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Influence of Bio-Oils as Cutting Fluids on Chip Formation and Tool Wear during Drilling Operation of Mild Steel

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Abstract: ***The importance of health and environment has forced Machining Industries to reduce the application of Petroleum-based cutting fluid. But to ease the machining process and to increase the tool life, cutting fluids must be used. Research has been done on vegetable oils as cutting fluids which is easy for disposal and does not affect the environment and the operator's health [1] . This paper discusses the machinability and tool life during drilling of a mild steel work piece using Neem, Karanja, blends of 50%Neem-50%Karanja, 33.3%Neem-66.6%Karanja, 66.6%Neem-33.3%Karanja as cutting fluid. Results obtained using petroleum-based oil are compared with the results obtained by using above mentioned combination of oils and also with dry cutting conditions.***

Index Terms: Drilling; Mild steel; vegetable oils; SAE 20W40; Cutting fluid.

I. INTRODUCTION

The Major waste products of machining operations are chips, cutting fluids and machining waste. During the machining process, a certain amount of material must be removed. So chips are unavoidable. In the absence of cutting fluids, chips and machining become problematic and chip removal, transport becomes difficult. Hence it is important to understand the formation of the chip. During the high production drilling operation, due to high cutting velocity, feed and depth of cut large amount of heat gets generated and results in high cutting temperatures. This high temperature reduces dimensional accuracy, tool life and the integrity of the surface of the product gets impaired. As the temperature increases, tools wear increases. This affects the hole roundness or shape of the chip and chip colour. The high

Emperatures directly impact hole sensitivity, roughness of the surface, and wear of the tool. Drills which are worn or Broken can destroy the finished part. As soon as the drill bit is placed into the operator, it starts to wear. As it wears, the temperature of the drill rises and this initializes the processes that are physically and chemically resulted in drill wear and therefore drill wears faster. The chips formed during the drilling process are evacuated through drill flutes. The chips evacuates slower than chips production due to the friction between chips and drill flutes are produced which results in chip clogging and drill breakage. By using good cutting fluid chip evacuation can be increased and leads to drill breakage less, low production costs, hole quality high and increase in productivity. There are significant raise in issues with regards to application, recycling and disposal of cutting fluids. Improper dispose of cutting fluids can cause environmental and health issues. These issues created a pathway to the introduction of animal, mineral and vegetable oils. A " Vegetable oil" is a triglyceride extracted from the plant. Vegetable oils are classified into edible and non-edible oils. Due to growing population and increased demands, using of edible oils as lubricants is restricted. Non-edible vegetable oils are an effective alternative. All tropical countries which are abundant resources of forests yield a significant quantity of oil seeds.

II. .PROCEDURE

A. Vegetable oils used

Neem oil is a non-edible vegetable oil from the fruits and seeds of the Neem. Neem is commonly used for organic farming and medicines. Karanja oil is from the seeds of the Pongamiaglabra tree, which is native to tropical countries. Any cutting fluid used during machining operation should have specific physical properties like high thermal conductivity, high flash and fire point, stable against oxidation, no unpleasant odour, relatively low viscosity, corrosion resistance etc. Vegetable oils which are acceptable environmentally and technically and are easily available resource for bio lubricants. There is a large scope for non-edible oils as metal working fluids which resulted in the selection of Neem and Karanja as cutting fluids. The physical properties of the oils selected as cutting fluid are given in the Table 1.

Table 1: Physical properties of cutting fluids

Sl. No	Type of cutting fluid	Flash point (°C)	Fire point (°C)	Dynamic Viscosity (N-s/m²)	Specific Heat (KJ/Kg. K)	Adhesive ness (g/m2)
1)	Neem	248	285	0.0345	1.6817	687
2)	Honge	220	245	0.0266	1.6761	412
3)	50%Neem 50%Honge	256	290	0.016	1.6991	359

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4)	33.3%Neem 66.6%Honge	228	256	0.013	1.6703	257
5)	66.6%Neem33.3%Honge	228	264	0.011	1.6789	367
6)	SAE 20W40	210	215	0.021	1.97	319

The highest flash point of 256˚C was recorded for the blend of 50% Neem- 50% Karanja. The blend of 50% Neem- 50% Karanja has got highest fire point of 290˚C. Optimum viscosity of 0.01648 N-s/m² was obtained for the blend of 50% Neem- 50% Karanja. Comparing the measured Specific heats of other cutting fluids, the blend of 50% Neem- 50% Karanja has got high specific heat of 1.6991KJ/Kg. K. The Adhesiveness of the cutting fluid used should be optimum, i.e. it should not be high as the fluid helps the chips in sticking to machined surface through and if it low fluid flow through the machining zone and will affect the lubricating property. For 50% Neem- 50% Karanja, the value is 359 g/m2, which is optimum compared to others used.

B. Experimental Setup

AISI 1014 mild steel having diameter of 25mm with 75mm length is drilled in CNC machine at 800 rpm at constant feed of 10mm/rev using Neem, Karanja and blends of Neem and Karanja in different percentages, petroleum based oils as cutting fluids and also in dry condition. The drill bit used here is of 10% cobalt with diameter of 13mm. The method of MQL (Minimum quantity lubrication) is used for supplying of cutting fluid. The chips formed are collected and taken for checking parameters. The physical parameters of the chips are found using profile projector.

III. RESULTS AND DISCUSSION

A. Study of chips

Machinability refers to formation of chips with ease during drilling operation and this depends on the machining of different types of materials. If the same work piece is used with the same machining parameters such as Feed, Speed, and Depth of cut using different cutting fluids, formation of chip completely depends on cutting fluid used. Chip formation usually depends on temperatures at the zone of machining. These high temperatures are the resultants of drill bit and work piece friction. Work piece chattering and high temperatures at surface of work during machining process breaks the Chip. This can be by using work piece of larger diameter. Figure 1 gives the chip length measured and Figure 2 shows chips that are formed during drilling operation of mild steel work piece using Neem, Karanja, blends of Neem and Karanja oil with varying percentage i.e. 50%Neem-50%Karanja,33.3%Neem-66.6%Karanja,66.6%Neem-33.3%Karanja, SAE 20W40 oil and also for dry cutting condition. Longer length chips of 33mm are formed when 50%Neem-50%Karanja is used as cutting fluid followed by 66.6%Neem-33.3%Karanja with 30.7mm , Karanja with 25.7mm, Neem oil with 24.5mm and SAE 20W40 oil with 23.9mm and broken chips are formed for dry cutting condition. This shows that the temperature at machining zone is less when 50%Neem-50%Karanja is used indicating that it good lubricant as well as good coolant due to which work piece is ductile in nature whereas for dry cutting condition, the machining zone temperatures are high resulting in brittle work surface and discontinuous chips.

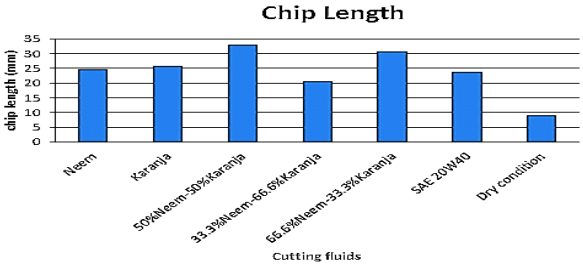

Figure 1: Length of the chips measured for different cutting fluids

Figure 2, below shows the length and chip color formed. Color of the chip indicates the temperature at the cutting zone. If the color is dark then the maximum temperature is absorbed by work piece and chip but not by the cutting fluid. For 50%Neem-50%Karanja, chip color is silvery and but not dark when compared to cutting fluids, this is due to oil absorbing more heat at the cutting zone than the heat which is transferred to work piece and to the chip. The results shows that blend of 50% Neem and 50%Karanja has better heat absorption capacity or cooling property compared to other oils used.

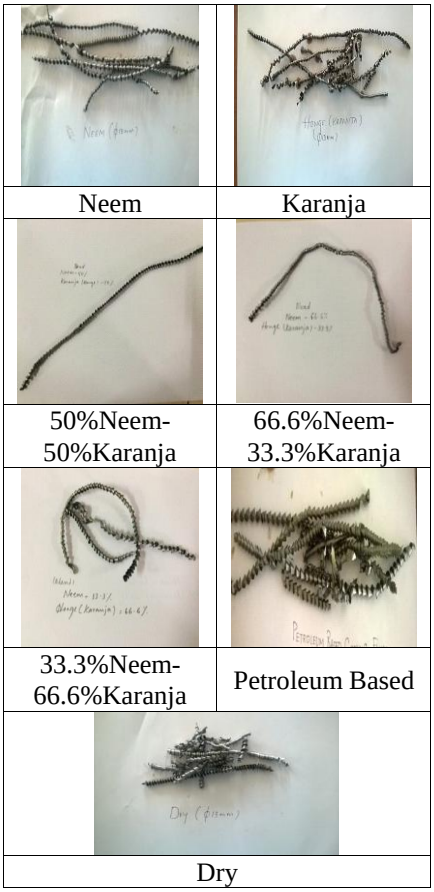

Figure 2: Chips formed for different variations of cutting fluids

B. Tool wear

The process of material removal from the surface of the tool due to abrasive action of counter body is called as wear. These results in micro cutting, micro-ploughing, deformation etc.,

Wear of drill bit can happen in various ways such as flank wear, crater wear, wear of chisel edge and chipping. The friction between surface of the newly machined work piece and tool flank contact area is called flank wear. The wore surface width is usually taken as wear measurement. The irregular patterned wear can be seen along the tool edge. The catastrophic failure at the early stages of the tool life is due chipping wear. The vibration of machine spindle is a mechanical issue which contributes wearing of chips. Higher loads on the tool will cause chip wear.

Material loss from the drill bit depends on type of material being machined, machining parameters like speed, feed and cutting depth, cutting fluids used, and tool holding devices and so on. Since all the elements are kept constant and only the cutting fluids are changed. Wearing of the drill bit depends on only the cutting fluids used. Figure 3 shows worn out surface of drill bit at chisel edge and drill bit point. For dry cutting condition, drill point is worn out as generated heat is high due to the friction between work piece and tool, whereas in case of Petroleum based oil, loss of material at drill point is less compared to dry condition. Tool wear is less when 50% Honge and 50% Neem blend is used as cutting fluid next followed by Neem and Karanja oil.

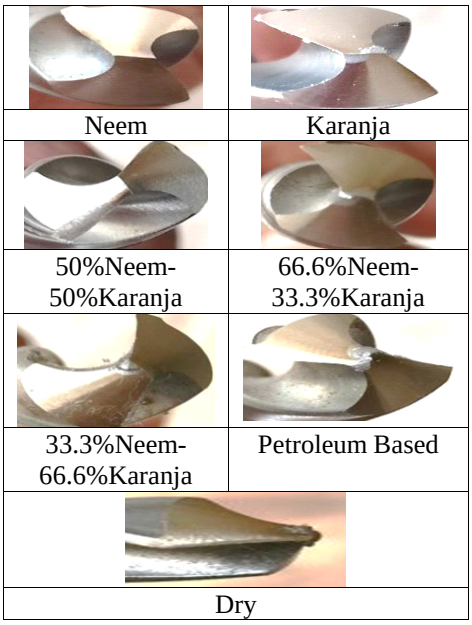

Figure 3: Worn-out drill bit

IV. CONCLUSIONS

• For 50%Neem- 50%Karanja, the formation of chips consistent and continuous compared to other fluids used, indicating that 50%Neem- 50%Karanja oil absorbs more heat and prevents the surface to be brittle in nature. The formation of chips for the blend of 50% Neem- 50% Karanja were in silver which indicates that less heat is carried by the chip. Also the length of the chip is continuous and long. When the cutting fluid has better lubricating and cooling properties, this type of chip is formed.

• For dry cutting condition, drill point and cutting edge is worn out as generated heat is high due to friction between work piece and tool. For Petroleum based oil, loss of material at drill point is less compared to dry condition. Tool wear at drill point and along cutting edge is less for 50% Honge and 50% Neem blend compared to when other cutting fluid are used.

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Dr. Jyothi P N is Professor in Department of Mechanical Engineering and has experience of 17 years in the field of teaching. She has published around 21 papers to various international as well as national journals. She is life member of Indian Society for Technical Education (ISTE) and Institution of Engineers (INDIA). Her research is on Understanding the Melt Flow Behavior of ZA alloys Processed through Centrifugal Casting and Evaluating the performance of vegetable oils as cutting fluids during Drilling and Turning operation of Mild Steel.

Susmitha Medarametla has done her B.E (Mechanical Engineering) from K. S. School of Engineering and Management. She has been working as SB Designer in TechMahindra from past 3 Years. She has published around 7 papers in various International and National Journals also presented papers in International Conference. She has been closely working with Dr. Jyothi P N to investigate Bio-oils as cutting fluids during drilling operation of mild-steel. This project has been awarded as Best Project of the Year for KSCST in 2016.

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