal Cutting Theory And Practice***. Broken Sound Parkway Nw. Boca Raton. USA.

Ardraviz, **Karakteristik Sifat Besi Tuang Cor Kelabu**. Online. https://ardra.biz/sain-teknologi/metalurgi/besi-cor-cast-iron/karakteristik-sifat-besi-tuang-cor-kelabu-gray-cast-iron/

Braucke, 2004. ***Establishment of a Database for Tool Life Performance***. School of Engineering and Science Swinburne University of Technology, Australia.

D Clough, S Fletcher, A P Longstaff And P Willoughby. 2012, ***Thermal Analysis For Condition Monitoring Of Machine Tool Spindles***, University Of Huddersfield, Uk.

Franke, JÖrg E. 2011. ***Experimental Evaluation of the Thermal Machine Tool Behavior for Model Updating, Institute for Manufacturing Automation and Production Systems***, Germany.

Gutowski, T, G., Dahmus, J. B., Thiriez, A. 2006. ***Electrical Energy Requirements for Manufacturing Processes***. *Leuven, Belgium, pp. 623-627. Proceedings of the 13th CIRP Conference on Life Cycle Engineering, ed. By Duflou, J. et al.*

Helmi A. Youssef, Hassan El-Hofy. 2008. ***Machining technology : machine tools and operations***. *Broken Sound Parkway NW, Suite 300 Boca Raton, FL 33487-2742 .CRC Press Taylor & Francis Group 6000.*

Hermann, C., Bergmann, L., Thiede, S., Zein, A. 2007. ***Framework for Integrated Analysis of Production Systems***; in Proceedings of the 14th CIRP Conference on Life Cycle Engineering, ed. by Takata, S., Umeda, Y., Tokyo, Japan, Springer, London, *pp*. 195-200.

Huda, Muhammad. 2010, ***Pengenalan Pola Citra Termografi Pada Pemantauan Kondisi Mesin Dengan Metode Pengolahan Citra igital***, Universitas Diponegoro, Semarang.

an, Serope. 1992. ***Manufacturing Engineering and Technology nd Edition***. Addison Publishing Companya Inc. California.

Kalla, 2009, ***Unit Process Life Cycle Inventory for Product Manufacturing Operations***, in: *Proceedings of the ASME International Manufacturing Science and Engineering Conference,* 2009.

Overcash M,. Twomey J., Kalla D,. **Unit Process Life Cycle Inventory for Product Manufacturing Operations**, in: *Proceedings of the ASME International Manufacturing Science and Engineering Conference,* 2009.

Rajemi. Mohamad Farizal. 2010. ***Energy Analysis in Turning and Milling***. A thesis submitted to The University of Mancheste for the degree of Doctor of Philosophy in the Faculty of Engineering and Physical Sciences. School of Mechanical, Aerospace and Civil.

Rajender Singh. 2006**. *Introduction to Basic Manufacturing Processes and Workshop Technology***. *Ansari Road*, Daryaganj, New Delhi – 110002. Publishing For One World New Age International (P) Limited, Publishers 4835/24

Ravel/Bfk. 2000 N. N. ***Typischer Energiefluss einer guten Produktions maschine***. *RAVEL/BFK, 724.397.12.54 D. Available from* http://www.energie.ch/themen/ industrie/infel/maschinen.htm

Rochim, 1993. ***Jenis Mesin Frais dan Pahat Frais***. Online. www.slideshere.net/mesin-frais

Skoczynski, 2013. ***Poland. Assesment of Energy Consumption by Machine Tools***. Wroclaw University Of Technology, Faculty Of Mechanical Engineering, Institute Of Production Engineering And Automation, Wybrzeze Wyspianskiego 27, Wroclaw.

Waclaw Skoczynski, Janusz Maczka, Zbigniew Wasiak, Andrzej Roszkowski, Pawel Pres. 2013. *Poland.* ***Assesment of Energy Consumption by Machine Tools***. *wroclaw university of technology, faculty of mechanical engineering, institute of production engineering and automation, wybrzeze wyspianskiego 27, wroclaw.*

2008. ***Teknik Pemesinan***. Jakarta :Direktorat Pembinaan ekolah Menengah Kejuruan.

L A M P I R A N

Lampiran Tabel

Hasil Pengukuran laju keausan pahat (V_B) pada kecepatan potong (Vc) Konstan

t (Menit)	V_B								
	Vc=30,14 m/min			Vc=46,16 m/min			Vc=67,82 m/min		
	0,035	0,070	0,140	0,035	0,070	0,140	0,035	0,070	0,140
0	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
3	0,010	0,020	0,032	0,011	0,025	0,033	0,021	0,037	0,052
6	0,019	0,032	0,053	0,027	0,044	0,072	0,034	0,062	0,094
9	0,022	0,042	0,072	0,035	0,056	0,087	0,048	0,074	0,114
12	0,029	0,059	0,086	0,049	0,080	0,114	0,068	0,103	0,151
15	0,042	0,068	0,110	0,067	0,096	0,137	0,084	0,117	0,167
18	0,049	0,074	0,121	0,081	0,113	0,149	0,106	0,142	0,185
21	0,055	0,089	0,138	0,090	0,134	0,184	0,127	0,156	0,201
24	0,064	0,094	0,147	0,108	0,144	0,195	0,149	0,184	0,233
27	0,069	0,098	0,153	0,113	0,162	0,207	0,157	0,199	0,245
30	0,077	0,108	0,165	0,125	0,167	0,227	0,173	0,227	0,273
33	0,086	0,118	0,177	0,132	0,188	0,247	0,184	0,238	0,312
36	0,091	0,123	0,190	0,144	0,195	0,259	0,198	0,257	0,350
39	0,099	0,136	0,198	0,157	0,208	0,277	0,213	0,269	0,403
42	0,108	0,148	0,204	0,169	0,226	0,287	0,225	0,282	
45	0,117	0,156	0,211	0,175	0,238	0,313	0,231	0,304	
48	0,124	0,161	0,221	0,185	0,249	0,328	0,249	0,321	
51	0,131	0,178	0,229	0,190	0,258	0,355	0,260	0,350	
54	0,139	0,186	0,238	0,204	0,273	0,368	0,270	0,404	
57	0,146	0,197	0,249	0,211	0,289	0,377	0,286		
60	0,154	0,204	0,262	0,221	0,308	0,408	0,304		
63	0,167	0,220	0,275	0,239	0,332		0,331		
66	0,178	0,232	0,286	0,260	0,351		0,363		
69	0,189	0,239	0,294	0,278	0,371		0,401		
72	0,200	0,256	0,313	0,290	0,388				
75	0,217	0,276	0,328	0,312	0,409				
78	0,227	0,288	0,362	0,329					
81	0,239	0,306	0,404	0,351					
84	0,253	0,321		0,373					
87	0,273	0,336		0,386					
90	0,293	0,361		0,406					
93	0,304	0,383							
96	0,325	0,402							
99	0,338								
102	0,354								
105	0,382								
108	0,408								

Lampiran Tabel

Hasil Pengukuran laju keausan pahat (V_B) pada Gerak Makan (f) Konstan

t (Menit)	V_B								
	f=0,035 mm/rev			f=0,070 mm/rev			f=0,140 mm/rev		
	30,14	46,16	67,82	30,14	46,16	67,82	30,14	46,16	67,82
0	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
3	0,010	0,011	0,021	0,020	0,025	0,037	0,032	0,033	0,052
6	0,019	0,027	0,034	0,032	0,044	0,062	0,053	0,072	0,094
9	0,022	0,035	0,048	0,042	0,056	0,074	0,072	0,087	0,114
12	0,029	0,049	0,068	0,059	0,080	0,103	0,086	0,114	0,151
15	0,042	0,067	0,084	0,068	0,096	0,117	0,110	0,137	0,167
18	0,049	0,081	0,106	0,074	0,113	0,142	0,121	0,149	0,185
21	0,055	0,090	0,127	0,089	0,134	0,156	0,138	0,184	0,201
24	0,064	0,108	0,149	0,094	0,144	0,184	0,147	0,195	0,233
27	0,069	0,113	0,157	0,098	0,162	0,199	0,153	0,207	0,245
30	0,077	0,125	0,173	0,108	0,167	0,227	0,165	0,227	0,273
33	0,086	0,132	0,184	0,118	0,188	0,238	0,177	0,247	0,312
36	0,091	0,144	0,198	0,123	0,195	0,257	0,190	0,259	0,350
39	0,099	0,157	0,213	0,136	0,208	0,269	0,198	0,277	0,403
42	0,108	0,169	0,225	0,148	0,226	0,282	0,204	0,287	
45	0,117	0,175	0,231	0,156	0,238	0,304	0,211	0,313	
48	0,124	0,185	0,249	0,161	0,249	0,321	0,221	0,328	
51	0,131	0,190	0,260	0,178	0,258	0,350	0,229	0,355	
54	0,139	0,204	0,270	0,186	0,273	0,404	0,238	0,368	
57	0,146	0,211	0,286	0,197	0,289		0,249		
60	0,154	0,221	0,304	0,204	0,308		0,262		
63	0,167	0,239	0,331	0,220	0,332		0,275		
66	0,178	0,260	0,363	0,232	0,351		0,286		
69	0,189	0,278	0,401	0,239	0,371		0,294		
72	0,200	0,290		0,256	0,388		0,313		
75	0,217	0,312		0,276	0,409		0,328		
78	0,227	0,329		0,288			0,362		
81	0,239	0,351		0,306			0,404		
84	0,253	0,373		0,321					
87	0,273	0,386		0,336					
90	0,293	0,406		0,361					
93	0,304			0,383					
96	0,325			0,402					
99	0,338								
102	0,354								
105	0,382								
108	0,408								

Lampiran Tabel

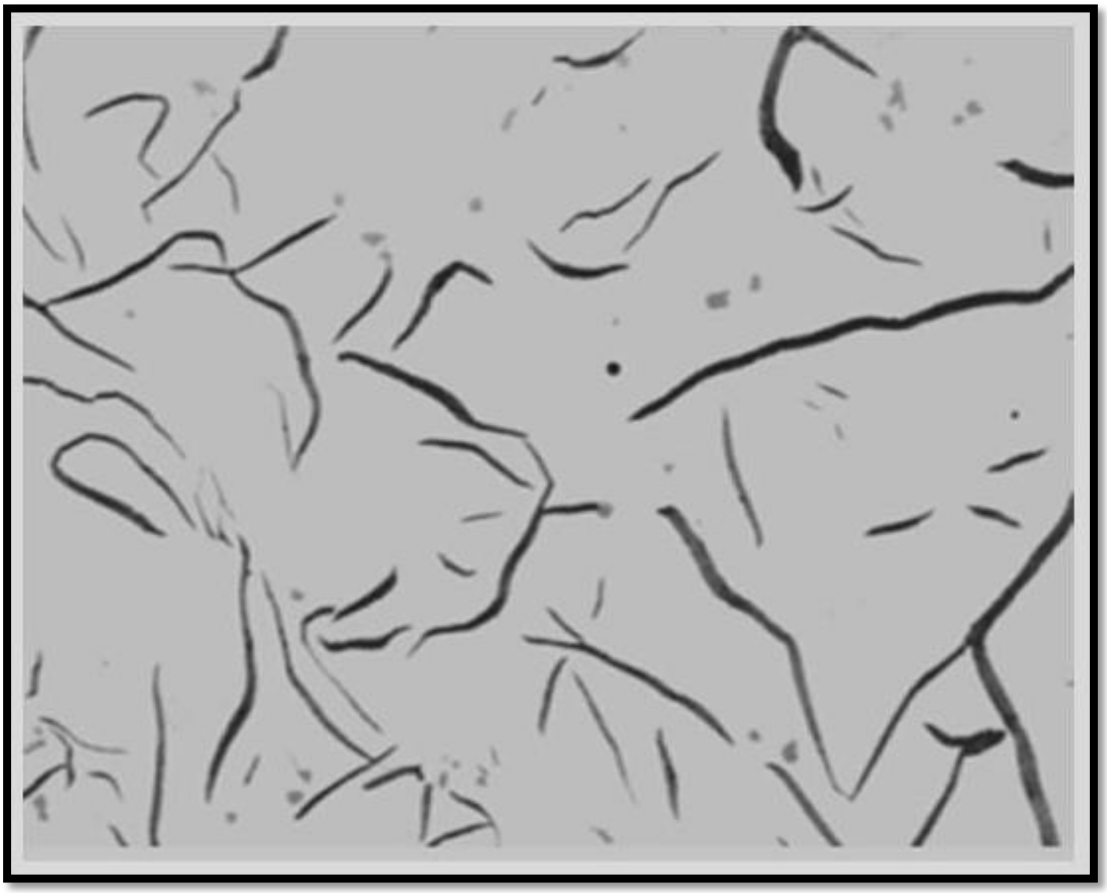
Karakterisasi Material Besi Cor Kelabu ASTM 40

Komposisi Kimia	C=2,7-4,0%; Mn=0,8%; Si=1,8-3,0%; S=0,07% P=0,2%
Densiti	$7{,}06x10^3$ - $7{,}34x10^3$ Kg/m^3
Mosulus Elastisitas	124 Gpa
Thermal Expansion (20^{o}C)	9,0 x 10^{-6} C^{-1}
Specific Heat Capacity (25^{o}C)	490 J/KgK
Konduktivitas Thermal	53,3 W/mK
Resistivitas Listrik	1,1 x 10^{-7} Ωm
Kekuatan Tarik	276 MPa
Elongasi	1%
Kekerasan	180-302 HB, Hardness Brinell

(sumber : https://ardra.biz/sain-teknologi/metalurgi/besi-cor-cast-iron/karakteristik-sifat-besi-tuang-cor-kelabu-gray-cast-iron/)

Lampiran

Hasil Foto Metalografi Struktur Mikro Besi Cor Kelabu



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L A M P I R A N

J U R N A L

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Tool Wear Analysis of Endmill Cutter Two Flute on the Cast Iron Perforation Process

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***Abstract*—This study aims to determine the effect of machining variables on the tools life of cutting tools Endmill two Flute from carbide materials in cast iron materials perforation process using milling machine. The research methode is exsperimental with machining parameter used Vc=46,16 m/minutes;Vc=46,16 m/minutes;f=0,070 mm/rev and f=0,14 mm/rev. After the machining process, measurement of tool wear is carried out every 30 seconds in the cast iron perforation process. Data obtained were assessed to determine tool life relationship with machining variables. Results of research showed that the greater the cutting speed the faster the time of tool wear occurs. Likewise, in the case of large feeding movements, the faster the time of tool wear occurs. From this research, the fastest wear is obtained at cutting speed Vc = 67.82 m/min and f=0.14 mm/rev which is 42 Minutes, while the longest wear time is obtained at cutting speed Vc = 46.16 m/min and f=0.070 mm/rev is 72 minutes**

***Keywords*—Tool Life,Tool Wear,Endmill Cutter,Cast Iron**

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I. INTRODUCTION

The milling machine is a tool that is used accurately to produce one or more surface workings using one or more cutting tools. The milling machine is also most capable of performing many tasks of all machine tools. Flat or curved surfaces can be done with special finishing and precision. Cutting corners, gaps, gears and niches can be done using various cutters.

In the metal machining process, tool life is influenced by tool cutting eye wear that occurs due to friction between the tool eye and the workpiece. This tool wear will increase to a certain extent, so the tool cannot be used anymore. The length of time to reach this wear limit is defined as the tool life.

The tool life is not only influenced by tool geometry, but al machining processes such as the ty orkpiece and tool, the cutting

conditions (cutting speed, depth of feed, feeding and feeding time) will also affect tool wear.

II. LITERATURE REVIEW

A. 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 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 [1].

B. 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 [2]. The criteria recommended by ISO 3685: 1993 to determine the effective tool life for carbides [2], high-speed steels (HSS) and ceramics are:

TABLE I. RECOMMENDED FOR FLANK WEAR SIZE VB_B ON MATERIAL CUTTING [2].

Tool Material		HSS	Comented Carbides	Carbides Coated
Operation	mm			
Roughing	VB_B	0,35-1.0	0,3-0,5	0,3-0,5
Finishing	VB_B	0,2-0,3	0,1-0,25	0,1-0,25

C. Cutting Parameters

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 [1]:

$$V_C = \frac{\pi d n}{1000} \qquad (1)$$

Where :

- Vc = Cutting Speed (m/minute)
- d = diameter of cutter (mm)
- n = spindle speed (rpm)

III. RESEARCH METHOD

A. Implementation

...ucted in May-June 2018 in the M... ...boratory of the Department of E... ...neering, Hasanuddin University.

B. Tools

- Endmill Cutter two flute

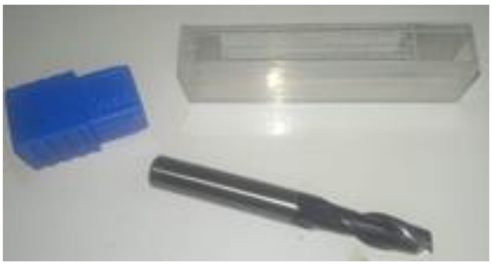


Fig. 1 Endmill Cutter two flute

- Digital Microscope

Fig. 2 Digital Microscope

C. Workpiece

The workpiece used in this study is a workpiece from Cast Iron material with a diameter of 76.20 mm and a length of 10 mm.

D. Variable

This study, the predetermined machining variables are as follows :

- Spindle speed = 2450 rpm and 3600 rpm
- Feed= 0.070 mm/rev and 0.140 mm/rev
- Endmill Cutter Diameter is 6 mm.

E. Data Collection

At this stage the perforation process will be carried out on a 10 mm long workpiece for each step of the work. after the steps are taken, measurement of the dimensions of the tool eye wear that occurs in the machining process is done using a digital microscope measuring device to obtain more accurate dimensions.

The measurement steps for tool wear dimensions are as follows:

- Microscope Calibration
- Measurement of tool wear with standard milling machine rotation speed to determine tool life length. The wear of the cutting eye with 0.4 mm in accordance with the existing literature study
- All measurement data is tabulated in the table

IV. Result and Discussion

A. Result

Based on predetermined parameters, the cutting speed (Vc) can be determined using (1) :

For n=2450 rpm, then Vc=46,16 m/minute

For n=3600 rpm, then Vc=67,82m/minute

Based on observations, the time needed to make 1 hole for each variable can be seen in the following table.

TABLE II. Time of Hole

n (rpm)	Vc (m/min)	t_f	
		f=0,070	f=0,140
2450	46,16	4	2
3600	67,82	2	1

Based on table II above, it can be seen that for cutting speeds of 46.16 m/min and feeding motion of 0.07 mm/rev, the milling machine takes 4 seconds to complete 1 hole in the workpiece, and for feeding motion 0.14 mm/rev takes 2 seconds per hole, while at a speed of 67.83 m/min, at a feeding motion of 0.07 mm/rev, the engine takes 2 seconds for each hole, and 1 second for each hole to feed 0,14 mm /rev.

Retrieval of endmill cutter wear data after tool carries out a perforation process for 0.5 minutes for each research variable.

The following is a table of results of the measurement of wear rate that occurs in the process of punching the workpiece.

TABLE III. Tool Wear Measurement Results

t (minute)	Vc=46,16 m/min		Vc=68,82 m/min	
	f=0,070	f=0,140	f=0,070	f=0,140
0	0,000	0,000	0,000	0,000
6	0,044	0,072	0,062	0,094
12	0,080	0,114	0,117	0,157
18	0,113	0,149	0,148	0,185
24	0,139	0,195	0,184	0,233
30	0,167	0,227	0,227	0,273
36	0,204	0,259	0,263	0,320
42	0,226	0,287	0,282	0,402
48	0,258	0,338	0,350	
54	0,293	0,408	0,406	
60	0,328			
66	0,351			
72	0,409			

B. Discussion

- Effect of cutting speed (Vc) on tool wear

In Figure 3 it can be seen that a significant reduction in tool life occurs when increasing the cutting speed constantly. This is because the higher the cutting speed, the friction between the tool and the workpiece will be greater so that the friction will result in a rising cutting temperature

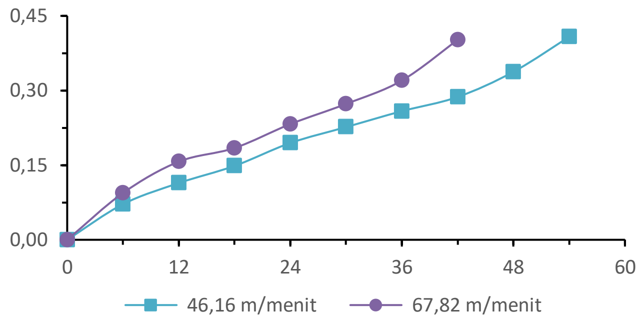


Fig. 3 Relationship of wear rate with cutting speed in feed motion (f) 0.14 mm/rev

.

As was done by Syafri and Yohanes, [3] with a study entitled determining age and analyzing HSS tool end mill wear at the MC-520 machining center the same as applying MQL and dry machining for high speed machining. The greater the cutting speed, the greater the friction between the tool and the workpiece so that the cutting temperature becomes high which causes the tool to experience faster wear

- Effect of feed Motion (f) on tool wear

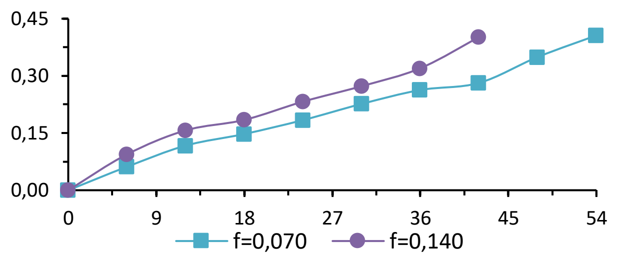
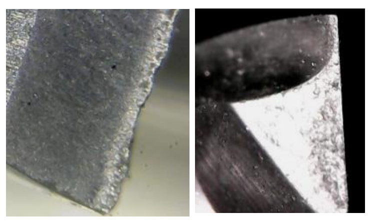


Fig. 4 Relation of Wear Rate and Infeed Motion (f) at cutting speed (Vc) 67.82 m/minute

In Figure 4 it can be seen that the reduction in tool life is shorter in lower feeding. This is due to the fact that when the feed is low, the cutting load is low, and the greater the feed movement, the greater the cutting load, causing the tool to wear out quickly. As done by Syafri and Yohanes, [3] that in addition to cutting speed, the parameters that affect tool wear are feeding motion. Because the greater the feed motion, the greater the cutting load, causing the tool to wear out quickly.

Figure 5 below is a photo of a wear endmill cutter type tool



(a) (b)

Fig. 5 Digital microscope image capture (a) Relief face; (b) Rake Angel face

V. CONCLUSION

Based on the results of the research that has been done about the effect of cutting speed on tool wear, the conclusions can be taken as follows:

- The highest chisel age was obtained at cutting speed of 46.16 m / min with a feeding motion of 0.070 mm/rev which was for 54 minutes, while the lowest tool life was at cutting speed 67.82 m/min with a feed motion of 0.14 mm/rev which was for 42 minutes (Table III).
- The greater the cutting speed (Vc), the faster the milling tool wear rate that occurs, which is caused by high temperatures as a result of friction between the tool and the workpiece
- The greater the feed motion (f) at a constant cutting speed, the faster the milling tool wear rate occurs, this is due to the difference in cutting load experienced for each level of feed motion.

REFERENCES

[1] N. Effiandi, Y. Yetri, And N. Nofriadi, "Kajian Korosi Pada Mesin Perkakas Akibat Perbandingan Coolant (Pendingin)Yang Tidak Seimbang," J. Tek. Mesin, Vol. 1, No. 1, Pp. 22–27, 2012.

[2] Z. Zainuddin, "Pengaruh Sudut Penyayatan Dan Jumlah Mata Sayat Endmill Cutter Terhadap Tingkat Kekasaran Permukaan Baja St 40 Hasil Pemesinan Cnc Milling Tosuro Kontrol Gsk 983 Ma-H," J. Nosel, Vol. 1, No. 4, 2013.

[3] Syafri dan Yohanes, 2008. Menentukan umur dan menganalisa keausan pahat HSS end mill pada machining center MC- 520 sama dengan mengaplikasikan MQL dan dry machining untuk high speed machining, Skripsi. Online

[4] Widarto, 2008. Teknik Pemesinan, Jakarta, Direktorat Pembinaan Sekolah Menengah Kejuruan

[5] Youssef, H., El-Hofy, Mahmoed H. Ahmed, 2011. Manufacturing Technology: Materials, Processes, And Equipment, CRC Press, United States

[6] Andriyansyah, 2013. Pengaruh parameter pemotongan terhadap kekasaran permukaan pada pengefraisan magnesium menggunakan vortextube cooler. Journal. Unila.