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Research Article

Investigating the performance of palm kernel oil coolant as an alternative to soluble oil coolant

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Abstract

The main purpose of this project is to investigate the performance of palm kernel oil application as a cutting fluid in (turning) machining operation. The developed cutting fluid from local materials will be compared with the soluble oil and this comparison will be made on the basis of surface finish of the work piece after machining using both cutting fluid. Mild steel materials will be used as work piece. Two work piece of equal materials (mild steel) with equal dimension will be turn on the conventional lathe using palm kernel oil prepared into cutting fluid as coolant in the turning of one of the work piece, and the soluble oil as the coolant use in turning the other work piece. The cutting parameters used were cutting speed 335rpm, feed rate 0.5mm/rev, and depth of cut is 0.5mm. All parameter tester tests are kept constant throughout the turning operations. Graphical representation of surface roughness value will be taken for each work piece which will show the surface roughness against cutting speed for palm kernel oil (PKO) cutting fluid, cutting surface roughness against cutting speed for soluble oil. The variation of the surface roundness of the work piece (mild steel) at different cutting speed palm kernel oil (PKO) coolant, also differentiating cutting speed for soluble oil coolant. Palm kernel oil performed very well the specific function of soluble oil as cutting fluid which include good chip formation, reduction of heat generation and realization of the a good surface finish. The surface roughness value of the work piece will increase with decrease in speed and vice-versa

Keywords: Palm Karnel Oil (PKO), Coolant, Mild steel, Soluble oil, Machining.

INTRODUCTION

The present scarcity of soluble oil necessitated the research into alternative raw materials as cutting fluids, which can be sourced locally. The need for a very high surface finish, high metal removal, total durability, and safety of the machinists is desirable in a machine shop. Coolant or lubricant are widely utilized to optimize the process of machining operations like turning, milling, boring, grinding, and drilling (Dilek *et al.,* 2001).

According to Lopez de Lacalle (2004). Cutting fluids carry away the heat in machining operations which can bring damage to the microstructure of metals. The metal removal rates can be increase by proper use of coolants.

During machining operation, friction between workpiece-cutting tool and cutting tool-chip interfaces result to high in temperature on cutting tool. Cooling and lubrication are important in reducing the severity of the contact processes at the cutting tool-workpiece interfaces. However, in the last decade a lot has been done aiming to restrict the use of cutting fluids in the production, due to the costs related to the fluids, ecological issues, and human health and so on (Heisel *et al.,* 1998; Kalhofer, 1997; Klocke *et al.,* 1997).

Corrosion of parts and machines and poor lubrication is a drawback in coolants. We require three elements such as oxygen, water and a metal surface susceptible for corrosion to occur.

Basically, this project will be conducted to compare the performance between soluble oil coolant with palm kernel oil coolant in turning operation and the performance is evaluated from the surface finish of the specimen machined.

The palm fruit looks like a plum. The outer fleshy mesocarp gives the PO, while the kernel, which is inside a hard shell (endocarp), gives the PKO and it is rather strange that the two oils from the same fruit are entirely different in fatty acid composition and properties. Unfortunately, the two oils had often been confused by nutritionists in earlier days. In PO, most of the fatty acids are C16 and higher, while in PKO, they are C14 and lower.

METHOD

Extraction of palm oil and palm kernel oils from the mesocarp and endocarp of oil palm

The fruits were separated from bunches and boiled for about an hour and crushed in a mortar to separate the pulp from the nuts. The oils were separated from the pulp by immersing the latter in water. The whole mass was stirred and the crude oil was skimmed off. The fibers were then sifted out of water and finally the nuts were collected and separated from the remaining fibers. The crude oil obtained was boiled in smaller vessels where any fiber still present sank to the bottom. The oil was decanted into a sterilized reagent bottle and used for the microbial tests without further purifications. The palm nuts obtained as a by-product in palm oil production were cracked to obtain the kernels. These were washed, dried and heated in a pot until the oil was extracted from the kernels and was decanted from the pot into a sterilized reagent bottle and used for microbial tests without further purifications as in palm oil extraction (Ekpa and Ebana, 1996).

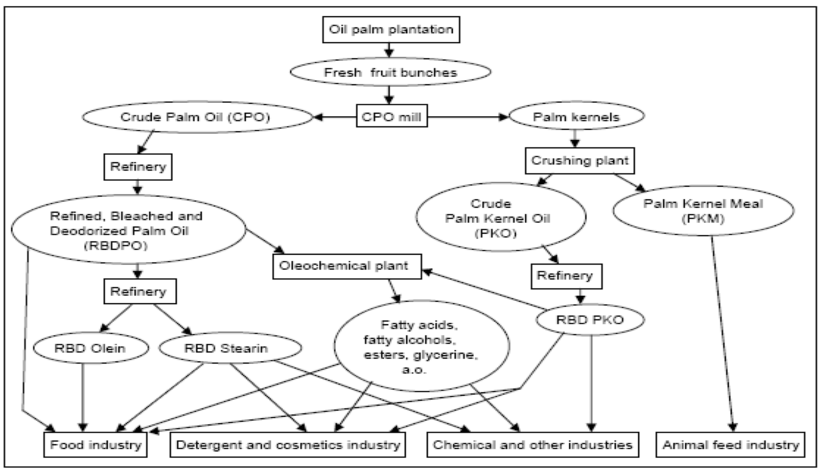

Figure 1. Overview of the oil palm production chain

Cutting fluid preparation

The oil sample that will be used in this work will be prepared into cutting fluid using the suggestions given by earlier researchers in this field (Ibhadode, 2001; Chapman, 1972).

In preparing the sample of cutting fluid, 50 ml of palm kernel oil will measured and mixed with water in oil to water ratio of 1:10 (Chapman, 1972). This mixture will be thereafter blended with at least 10% vol/vol ordinary soap, all at room temperature. The formulations are tabulated in table 1 below

The samples of cutting fluid that will be used for the experiments are labeled samples A and B and their fixed oil constituents are as follows:

Sample A: As purchased cutting fluid (soluble oil coolant)

Sample B: Palm kernel oil coolant

The cutting fluid developed has the following formula:

Table 1. Cutting fluid formula

Material	Function	Content(% volume/volume of fixed oil)
Palm Kernel Oil	Base oil(lubricant)	9
Washing soap	Emulsifier	1
Water	Solvent(coolant)	90

Performance test methods

The major test parameter that is used to investigate the performance of each of the cutting fluids is the surface roughness of the workpieces being machined, using the cutting fluids as coolants in the process.

Workpieces (mild steel) will be machined (turned) at constant feed rate (0.5mm/rev) and varying speeds. Five different speeds (76rpm, 150rpm, 240rpm, 305rpm and 600rpm) will be set on the lathe used. The workpieces will be turned at each of the different speeds and their surface roughness values will be read on the workpieces for each speed using a surface roughness tester (TR100).The surface roughness values will be read twice and then recorded for each speed and the averages values also calculated. This process will be carried out using the soluble oil coolant thereafter the palm kernel oil coolant.

Cooling Ability of Cutting Fluids

Aiming to classify the main cutting fluids based on their cooling ability, Sales (1999) developed a methodology which consisted in heating a standard workpiece and monitoring the cooling curve of it. This workpiece was fixed to the clutch of jigs and rotated at 150 rpm and its temperature was measured using an infrared sensor. The data acquisition started when the workpiece temperature reached 300°C and the measurement continued up to room temperature. Emulsions and synthetic fluids were applied using a concentration of 5%. Synthetic fluids are containing water and additives. The synthetic oil 1 is different from synthetic oil 2 due to small variations in their formulas (Sales *et al.,* 2001). Figure 2 shows the results of this experiment.

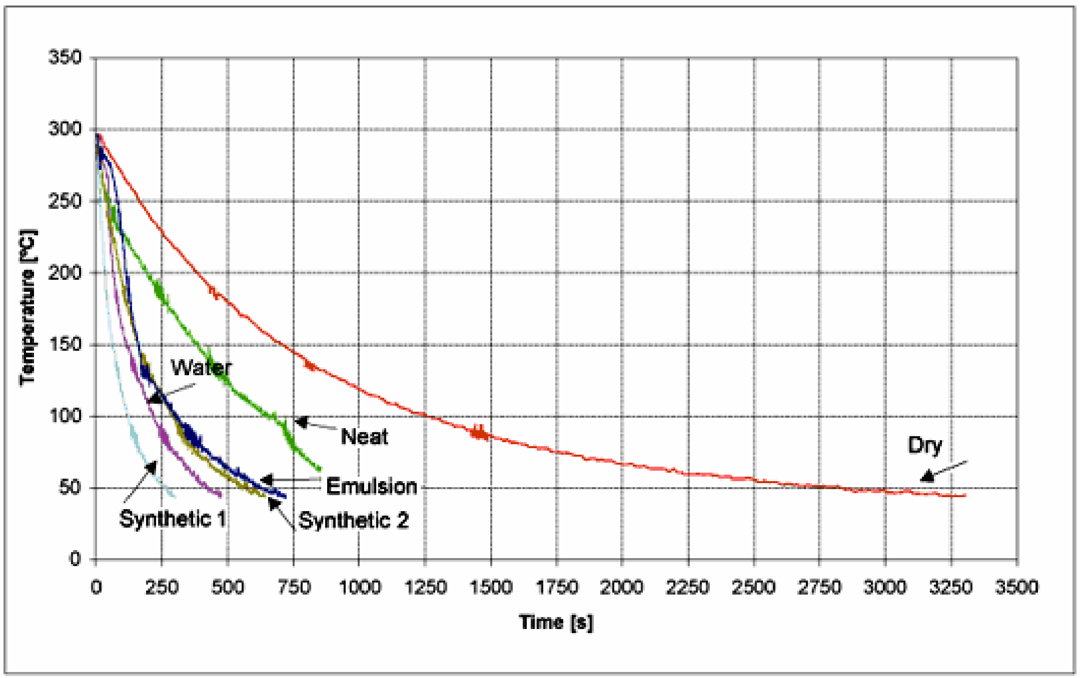

Figure 2. Cooling curves of all fluids experiment (Sales, 1999).

The cooling ability in crescent order is dry cutting, neat, oil emulsion, synthetic-2, water and synthetic-1. The fact that synthetic oil 1 presented a cooling ability greater than water, which theoretically has greater convection ability, was a surprise. A deeper analysis of the curves behavior in high temperature showed that water presented lower cooling ability even than synthetic oil 2 and neat oil (Sales *et al.,* 2001).

The explanation of these results may be found on the phenomenon occurring when a fluid like water, with low ebullition point (100°C), starts contacting a body in high temperatures. At this moment the quick heat transfer causes the liquid evaporation. This process reduces a little the hot body temperature, but the vapor forms a barrier preventing fresh volume of liquid, from reaching its surface and, therefore, decreases the heat transfer efficiency. Another important factor is the fluid wet ability, which is regularly higher for cutting fluids than for water. The higher wet ability of the cutting fluid implies in less splashing action and therefore a greater chance for heat exchange (Sales *et al.,* 2001).

RESULTS

The advantages, disadvantages and applications of each fluid are summarized below

Table 2. The advantages, disadvantages and applications

	Advantages	Disadvantages
Straight Oils	Excellent lubricity; good rust protection; good sump life; easy maintenance; rancid resistant.	Poor heat dissipation; increased risk of fire; limited to low-speed cutting operation.
Soluble Oils	Good lubrication; improved cooling capability; suitable for light and medium-duty operations involving a variety of ferrous and non ferrous applications.	More susceptible to rust problems, bacterial growth, tramp oil contamination and evaporation losses.
Synthetics	Excellent microbial control and rancid resistant; relatively nontoxic; superior cooling qualities; easy maintenance; relatively long service life; capable of handling heavy-day cutting operations.	Reduced lubricity; may cause misting, foaming and dermatitis; may emulsify tramp oil; easily contaminated by other machine fluids.

General functions of cutting fluids

1. Removing heat and reducing friction,
2. Washing away chips (especially in grinding and milling),
3. Reducing the temperature of the work-part for easier handling,
4. Reducing cutting forces and power
5. Improve dimensional stability of work-part
6. Prolong the life of the cutting tool
7. Reduction of labor costs (Tools life longer and require less regrinding, less downtime, reducing cost per part.

Benefits of cutting fluid

There are many benefits of cutting fluid or coolant application. Effective uses of coolants can (Senay, 2001):

Table 2. Benefit of cutting fluid

Improve Part Quality	The use of cutting fluids reduces friction and heat. The removal of the heat prevents the work piece form expanding during the machining operation, which would cause size variation as well as damage to the material's microstructure.
Reduce tooling costs	Proper use of cutting fluids increases tool life, which reduces the tooling costs. Increased tool life also reduces tool changes and downtime that decreases labor costs.
Increase Cutting Speeds and Feeds	Cutting tools reduce friction and heating a machining operation. This allows high speeds and feeds to be used to achieve optimal cutting conditions.
Improved Surface Finishes	Effective use of cutting fluids helps remove the chips. This prevents the chip from being caught between the tool and work piece where it causes scratches and a poor surface finish
Reduces Bacterial Growth	Bacteria can drastically affect cutting oils. Bacteria growth can turn a cutting fluid rancid. Additives in coolants help reduce the effects of bacteria but it is important that pure water is used for coolant mixing.
Rust and Corrosion Prevention	Cutting fluids should protect the tooling, machine and work piece against rust and corrosion. Cutting fluids should leave a small residual film that remains after the water has evaporated

CONCLUSION

Surface roughness value will be taken for each work piece through the surface roughness testing machine; this value will be represented in grapes and chart, which will show the surface roughness against cutting speed for soluble oil and palm kernel oil (PKO). The variation of surface roughness of the work piece (mild steel) at different cutting speed for palm kernel oil (PKO) coolant, also differentiating cutting speed for soluble oil coolant.
Palm kernel oil coolant is suitable in machining operation and also chipper in the aspect of cost since it was extracted from local source.

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