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Experimental research to investigate the performance of bio coolant when turning of mild carbon steel

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Abstract. Some literatures have been reported that the using bio coolant show better lubricating and cooling performances and reduce the occupational health risks associated with petroleum-oil-based coolant since they have lower toxicity. This paper investigates the effect the cutting conditions on the surface roughness through turning of mild carbon steel using dry, coolant and bio coolant. Measurement of surface roughness was conducted and then compared with the change of the cutting conditions. The relationship between surface roughness and cutting conditions was created in a curve for different of the cutting speed and coolant. The results indicate that the surface roughness was reduced when the speed of cutting is set to the highest level for all of coolant conditions (dry, coolant, and bio coolant) and constant of DOC and feed. The surface roughness had better performance using bio coolant than coolant conventional (mineral fluid).

1. Introduction

Nowadays, competitions in manufacturing industries continue to grow. In order to survive, the manufacturing industry should strive to have run its operations effectively and efficiently. Besides, it also consumer awareness of the importance of product quality also improved. The manufacturing industry had to maintain the quality of their products to fit the needs of consumers. Environmental issues (environment) as well as the safety and well-being are also factors that affect business activity. Increasing public awareness of environmental issues, safety, and health and government regulation caused the manufacturing industry will conduct its operations with due regard to environmental factors, occupational safety and occupational health.

AISI 1018 mild carbon steel has excellent weldability and produces uniform. AISI 1018 mild carbon steel offers a good balance of toughness, strength and ductility. Equipped with high mechanical properties, AISI 1018 hot rolled steel also include improved machining characteristics.

Special manufacturing controls used for surface preparation, chemical composition, rolling and heating processes. All these processes develop the highest quality products suitable for fabrication processes such as welding, forging, drilling, machining, cold drawing and heat treating.

Machining process was an important process in manufacturing industries [1]. Machining process was useful for removing unwanted material from the workpiece. Precise machining parameters needed to make the machining process implemented efficiently and effectively and to produce a quality product. One of the important parameters in the machining process is the use of cutting fluid. Machining process was resulting in high temperature that caused by friction between the cutting tool



and workpiece. It was affect the dimension and surface machined. The high temperature in machining could be minimized by using a coolant.

Coolant and lubricants are usually employed in machining operations, including turning milling, drilling or grinding. The increased concern for environment and sustainability are pushing industry towards the new concept of sustainable production [2,3]. The use of liquid cooling was a simple way which can be used as coolant and lubricant. On the other hand, the use of coolant can cause environmental pollution and water for disposal [4,5]. Today, the using petroleum-oil based coolant is being debated for reasons of economy, health, and environment. Bio coolant and minimum quantity coolant have great potential, although still usage limited. Minimum quantity coolant has been used widely in the literature [6-9].

The researcher of Technical University of Denmark was stated that the use of bio coolant (e.g. vegetable oil) produce a better performance than other coolant [10]. The surface roughness is one of essential requirements to be considered in machining parts by customer [11]. This paper presents the influence speed of cutting and bio coolant on surface roughness.

The main goal of this experimental is to investigate the effect of the quantity of cutting fluid in turning of mild carbon steel under method of dry and wet (oil coolant and bio coolant). Other objective is to compare the parameters like workpiece quality of the machined surface under dry method and flood coolant method.

2. Bio coolant

Bio coolant, also known as bio-based coolant or bio-lubricants, are made from a variety of vegetable oils, such as rapeseed, canola, sunflower, soybean, palm, and coconut oils. The best application for bio coolants is in machinery that loses oil directly into the environment during use, and in machinery used in any sensitive areas, such as in or near water. Compared to petroleum-based coolant, use of bio coolant:

- Produces a cleaner, less toxic work;
- Environment and fewer skin problems for those working with machining;
- Offers better safety due to higher;
- Highly biodegradable;
- Costs less over the product's life-cycle;
- Due to less maintenance, storage and disposal requirements.

The increasing demand for biodegradable materials has opened the way for the use of vegetable oils as an alternative to petroleum-based ingredients polymer [12,13], especially in the operation of the machine. Awareness of the community on environmental issues has been continually evolving [14]. Vegetable-oils, especially canola [15] and rapeseed [16] are some of the more hopefully candidate as a base material for lubricants. They are more easily biodegradable and less expensive than synthetic base stocks. They frequently perform quite acceptable as a lubricant [17].

3. Experimental design

3.1. Cutting tools and materials

This paper was based on the experimental data which to assess the surface roughness in turning process. Machining tests were performed on a PL1000G lathe machine with 10kW of horse power and 7000 rpm of maximum speed. The cutting tool was ceramic insert (Sandvik) which the cutting parameters are shown in Table 1.

The material of experimental trials was AISI 1018 mild carbon steel round bar with 100 mm of diameter and 300 mm of length. The composition of AISI 1018 is shown in Table 2.

Table 1. The cutting parameters detailed

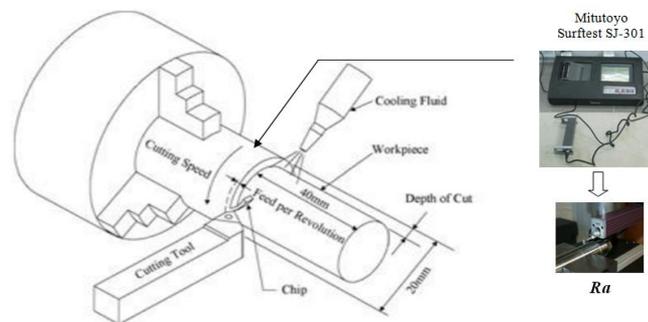
Parameters	Values
Speed of cutting (rpm)	500, 550, 700, 840, and 910
Depth of cut (mm)	0.5
Feed (mm/rev)	0.07
Coolant	Dry, Coolant and Bio Coolant

Table 2. The chemical composition of AISI 1018

Items	Composition
Carbon (C)	0.14 – 0.20 %
Iron (Fe)	98.81 – 99.26 %
Manganese (Mn)	0.60 – 0.90 %
Phosphorous (P)	≤ 0.04 %
Sulfur (S)	≤ 0.05 %

3.2. Experimental setup

The schematic of the experimental setup is shown in Fig.1. A Mitutoyo surface tester 301 was used to measure the surface machined for each turning test.

**Figure 1.** The schematic of experimental setup.

4. Results and discussion

Surface finish produced during machining has a direct impact on the condition of the tool. As the tool condition deteriorates, the surface roughness increases. It is accepted fact that the feed rate has a direct bearing on the surface finish of the machined work surface.

The value of the experimental surface roughness parameters was gained by stylus instrument and can be calculated theoretically, contemplating only the geometric component. The following equations [18, 19] can be used for the calculus of theoretical surface roughness parameters (R_a and R_t) in μm :

$$R_a = \frac{f^2}{32r} \times 1000 \quad (1)$$

$$R_t = \frac{f^2}{8r} \times 1000 \quad (2)$$

The experiment of turning on mild carbon steel shows that the surface roughness tends to decrease for higher speed of cutting. It can be shown in Fig.2 which shows that the surface roughness was proportional to speed of cutting also for using the coolant and bio coolant.

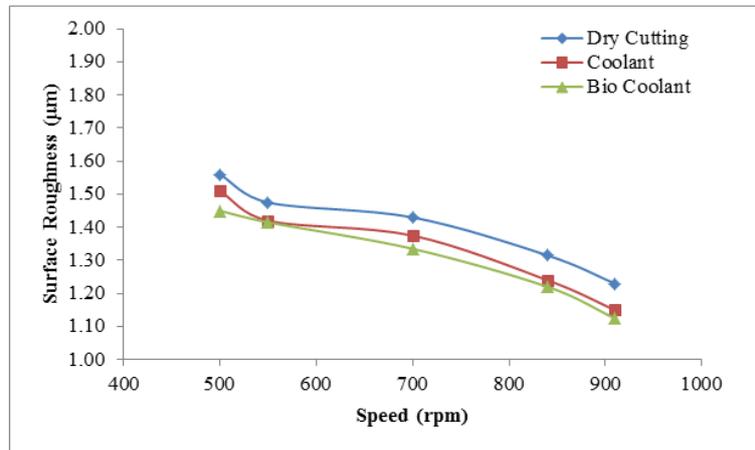


Figure 2. The graph of surface machined for different speed at feed of 0.07 mm/rev.

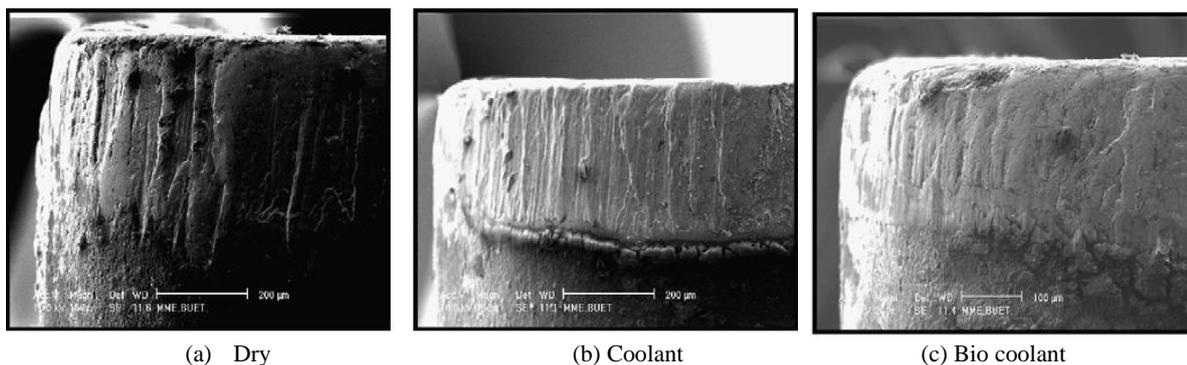


Figure 3. The SEM views of flank wear after turning under dry, coolant and bio coolant at feed of 0.07 mm/rev

The decrease of surface roughness was affected by the use of coolant for the increasing speed. This result was confirmed by Xavior and Adithan in their investigation, which stated that coconut oil had greatest effect on the surface roughness and tool wear than compared to conventional mineral oil when turning of AISI 304 austenitic stainless steel with carbide tool [20]. Krishna *et al.* studied the performance of SAE-40 and coconut oil when turning of AISI 1040 steel using cemented carbide [21]. It was reported that surface roughness initially minimized and then increased with increase in cutting speed at all the lubricating conditions and increased with increase in feed rate. They concluded that surface roughness decreased significantly with coconut oil-based nano-particle suspensions showed better performance compared to SAE-40. Another investigation was by confirmed by Nur *et al.* with different result. They present that surface roughness was only affected by changes in feed rate [22]. Sahin and Motorcu stated that the feed rate was main affecting factor on the surface roughness during turning of mild steel with coated carbide tools [23].

5. Conclusion

Lubricant and coolant are essential in minimizing the severity of processing contact between cutting tool and workpiece. Historically, the use of water was the main cooling materials due to the high of

thermal capability and availability [24,25]. The aim of this investigation was to study the turning of mild carbon steel using coolant, bio coolant and dry coolant for the surface roughness as resulting performance. It concluded that bio coolant had better performance in surface roughness than compared to conventional mineral oil and dry coolant. The increment of speed will be decrease the surface roughness for all of coolant conditions.

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