The Significant Study of using Vegetable Oil as a Cutting Lubricant on Conventional Lathe Machine

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Abstract. The occurrence of tool wear in machining is a natural phenomenon that cause failure. The deformation during cutting at the interface between the tool face and workpiece tends to generate high cutting temperature. The application of flood coolant to reduce the friction at the tool-work piece may create several environmental problems. The introduction of Minimum Quantity Lubrication (MQL) as an alternative technique which is the process of pulverizing a very small amount of oil (< 30ml/h) can be regarded as replacement of dry machining while it may also be considered as an alternative to flood cooling. The effect of vegetable oil lubricant and cutting speed on tool wear and surface integrity were the research scope. Three machine speed; 120, 141, and 174 m/min were used in the experimental setup on mild steel and carbon steel on work material using cemented carbide tools. The result of surface roughness and tool wear using canola oil mixing with 2 weight percent (wt%) of Zinc-diylkyl-dithio-phosphate (ZDDP) were compared against synthetic oil coolant. Comparison results show that canola oil mix can perform better compare to the synthetic oil coolant in term of surface finish. From tool wear perspective, canola oil mix show 26.5% smaller area compare to the synthetic oil coolant.

1. Introduction
The interface during machining process between tool bit and the work piece tends to create high cutting temperature. At this point the cutting liquid/coolant or cutting oil take part in the machining procedure. The present of cutting fluid or coolant is to decrease the cutting temperature and friction, additionally to facilitate the removal of the chip introduce during the process and also improving surface finish. Flood distribution is a normal method to cool down the work material. This method typically consumes large volumes of cutting fluid at low velocity and with huge volume of cutting fluid used will rise an environment issue towards global [1]. Improper handling of cutting fluids may damage soil and water resources which will cause a huge loss to the environment, besides that for companies, the expenses related to cutting fluids represent a large amount of the total machining costs [2]. Thus MQL was introduced to overcome this issue. In this method, the lubricant used in the form of spray and aerosols is subjected to high thermal and mechanical loads. It is highly important to ensure non-toxic and harmless lubricants are used in MQL [3].

The cutting liquid or coolant that widely used in machining industry had cause some environmental concern such as harming the soil and water contamination when using coolant. Every year, for European Union alone using roughly 320,000 tons MWF (Metal Working Fluid), no less than 66% should be disposed and it is expanding a years by years due to high request of the machining process [4]. Research study on dry machining and (MQL) minimum quantity lubrication found that utilization of cutting
lubricant gravely impacts nature and human wellbeing both during usage and transferred [5]. MQL is introduced by manufacture to overcome the cutting lubricant used in the industry, which is a low amount of lubricant strategy contrasted with the coursed oil method technique with emulsions. Usually the type of cutting lubricant used in MQL is biodegradable oil that not harmful to the environment. This implies utilizing clean oils that are fatty alcohol or ester based [6]. This shows that the synthetic cutting lubricant is not guarantee that is safe to environment or human.

Cutting fluids have been utilized as a part of machining procedures to diminish the temperature during machining by splashing the coolant into the machining zone straight forwardly on the cutting tool and the part, however the amount used of the lubricant due to the toxic content is worrisome [7]. Thus, achieving sustainable manufacturing are priorities and the possible solution in this problem are dry machining. But due to huge capital investment on dry machining method will not be cost effective solution. Cutting fluid are unpredictable in their composition which may lead to other issues. Microbial poisons are likewise produced by microscopic organisms and growths exhibit, especially in water-solvent cutting liquids [8]. The toxins and bacteria can cause harmful to the user in long term period. Regular contact with the lubricant would increase the probability of getting affected to the bacteria and lead to other discomfort. However, in this study canola oil that been used in cooking will be used as cutting lubricant in a machining process using conventional lathe machine. The vegetable oil has become frequent option to be used as cutting lubricant in most of the industry. Vegetable oil innovation has been appeared to convey extensive headways in profitability and longer tool life. Utilizing vegetable oil-based coolants amid machining can accomplish surface completions and dimensional resistances with agreeable edges [9]. The purpose of this study is to investigate whether the alternative environmentally friendly lubricant that replace cutting fluid will affect surface roughness and tool wear.

Tool wear has a great impact to tooling expense and part quality due to contact among tool and work piece or between the tool and chip. Flank wear which is one of tool wear affected the surface roughness of the machined material by using MQL with the present strategy has reduce flank wear and thus able to enhance instrument life [7], [10]. For work material, mild steel and carbon steel will be used to compare the level of surface roughness and tool wear. Mild steel is a standout among the most adaptable, versatile and imperative materials. It is widely used due to from its great structure and mechanical properties, and flexibility [11], [12].

2. Methodology
This study consists of 4 stages that involved to investigate whether the vegetable oil will give any positive result to this study. The study starts with selection of vegetable oil. The canola oil was selected based on several literature review that had been done related to this study.

2.1. Experimental Setup
In this experiment cemented carbide had been used. Cemented carbide is quite a common tool bit used that been used in the industry. This experiment only focuses on single type of tool against the vegetable oil coolant and the synthetic coolant to identify the tool wear. Four faces tool bit of cemented carbide had been used in this experiment for both vegetable oil and synthetic coolant; two sides for the vegetable oil coolant and other two side for the synthetic coolant. The usage of these tool bit side is divided as according to Figure 1 and Table 1.

In this stage, the conventional lathe machine parameter will be set into the parameter that assigned. The original mild steel diameter is 50 mm. During the facing process the mild steel and carbon steel work material had been machined to 30mm diameter. Turning process were machined on mild steel and carbon steel become from 100 mm to35 mm length. The process had been repeated three times on mild steel and carbon steel for each parameter in Table 2.
After the experiment complete, two tests had been done on the work material and cemented carbide tool; surface roughness and tool wear test.

3. Result and Discussion
This section presents obtained results and following by discussion.

3.1. Surface Roughness Test
Surface roughness test has been accomplished by using Mitutoyo Surftest SJ-401 to determine the smoothness of the surface of the part after being machined using same tool bit with different type of lubricant. Below is the result and the comparison of mild steel that are being machined with synthetic and canola oil.
Figure 2 and Figure 3 show that canola oil + 2 wt % ZDDP can perform better than the synthetic oil coolant. This shows that canola oil can perform better compared to the synthetic oil coolant in terms of surface finish. Even though the difference is small between these two coolants, overall, canola oil can perform as good as synthetic oil coolant for machining purposes. Based on Figure 3, the greatest surface finish is achieved at 174 m/min with a value of 4.697 μm on carbon steel work material. While the value of surface roughness on mild steel work material, obtained at 174 m/min with a value of 2.990 μm. Theoretically, every machining process with high spindle speed can get a good surface finish compared to the slow one. But in terms of coolant that is used in machining processes, canola oil + 2 wt % ZDDP can get a smoother surface finish compared to the synthetic oil coolant.

3.2. Tool Wear

Tool wear is a regular occurrence in a cutting tool after going through a machining process. Tool wear conditions are formed due to the distribution of stress. Tool wear usually appears due to the friction between a cutting tool area and the workpiece material itself. Tool wear can be measured using a tool wear tester, and for this study, an optical microscope Nikon Measuring Microscope MM-800 with high specification was used to obtain the wear of cemented carbide cutting tool.

Figure 4 shows the tool wear area.
Material: Carbon Steel  
Type of oil: Synthetic oil coolant  
Area of wear (mm x mm): 1.8762 mm²  
Length: 13.6112 mm

Material: Carbon Steel  
Type of oil: Canola Oil + 2 wt % ZDDP  
Area of wear (mm x mm) = 1.1834 mm²  
Length = 9.2743 mm

**Figure 4. Tool wear area (cont.)**

The result in Figure 4 shows the area of wear for canola oil + 2 wt % ZDDP have lower area of wear compared to the synthetic oil coolant. This indicate that the usage of coolant also plays a major role to ensure long lasting tool life. Canola oil + 2 wt % ZDDP have about 26.5 % smaller area of wear compared to the synthetic oil coolant. This proves that additives such as ZDDP able to prolong the tool life with the ability to reduce tool wear. As for carbon steel, Figure 5 also shows that canola oil + 2 wt % ZDDP have lower area of wear compared to the synthetic coolant oil. Canola oil + 2 wt % ZDDP is 69.3 % lower than synthetic oil coolant wear.

**Figure 5. Comparison of area tool wear**

Figure 5 indicate that the lowest area of wear can be obtained when using mild steel as the material and canola oil + 2 wt % ZDDP as the cutting lubricant to perform the machining process. This is due to mechanical properties of mild steel that is less stiff compared to carbon steel. That is why the tool wear on carbon steel is larger than mild steel. Overall, canola oil + 2 wt % ZDDP can perform better in tool life. Cutting lubricant used in the machining process plays an important in tool life period beside the set feed rate. In this experiment, feed rate and depth of cut are constant variable which is 0.1 mm/rev for feed rate and 1 mm for depth of cut but cutting conditions and machining parameter will also influence the output. The cutting contact level stress also could be the reason of the reduced area of wear.
4. Conclusion
This paper has presented the minimum quantity lubrication method as an alternative technique of dry machining which using very small amount of oil using vegetable oil lubricant. From the results, it can be concluded that canola oil mix can perform better compare to synthetic oil coolant in term of surface finish, but from tool wear perspective, canola oil mix show 26.5% smaller area compare to synthetic oil coolant.

Acknowledgement
Authors gratefully acknowledge the support of Universiti Teknikal Malaysia Melaka through Short Term Grant PJP/2018/FTK (14D)/S01640.

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