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Experimental Investigation on the Performance of Soyabean Oil and Blassocut-4000 during Turning of AISI 4130 in terms of Cutting Forces

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ABSTRACT

Cutting fluids used in machining process act as a coolant as well as lubricant. However these cutting fluids are environment unfriendly, toxic and costly. They may create several ecological problems such as polluting the water resources, damaging the soils. Now a days efforts were made to completely eliminate the poisonous fluids .In this regards interest in vegetable oil is growing. Combination of MQL and vegetable based cutting fluids can be used to improve the productivity and avoid environmental effect. This paper focuses on development of low cost, simple MQL system and to evaluate performance of vegetable oil based on cutting forces, temperature. The experimental results show that vegetable oil outperforms the mineral based fluid.

Keywords: MQL, Vegetable Oil, Turning

I. INTRODUCTION

High speed machining escalates temperature of the cutting tool and work surface. This high cutting forces results into increased temperature, tool wear and decreased tool life. It also affects the product quality. To reduce the undesirable effect of the heat, friction on the tool and work piece, cutting fluids are used. Generally cutting fluids with mineral oil base are used. These mineral based cutting fluids may damage the soil and contaminate water resources, causing serious environmental impact. The operator may suffer from skin and respiratory diseases. The cutting fluids may be allergic as well as toxic. Environmental issues are now discussed at international levels and it is obligatory for each country to keep the pollution level below certain limit. [1] [2].

Due to high frictional forces, temperature, poor surface quality, ecological concern and government regulations, enormous efforts are made to reduce the petroleum based cutting fluids.,Dry cutting (no cutting fluid) is one of the alternatives but increased wear rate, elevated temperature is major concern. Minimum Quantity Lubrication is emerged as substitute for dry machining and flood cutting. MQL uses very small amount of cutting fluid (50 ml to 500ml per hour) which is very low than conventional flood lubrication system (1liter to 10liter per min).MQL consist of mixture of high pressure air and cutting fluid applied directly into the interface of cutting tool and work piece. It works on the principle that droplet of the liquid is atomized by high pressure air flow distributed and moved in the direction of air flow. [3][4]. Vegetable oils are plant based agricultural product. They are renewable, biodegradable and non-hazardous. They possess high viscosity, boiling point and flash point. Vegetable oil consists of triglyceride i.e. tri esters of the long chain of the fatty acid. The triglyceride structure of the vegetable oil provides desirable quality of the boundary lubrication and high viscosity. Since vegetable oil has long heavy dipolar molecule that gives strong and homogeneous film. Vegetable oils are, thus considered as feasible alternative to mineral-based cutting fluids. Performance of soyabean oil is compared with mineral based oil Blassocut-4000 in terms of cutting forces.

II. METHODS AND MATERIAL

Literature Review

Dry cutting is one of the alternatives to flood cutting but not proved as solution to reduce the cutting fluid use. Minimum Quantity Lubrication or near dry machining

has been considered as substitute to flood lubrication and dry machining. As per to the U.S. Occupational Safety and Health Administration (OSHA) and the U.S. National Institute for Occupational Safety and Health (NIOSH), only 5 mg/m³ and 0.5 mg/m³ of metal working fluid is permissible for exposure during use of cutting fluid. [2]Uwe Heisel et al (1994) gave brief idea about applications of minimum quantity cooling systems in machining. [3] F. Klocke et al (1997) discussed the most recent developments in dry cutting. [4].Varadarajan et al (1999) proved that overall MQL has superior performance than dry, wet cutting in terms of cutting temperature, and cutting forces while tool life, surface finish. [5]According to K.Weinert and I. Inasaki et al (2004), dry machining operations, needs to be scrutinized properly due to higher temperature issues. Authors were of the opinion that MQL system is not yet used in industrial application but different research activities might results into extensive use of this technique. [6] S.A. Lawal et al (2012) reviewed, the applicability of vegetable oil-based metalworking fluids in machining of ferrous metals.[7] The performance of vegetable oil was different for different type of steel. N.R.Dhar, M.W.Isalm and team (2007) performed experimental investigations to find effect of MQL on cutting temperature, chip formation and product quality during turning of AISI-1040 [8]Babatunde Lawal a et al (2008) assessed lubricants like black soap, ground nut oil, palm kernel oil, red palm oil and shea butter oil. [9] According to M.M.A. Khan, M.A.H. Mithu, N.R. Dhar, (2009) determined effect of MQL by vegetable oil on low alloy steel AISI 9310.[10]]

All the studies highlighted the advantages of using MQL in machining processes under different lubricants. However, MQL system using vegetable oil as cutting fluid is still an innovative investigation area that needs to be explored.

Testing is conducted on AISI 4130 MS bar of 60 mm diameter. Carbide tipped single point cutting tool is used for the investigation. Blassocut-4000 and soyabean oil are used as cutting fluid during MQL cutting. Cutting forces are measured with the help of lathe tool dynamometer.

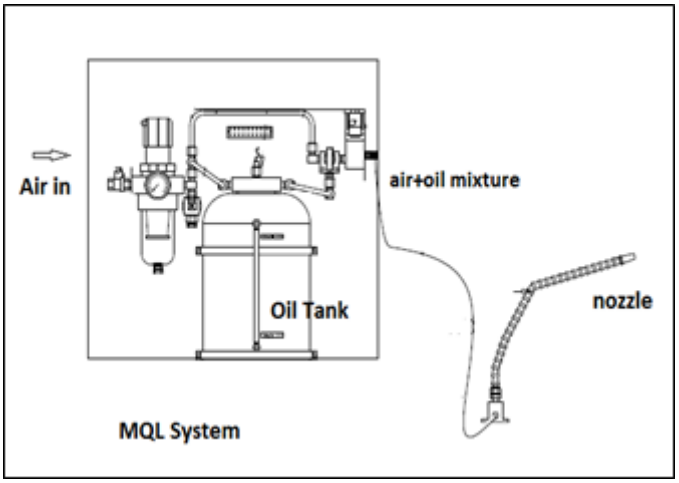

Figure 1. MQL System

MQL system works on siphoning principle. It consist of medium capacity air compressor, oil tank, air filter regulator, Siphon tube with Suction strainer, Oil Control Valve, Coolant Pipe, Air Pressure control valve and Nozzle etc. MQL system designed is cost effective so that small scale industry can afford it.Table 1 gives details of the experimental condition, and selected machining parameter.

Table 1. Experimental Condition

Expt. Condition	Description
Parameter	Cutting speed V (m/min)= 34.27,53,79.73 Feed Rate ,f (mm/rev)=0.35,0.40,0.45 Depth of cut ,d(mm)=0.5,1,1.5 MQL-50ml/hr.

III. RESULTS AND DISCUSSION

Figure 2 and 3 shows variations of cutting forces at various speed, feed and depth of cut. Cutting forces increase with increasing feed rate and decreases with increase in speed. With increase in cutting speed, frictional forces are decreased, which results in decrease in cutting forces.

Increase in depth of cut results into increased tool work contact length, hence frictional force will be more. Cutting tool penetrates into the work. Figure 2 shows variation of cutting force with respect to the depth of cut. As depth of cut increases, there is increase in cutting

force. Soyabean oil gives superior results when compared to mineral based oil Blassocut-4000 Soyabean oil shows 6 to 8 % reduction in cutting forces as compared to Blassocut. Even though Blassocut has more viscosity but evaporation losses might be more than soyabean. Soyabean oil lubricate the interface as well as protects the sharpness of tool by its additional cooling capability as compared to Blassocut-4000.

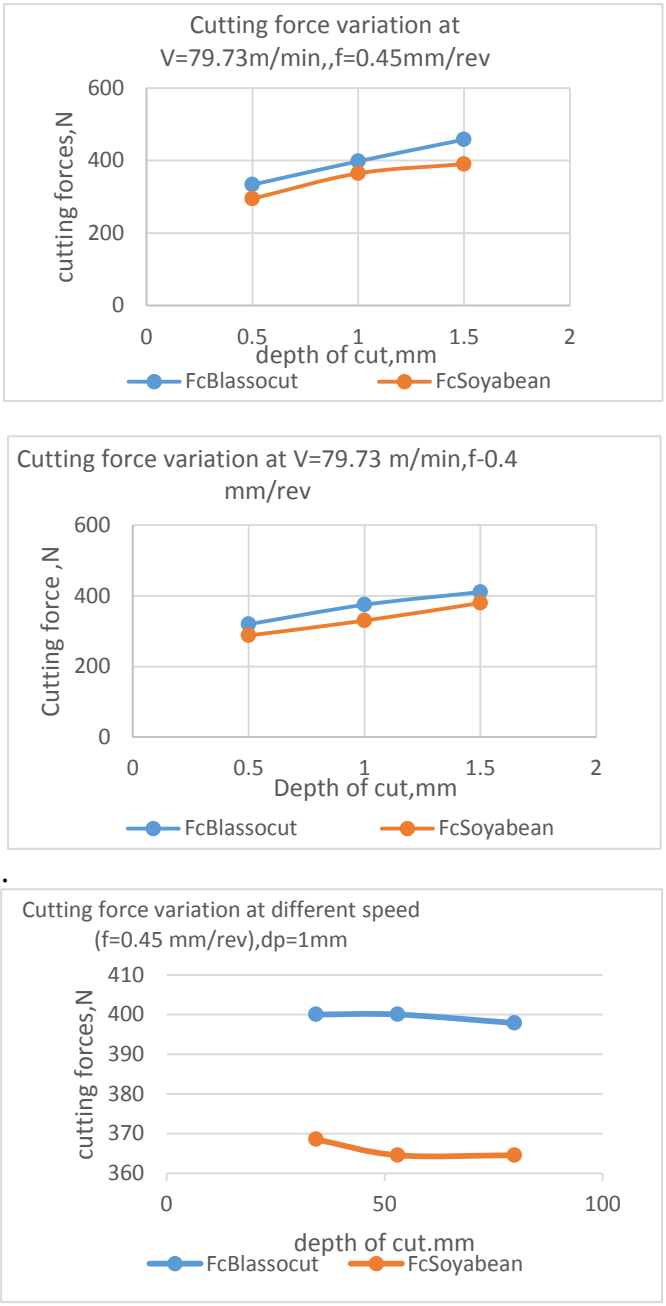

Figure 2. Variation of Cutting Forces With Respect To Depth of Cut

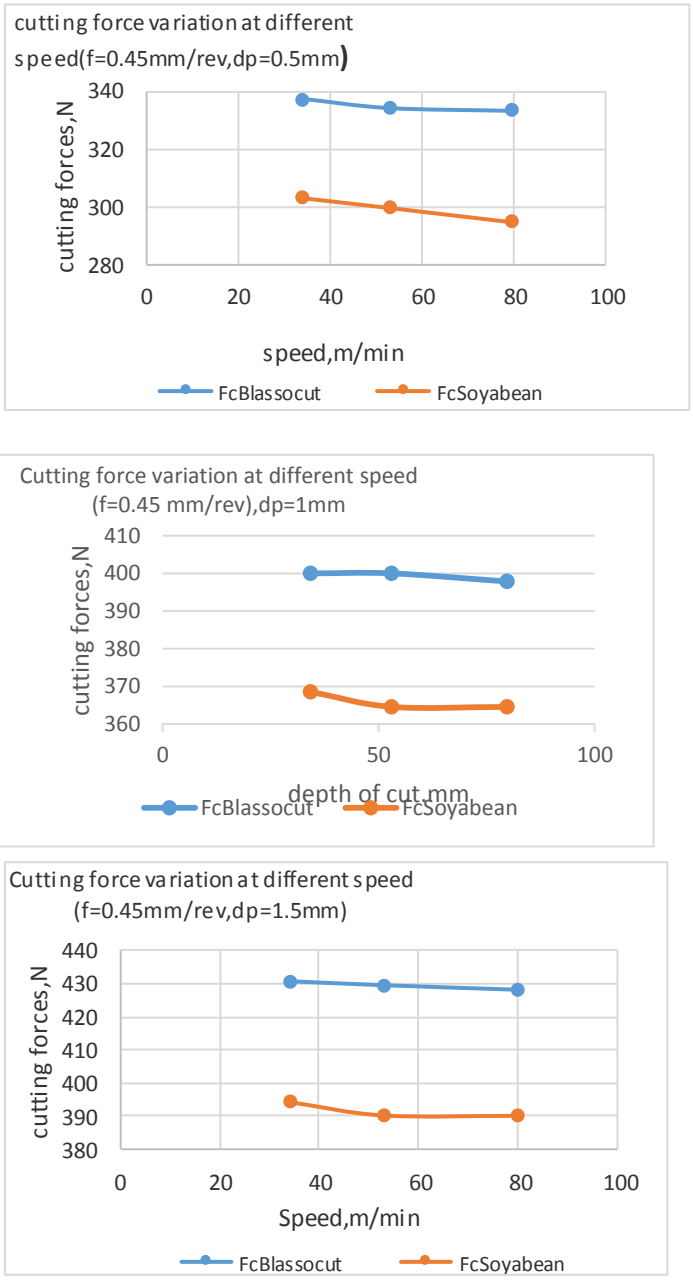

Figure 3. Variation of Cutting Forces With Respect To Speed

Figure 3 shows that there is decreases in cutting forces as cutting speed increases. The values of cutting forces in case of Blassocut are in the ranges of 325 N to 450 while for soyabean the maximum. Cutting force is less than 400 N, this shows that as cutting forces will will be less ,power consumption will be aslo less,in case of soyabean oil. This results into energy as well as money saving. In addition to this vegetable based oil are enviro-friendly, less harmful to the operator.

IV. CONCLUSION

There is notable decrease in cutting forces approximately 5% to 10 % in case of MQL. Use of Soyabean oil results into decrease in cutting forces as compared to mineral based oil Blassocut-4000.8-10% reduction in cutting forces is observed as compared to Blassocut Vegetable oil are easily available, less costly that mineral oil. This shows that there is substantial cost saving without harming environment as well performance parameter.

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