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EDIBLE OIL-BASED CUTTING FLUID IN MACHINING - A REVIEW

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Abstract

Growing awareness about environment pollution and regulations of the government on use of cutting fluids has forced the industrialists to come up with new alternatives of cutting fluids. In metal cutting operations cutting fluids have been extensively used for many years. Earlier only oils were used as lubricants in machining. As the severity of machining operation increased the complexity of cutting fluid formulation also became complex. Many types of cutting fluids are now available in market and are also known as cutting oils. In this paper the application of cutting fluids for different types of steels has been given. The advantages of cutting fluids and its performance with respect to different parameters have been described. The main objective of this paper is to highlight the benefits of edible oils in machining process.

Keywords:*Edible; oil; machining; Low-carbon; steel; cutting; fluid*

Introduction:

Cutting fluids are type of metalworking fluids which are used in machining operation requiring lubrication and cooling both [1,2]. Cutting fluids are generally formulated from mineral oils as base oils. These are then mixed with different additives in order to improve their machining performance [3,4]. Cutting fluids are used in huge quantity in manufacturing industries [5]. It is estimated that in the year 2015 the cutting fluid consumption was 320000 tonnes [6]. Cutting fluids have negative impact on environment and human. It was found that cutting fluids affect a major portion of humans affected by occupational diseases [7,8,9]. Direct contact of skin with cutting fluids causes many skin diseases [10-14]. It also causes respiratory diseases in workers who work near them [15-17]. Cutting fluids are very essential for manufacturing industries. These are used for reducing the heat generation in machining and to provide lubrication in machining operations [18-20]. The secondary function of cutting fluids is to wash the chips away from the cutting zone. If cutting fluids are not used in machining process/operation, the high heat generated can cause weakening of the cutting edge of the cutting tool [21].

Due to the adverse effects of mineral oil based cutting fluids there is a need for developing environment friendly cutting fluids. The alternate to mineral oil based cutting fluids is edible oils. Edible oils have high degree of lubricity [22,23]. These are non toxic and have high degree of biodegradability [24,25]. Edible oils have a triglyceride structure as shown in Figure 1. The life cycle of renewable resources used in cutting fluids\

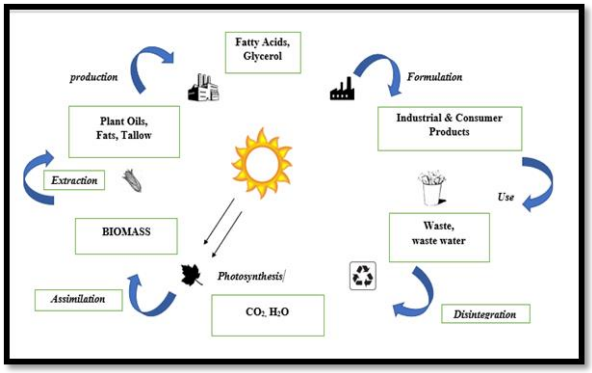

Figure 1 The life cycle of renewable resources used in cutting fluids.[18]

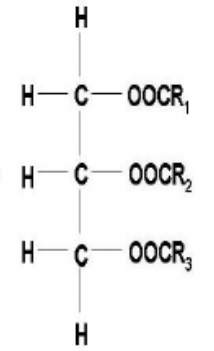

Figure 2Triglyceride structure of edibleoils[19]

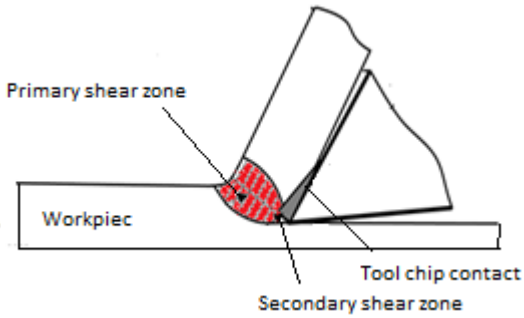

Figure 3 Zones of heat generation in machining

Edible oils in machining

Kolawale and Odusote [26] used vegetable oil based cutting fluid for turning mild steel. They compared the performance of palm oil and groundnut oil in machining mild steel in terms of temperature and chip formation rate. The authors chose different levels of cutting speed, feed rate and depth of cut. The performance of both the vegetable oils was compared with mineral oil. The authors reported almost similar temperature of groundnut oil and mineral oil indicating that groundnut oil performs at par with mineral oil in terms of reducing temperature. Highest chip thickness was achieved with palm oil (0.27 mm) followed by mineral oil and palm oil with each giving a chip thickness ration of 0.17 mm. The authors studied the micrograph of the machined surfaces and found a smooth view with groundnut oil in comparison to mineral oil thus giving an indication of better lubricating property of it. They concluded that vegetable oil based cutting fluids can replace the mineral oil based cutting fluids in machining. They also reported that a slight modification of the oils can improve the machining performance of vegetable oils.

Ojoloetal [27] carried out cylindrical turning of different materials - mild steel, aluminium and copper using straight biological oils. They compared the performance of these vegetable oils in terms of cutting forces in cylindrical turning at different machining conditions. The authors reported that Groundnut oil exhibited highest reduction in cutting forces when Aluminium was machined with Groundnut oil at an optimum speed of 8.25 m/min.With copper, palm kernel oil performed the best at low feed rates. But at higher feed rates coconut oil performed the best in terms of cutting force reduction. This indicates thatat different machining parameters different results are obtained with different oils. The authors concluded that groundnut oil and palm kernel oil are effective in reducing the cutting forces during turning operation of mild steel. The authors also concluded that the lubrication and cooling action depends on the type of material. Among all the oils, groundnut oil performed the best.

Adekunleetal[28]compaed the performance of groundnut oil and melon oil as cutting fluid in machining operation. They used carbide cutting tool in machining mild steel with these selected cutitng fluids. Surface quality, chip morphology and temperature were studied and compared. The authods reported that melon oil had greater cooling ability than groundnut oil. Melon oil was able to reduce surface roughness better than groundnut oil. This was due to better lubricity of melon seed oil than groundnutoil.

Chinchanikaretal[29] used coconut oil based cutting fluid in machining hardened AISI 52100 steel using PVD coated cutting tool. They reported good performance of coconut oil as cutting fluid in machining hardened steel in terms of surface finish. Adejuyigbe and Ayodeji[30] used soyabean oil as an alternate to conventional mineral oil based cutting fluid. They reported that only slight corrosion after a period of 70 days when mild steel was kept ion contact with soyabean oil

Ozceliketal [31] studied the performance of refined sunflower oil and canola oil using extreme pressure additive mixed with semi-synthetic and mineral cutting fluids in turning process. They compared cutting force, feed force, surface roughness and tool wear during at

longitudinal turning of AISI 304L with different cutting fluids. The experimental results were compared with dry turning. They reported that 8% additive in canola oil enhanced the surface finish by 35.5% as compared to sunflower oil with EP additive and 23.6% with respect to mineral oil. The authors attributed this property to the higher lubricity of canola oil mixed with EP additive. The authors concluded that refined sunflower and canola oil mixed with EP additives can be a good alternative to mineral oil based cutting fluid. They reduce health risks associated with the conventional cutting fluids. They also reduce costs related to waste treatment. These oils are also highly biodegradable. Similar results were obtained by the authors in machining AISI 304 stainless steel with vegetable oils [32]. The authors reported better performance of vegetable oil based cutting fluids in comparison with the mineral oil based cutting fluids.

Sharma and Singh [33] carried out and investigation using vegetable oil which is environment friendly as lubricant to avoid the use of petroleum and mineral content lubricants for turning operation. They used AISI D2 steel for the operation. They compared the performance of vegetable oil and petroleum-based oil and found that vegetable oil performed better than the petroleum-based lubricants as vegetable-based oil gave better surface integrity and better surface finish. It also reduces the damage at the cutting tool tip. Further, they observed that the temperature of the operation was reduced by 50% which is a good improvement in the machining performance. The author found out that inmost of the aspect vegetable oil performed better than the mineral and petroleum-based lubricants.

Srikant and Ramana [34] experimented on the AISI 1040 steel using coconut oil mixed with CAPB in varying percentage (5%,10%,15%,20%.25%). They compared the performance of all the formulations with a mineral oil based cutting fluid in terms of cutting force, surface roughness, tool wear and temperature. They reported 35% reduction in tool wear with 10% emulsifier content. On further increase in content of CAPB, not much change was observed. 40% decrease in temperature was observed with 10% CAPB as compared to dry machining. 10% CAPB performed at par with mineral oil in terms of reducing surface roughness.

Kumaretal [35] used vegetable based cutting fluids sesame and coconut oil with EP additive on machining operations. Turning of the AISI 1040 steel was carried out using coated carbide tool. When EP additive oils were compared with conventional mineral oil based cutting fluids, it was found that feed force was decreased by 31%, there was a decrease of 28% thrust force, the cutting force decreased by 20%. It was also observed that the cutting tool temperature was decreased by 7%. The surface roughness decreased by 33% in comparison to sesame oil having EP additive.

Conclusion

Cutting fluids are hazardous and cause negative effect on human and environment. Their disposal is costly and alternative to mitigate the hazardous effect of mineral oil based cutting fluids is to used vegetable oil based cutting fluids. Vegetable oil based cutting fluids are environment friendly, non-hazardous, non-toxic and safe for human. Their disposal does not require any neutralisation which reduces the additional disposal cost associated with it. In this paper the effectiveness of vegetable oil based cutting fluids over conventional mineral oil based cutting fluids is presented. It is evident that vegetable oil performs better than their mineral oil counterpart. They are effective in increasing the machining performance and are also environment friendly. They are renewable, cheap and safe for human.

Future Scope:

Research can be done on studying the effect of different additive in edible oils.

Different materials can be tested to study the effect cutting fluid on different material

Different machining methods can be used with edible oils in order to improve the efficiency of machining.

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