CHARACTERISATION OF ALOE VERA AS CUTTING FLUIDS

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Cutting fluids provide a challenge to reduce environmental effects. This study discusses aloe vera cutting fluid (AVCF) as an environmentally friendly alternative to oil-based cutting fluids mixed with water 1:5 (OBCFM). A turning process with low cutting speed (20.232 m/min) requires high cooling power. The turning process was conducted (cutting speed:20.232 m/minute, feed rate: 0.24 mm/rev, and cut depth: 1 mm)on a cast-iron workpiece with 44 HRC or Rockwell Hardness (diameter:28 mm and length;300 mm). The high-speed steel cutting tool with average hardness 67.25 HRC was tested via machining with a cutting time of 56.550 seconds, and the flank wear was measured(AVCF: 0.311 mm; OBCFM:0.284 mm; dry machining:0.576 mm). Flank wear of the cutting tool using AVCF is almost equivalent to that of cutting tools using OBCFM; thus, AVCF is an environmentally friendly cutting fluid compared to OBCFM.

KEYWORDS:

cutting fluids, aloe vera, turning process, flankwear

1 INTRODUCTION

The characteristics of cutting fluids regarding the turning process influence the environment. Currently, researchers have developed cutting-process technology and the use of vegetable oil as a cutting fluid.

Based on ASM, *machining* is a term that includes a manufacturing process designed to remove a piece of the material. The machining process will produce chips. The turning process is the removing some of the diameter and/or cylindrical metal to achieve the desired size by reducing the volume of the workpiece. The product results from the turning process are expected to fit the size and produce a smooth surface. To obtain a smooth surface, an important parameter to note is the tool wear. Tool wear can be observed from crater-wear and can also be from cutting-edge flank-wear of a cutting tool.

This study investigates the cutting-edge wear that occurs in the chip field ($A\gamma$) and on the principle tool ($A\alpha$) field as an effect of the use of cutting fluids. Experimental studies of environmentally friendly vegetable-based cutting fluids have also been newly developed, including sunflower oil and refined canola, where the cutting fluid is carried out in a longitudinal turning process with observed surface roughness, cutting force and tool wear; observations say that 8% of high-pressure additives in canola-based cutting fluid are better performance than other cutting fluids [Ozcelik 2011]. Efforts to address environmental concerns require renewable and biodegradable purification fluids. The bio-based cutting fluids, using a variety of vegetable oils, have undoubtedly improved machining performance, which has significantly reduced ecological problems caused by mineral cutting fluids, machining process of dry cutting, minimum quantity lubrication (MQL), and cryogenic cooling can be presented to minimize the amount of cutting fluid in the dry machining process which shows better results than the method of a wet machining process [Debnath 2014]. This research compared the performance of palm oil and peanut oil to mineral-oil cutting fluids during the machining process. The peanut oil has better fluidity and faster cooling capacity than other oils. The use of mineral-based cutting fluids shows a good microstructure, as well as the use of peanut-oil cutting fluids by obtaining a smooth surface morphology this means increased surface roughness compared to the use of other cutting fluids. Peanut oil and palm oil are recommended as viable alternative lubricants [Kolawole 2013]. The development of lubricants such as vegetable oil is proposed, and these have been tested as cooling fluids. It is possible to obtain coolant fluids with high lubrication, better thermal conductivity, and good environmental properties. The results of the tests using vegetable-based liquids show good performance and environmental properties on CBN grinding, which is comparable to those obtained with mineral oil [Alves 2008].

In Indonesia has also been investigated the application of vegetable oil-based cutting fluids, in the machining process has shown its advantages about the performance of cutting forces, workpiece surface results, tool wear and heat that occur. This vegetable-based cutter is also environmentally friendly [Lawal2011]. The use of conventional machining is questionable because of the adverse effects on the environment and human health. Therefore, the trend is directed to various alternatives, such as vegetable oil. Vegetable oil has good biodegradability and high lubrication, low toxicity and volatility, a high flash point and high viscosity index, and is environmentally friendly and compatible with additives. The experimental setting was performed 25 and 27 experiments with variance analysis used to evaluate the effect of roughness and flank wear on the cutting tool, an obtained surface roughness of 0.56 µm and 1.81 µm with Percentage Contribution Ratio (PCR) of 94.4%. [Shyha 2015]. Proposed an alternative approach in the cutting process by predicting the flank-wear process parameters to determine the kind of environmentally friendly cutting fluids.

The role of cutting speed, feeding, and depth of cut parameters in the Turning process will affect the size of the cutting temperature, this will affect the life of the cut and the roughness of the cut. If the cutting speed and depth of cut are increased then the cutting temperature will increase. This is because the higher cutting speed will increase the cutting force, the increased cutting force causes increased cutting power. And most cutting power is converted to heat through friction. Cutting fluid is used to lower the cutting temperature, as well as the lubricant during the cutting, takes place in the contact plane between the fur and the sculpting field, thus accelerating the discharge rate of the cutting heat and extending the life of the chisel. In the Turning process, the use of this cooling fluid will slow the process of heat, both on chisels and workpieces. Thus the use of cooling fluid can affect the wear rate of the chisel and also the roughness of surface results.

The selection of coolant fluids is very important because there are other considerations that are related to health and the environment. The cooling fluid in the Turning process, currently still uses chemicals whose effects on health and the environment are still not good. So it takes an alternative cooling fluid (Cutting Fluid) is not harmful to health and the environment. The researchers found the alternative is to use coolant from aloe vera plant (Aloe Vera). The largest composition of gel from aloe vera plants is water that is 99.20% and the rest is a solid consisting mainly of carbohydrates, namely mono and polysaccharides. Aloe vera gel polysaccharide consists primarily of glucomannan and a small amount of arabinan and galactan. The monosaccharides are D-glucose, D-mannose, arabinose, galactose and xylose (Setiabudi 2008).

2 RESULTS OF EXPERIMENT

Two types of cutting fluids are used. First, the Aloe Vera plant is peeled and the gel is taken, made into a liquid by way of juice and filtered, which then function as an aloe vera cutting fluid (AVCF). Aloe Vera is used as a cutting fluid with a heat coefficient of 99.919 W/m ·K and viscosity of 71,897 cSt. Second, the fluid oil used in the machining process has a heat coefficient value of 95.188 W/m ·Kand viscosity of 7.466 cSt, and further function as oil-based cutting fluid mixed with water 1:5 (OBCFM). The cast-iron workpiece has 44 HRC and tensile strength σ_u = 128.65 MPa with a diameter (D) = 28 mm and length (L) = 300 mm. The high-speed steel (HSS) cutting tool has an average hardness = 67.25 HRC with dimensions = 12x12x80 mm. The geometry of the cutting tool is as follows: side relief angle = 8°, side rake angle = 10°, side cutting edge angle = 14°, end cutting edge angle = 7°, end relief angle = 7°, and back rake angle = 10°. Machining with surface process using turning with spindle speed setting of 230 rpm and with specifications: Brand: ANN YANG MACHINERY co., ltd; Main Motor: 5.6 KW/380 V/50 Hz/3 PH; Model: DY-410X1000G
Made: Taichung, Taiwan.

2.1 Experimental Methods

Experimental setup involves three experiments: dry machining, wet machining with the oil-based cutting fluid mixed with water 1:5(OBCFM), and wet machining with the aloe vera cutting fluid (AVCF). The wet machining process requires cooling fluids and good lubricants. Aloe vera is a suitable alternative to other cutting fluids. Aloe vera juice is filtered as a cutting fluid with 80 mesh. The AVCF has cooler character, and the lubricant is sufficient according to the heat coefficient and viscosity tests. For fluid flow velocity at machining process is 0.568 $.10^{-3}m^3$/min and the performance test of the AVCF is performed using a turning process. The cutting time (T) was found to be 56.550 seconds with the following cutting parameters: feed rate (f) = 0.24 mm/rev, depth of cut (a) = 1 mm and cutting speed (v) = 20.232 m/minute. The cast-iron workpiece and the HSS cutting tool have parameters as listed above. Measurements of flank wear with a tool microscope were obtained for flank wear VB_{AVCF} = 0.311 mm and VB_{OBCFM} = 0.284 mm, which were measured as observation data.

2.2 Figures and tables

The experimental to obtain the heat coefficient of the cutting fluid can be seen in Fig. 1, It consists of series: thermocouple, ampere meter, voltmeter, and tube made of metal as the place of cutting fluid.

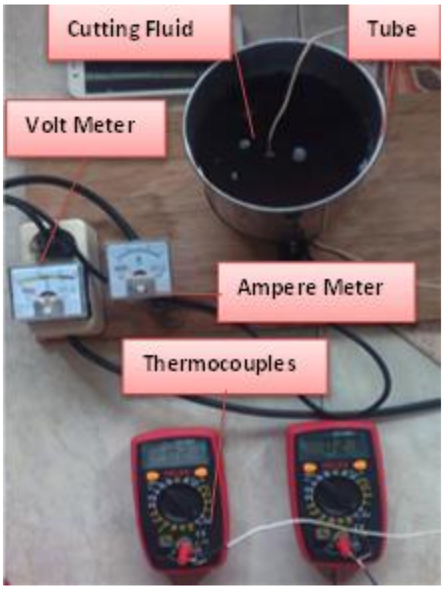

Figure 1. The measurement circuit of the heat coefficient value of OBCF, AVCF, and OBCFM

The experimental results are as follows. In Fig. 2, the value of the heat coefficient for OBCFM is 95.188 W/m ·K In Fig. 3, the value of the heat coefficient for OBCF is 90.203 W/m ·K, while Fig. 4, shows a heat coefficient value for AVCF of 99.919W/m ·K. The coefficient of heat in Fig. 2, is obtained from observations of the temperature when the heating element and OBCFM are heated for 1,171 seconds and stabilised, recording the data of temperature do any less is more 10 seconds, start condition up to 1,171 seconds. After obtaining the temperature data from the heating element and OBCFM, this was used to calculate the heat coefficient, and the coefficient of heat in Fig. 3,is obtained from observations of the temperature when the heating element and OBCF are heated for 2,444 seconds and stabilised, recording the data of temperature do any less is more 10 seconds, start condition up to 2,444 seconds. After obtaining the temperature data from the heating element and OBCF, this was used to calculate the heat coefficient, which is shown in Fig. 4. The observations are for 1100 seconds in which the temperature of the heating elements and AVCF are stable, and recording the data rise in temperature of any less over 10 seconds. The formula that is used follows:

$$h = \frac{q}{\Delta T} \tag{1}$$

where q is the amount of heat transferred (heat flux in W/m2; i.e., the thermal power per unit area, q= d/dA),h is the heat transfer coefficient W/m ·K), and ΔT is the difference in temperature between the solid surface and the surrounding fluid area in K.

It is used in calculating the heat transfer, typically by convection or phase transition between a fluid and a solid. The heat transfer coefficient has SI units in watts per square metre kelvin W/m ·K).

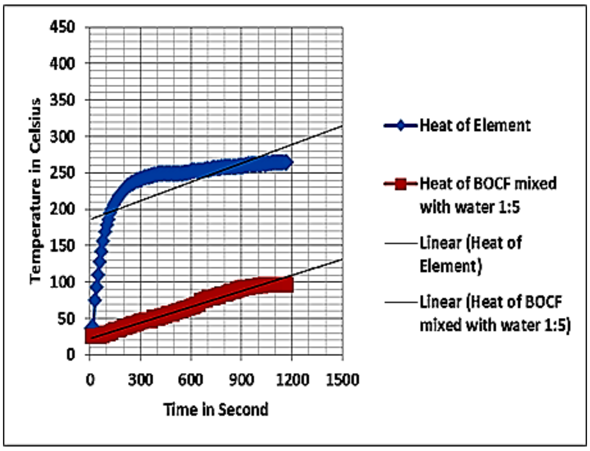

Figure 2. Relationship between time and temperature of OBCF mixed with water 1:5.

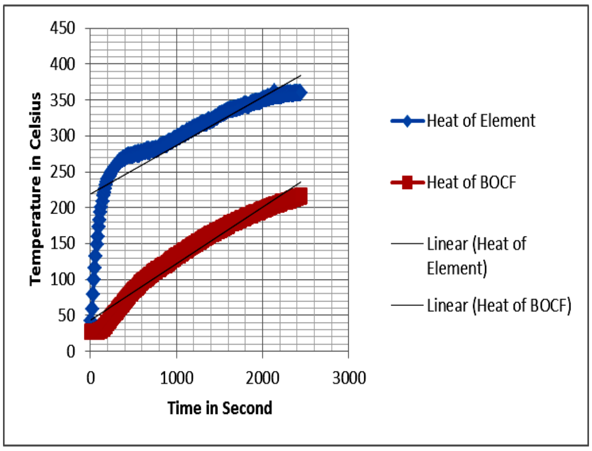

Figure 3. Relationship between time and temperature of oil-based cutting fluid.

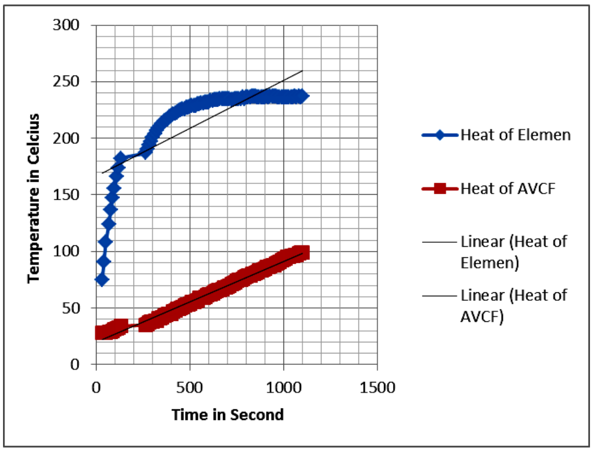

Figure 4. Relationship between time and temperature of AVCF.

In Fig. 5,the viscosity values are as follows: OBCF= 93.429 cSt filtered AVCF= 17.293 cSt, AVCF= 71,897 cSt, filtered AVCF with his skin= 8.805 cSt, and OBCFM = 7.466 cSt. In this study, the viscosity was an experimental review because the viscosity value influences the determination of the cutting parameter. The turning process uses a low cutting speed value because the cutting fluids have a high viscosity value.

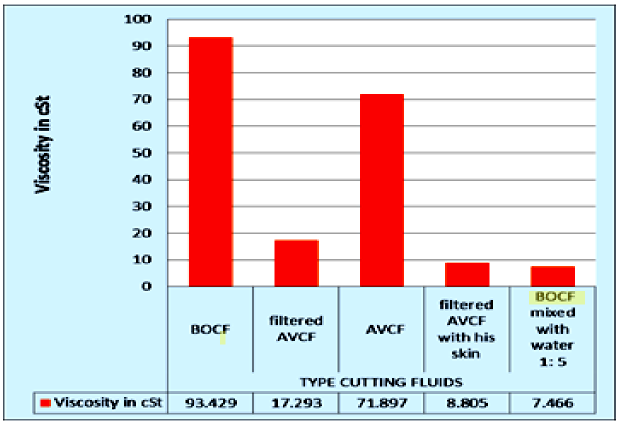

Figure 5. Viscosity value by type of cutting fluid.

Based on the measurement of flank wear according to Tab.1,the dry machining (VDM) process value was 0.576 mm, while the flank-wear (VB) value with OBCFM (VBOBCFM) was 0.284 mm, and the VB value with AVCF (VBAVCF) was 0.311 mm.

Dry Machining (DM)		Oil-based Cutting Fluidsmixed with water 1:5 (OBCFM)		Aloe Vera Cutting Fluids (AVCF)	
VB (mm)	T (second)	VB (mm)	T (second)	VB (mm)	T (second)
0.303	28.300	0.146	28.27	0.156	28.28
0.397	38.060	0.192	37.697	0.209	38.025
0.488	46.735	0.240	47.123	0.253	46.077
0.576	**56.550**	**0.284**	**56.550**	**0.311**	**56.550**

Table 1. Experiment data for a feed rate of 0.24 mm/rev, depth of cut of 1 mm, and cutting speed of 20.232 m/minute for cast-iron workpieces with diameter 28 mm and length 300 mm and a high-speed steel cutting tool with average hardness 67.25 HRC.

With statistical methods obtained, the mean value on the comparison of VBDM and VBOBCF Mis 0.226 mm. The standard deviation on the comparison of VBDM and VBOBCFM is 0.058. The value of T arithmetic on the ratio of VBDM and VBOBCFM is 6.751 is for T table = 5.841. This means there is a significant difference in flank wear from cutting tool.

For the mean value on the comparison of VBDM and VBAVCF is 0.209 mm. The standard deviation on the comparison of VBDM and VBAVCF is 0.052. The value of T arithmetic on the ratio of VBDM and VBAVCF is 6.960 is for T table = 5.841. This means there is a significant difference in flank wear from cutting tool.

For the mean value on the comparison of VBAVCF and VBOBCFM is 0.017 mm. The standard deviation on the comparison of VBAVCF and VBOBCFM is 0.007. The value of T arithmetic on the ratio of VBAVCF and VBOBCFM is 3.915 is for T table = 5.841. This means there is not a significant difference in flank wear from cutting tool.

for the level of significant value of the above mentioned three comparisons is given 1%

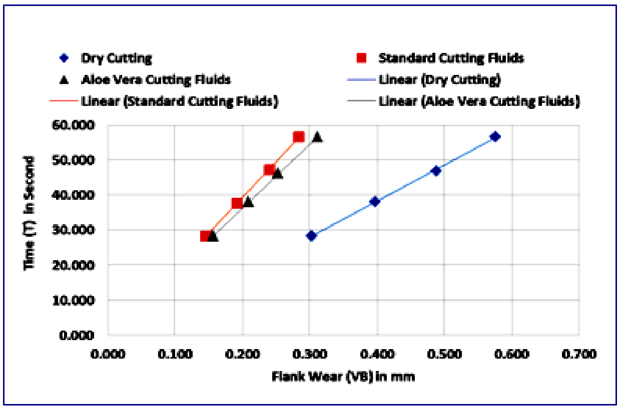

Figure 6. Flank wear with cutting time for dry machining: aloe vera cutting fluid (AVCF) and standard cutting fluids is oil-based cutting fluid mixed with water 1:5 (OBCFM).

In Fig.6, a different flank wear rate growth is caused by a noncutting fluid or dry machining, which results in high heat due to friction, while the machining using cutting fluid or wet machining will result in a slower flank wear growth rate than without the cutting fluid. This is because the heat may be reduced using the cutting fluid. The cutting fluid acts as a coolant in terms of its heat coefficient value and as a lubricant in terms of its viscosity value, which results in a flank wear of VBOBCFM = 0.284 mm and VBAVCF = 0.311 mm. The difference in flank wear that occurs between VBDM and VBOBCFM is 51%, between VBDM and VBAVCF is 46%, while between VOBCFM and VAVCF is 8.68%. This means that AVCF can be used as an environmentally friendly cutting fluid alternative to OBCFs.

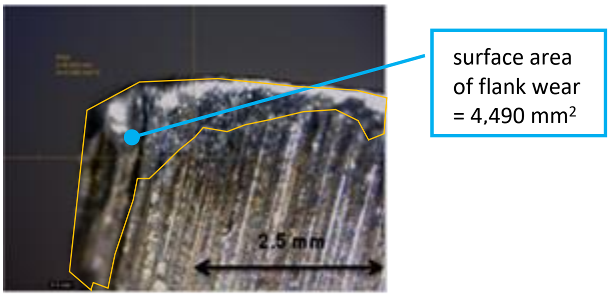

Figure 7. Image result of flank wear of oil-based cutting fluid mixed with water 1:5.(VOBCFM)

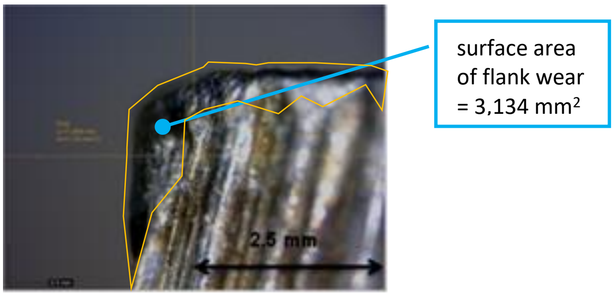

Figure 8. Image result of flank wear of aloe vera cutting fluid.(VOVCF)

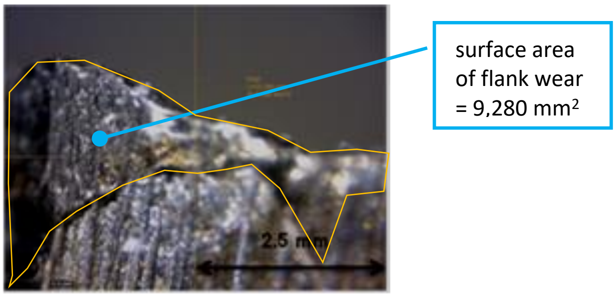

Figure 9. Image result of dry machining process (VDM).

In Figs. 7, 8, and 9, the images are magnified100x with a 0.5 mm image scale. The results of flank wear of a cutting tool in the process of machining that uses OBCF mixed with water 1:5 is has outside surface area = 4,490 mm^{2}shown in Fig.7. The result of the process of machining using AVCF on the cutting tool flank wear is has outside surface area = 3,134 mm^{2}shown in Fig.8. After the dry machining process, the flank wear on the cutting tool is has outside surface area = 9,280 mm^{2}shown in Fig.9. Measurements of flank wear with a tool microscope were obtained for flank wear (V_{DM} = 0.576 mm, VB_{AVCF} = 0.311 mm, and VB_{OBCFM} = 0.284 mm) with cutting time at 56.550 minutes.

3 CONCLUSIONS

The viscosity value is as follows: OBCF = 93.429 cSt, while AVCF is filtered with 80 mesh = 17.293 cSt, AVCF = 71.897 cSt, AVCF filtered with skin with 80 mesh = 8.805 cSt, and OBCFM = 7.466 cSt. In this study, viscosity is an experimental study because the value of viscosity affects the determination of cutting parameters. The turning process uses a low cutting speed value because the cutting fluid has a high viscosity value. Based on the measurement of flank-wear (VB) according to Table 1., the value of VB in the lathe process which does not use the cooling fluid (VBDM) is 0.576 mm with an area of 9.280 mm2, and VB with OBCFM 0.284 mm with an flank wear area of 4.490 mm2, and the value of VB with AVCF is 0.311 mm with an flank wear area of 3.134 mm2. The experimental cutting process using AVCF predicted its beneficial use as a cutting fluid. Regarding the results for VBAVCF and VBOBCFM, the difference in flank wear that occurs between VBDM and VBOBCFM is 51% with a ratio of percentage of flank wear area of 48.38%, and between VBDM and VAVCF is 46% with a ratio of percentage of flank wear area of 33.77%, while between VOBCFM and VAVCF is 8.68% with a ratio of percentage of flank wear area of 69.79%. Therefore, AVCF has a great potential as an environmentally friendly cutting fluid compared to OBCFs.

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