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Non Conventional Cutting Fluids in Manufacturing – Trends and Advancements: An Outline

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Abstract—*Met.al. working fluids are a lubricants be used in the met.al. working industry. Various met.al. working processes which may or may not involve material removal use these met.al. working fluids either in their native form or in the water soluble form. It has been estimated that met.al. working fluids are used in very large quantities every year, of the order of million tons. Vegetable oils have such inherent molecular structure which gives them a high inherent lubricity without the need for mixing with additives. Various literatures show that the vegetable oil based MWFs have good performance as compared to the mineral oil based met.al. working fluids. The current trend is shifting from using only edible oils to use of non edible oils as well. Also, researches are being done in other areas of including nano powders in cutting fluids as nano-emulsions. A brief report is provided.*

Keywords*: Met.al. working fluid, Biodegradable, cutting fluid, MQL*

1. INTRODUCTION

The functions of a m*et.al.* working fluids are minimizing the friction between the rubbing surfaces, producing better surface finish, carrying away chips from the cutting zone and minimizing workpiece deformation due to heat generation [1-4]. The m*et.al.* working fluids can be used either directly or mixed with water, depending on the requirement of lubricity and reduction in heat carrying away. For high speed machining processes, the requirement is generally of taking away the heat and providing lubricity whereas in low speed machining the requirement is lubricity more than heat carrying capacity [4].

The mineral oil based m*et.al.* working fluids are mixed with additives and performance enhancers such as EP additives which are also petroleum based products [5]. Mineral oil and petroleum based lubricants alone constitute around 85% of all the lubricants being used in the industry [5]. All these products are petroleum based and hence are carcinogenic, toxic and pose negative effect on the environment [6]. Various occupational health disorders have been reported to be caused by these m*et.al.* working fluids [6]. Skin cancers, lung cancers, throat cancers, eczema etc are a few of the diseases which have been shown to caused by long term exposure to these m*et.al.* working fluids. Owing to these short comings and dangers, focus is being shifted to environment friendly m*et.al.* working fluid developments. Environment friendly m*et.al.* working fluids are composed of base oil derived from vegetables [7]. Most work has been reported on edible vegetable oils such as coconut oil, castor oil, soybean etc

Vegetable oils have some inherent advantages which are not present in the mineral oil which makes them a good competitor against the mineral oil based cutting fluids. It has been reported that vegetable oils outperform the conventional mineral based cutting oils even without any additive or performance enhancers [8,9]

Kuram *et.al.* [10] carried out experiments to determine the effect of vegetable based cutting fluids on thrust force and surface roughness during drilling of AISI 304 austenitic stainless steel with HSS. They reported that least thrust forces were obtained with sunflower oil as compared to the regular mineral based cutting fluid..

Xavior and Adithan [11] tested the performance of coconut oil based cutting fluid, emulsion formulated from coconut oil and a straight oil(neat oil) on Austenitic steel (AISI 304). The results of surface roughness and tool wear were compared were compared. The authors reported a reduction in flank wear of the cutting tool red and also a reduction in the surface roughness with use of oil made from vegetables.

Salete and Oliveira carried out biodegradability test for a new cutting fluid developed from castor oil and mineral oil. The result showed that the new cutting fluid exhibited high degradation rates while mineral oil was degraded to 20 – 60% only [12]. Srikant et al. [13] found a major drawback in the formulation of cutting fluids that the vutting fluids formulated from vegetable oils have petroleum based additives which are not suitable for environment. They formulated a totally biodegradable cutting fluid out of vegetable oils and CAPB. The performance was compared with a conventional cutting fluid which had mineral oil contents in machining AISI 1040 steel. The newly made totally biodegradable cutting fluid performed better in cutting force reduction, tool wear reduction and surface roughness reduction. Zhang et al. [14] compared the performance of soyabean oil based cutting fluids

with petroleum based cutting fluids. They reported an improved surface finish and less tool wear with the soyabean based cutting fluid than the petroleum based cutting fluid. Mohamed Handawi *et.al.* [15] used castor oil and a new method of lubrication – MQL to evaluate the performance of the cutting fluid on hardened stainless steel. They reported that even a small amount of lubricant was able to produces better results compared to dry cutting. Longer tool life and reduced surface roughness were achieved.

Sharif *et.al.* [16] also worked on MQL in milling operation of hardened austenite steel and coated carbide materials. They compared cutting forces, tool life and surface roughness with different cutting fluids viz fatty alcohol, palm oil and palm oil with two different additives. They reported low wear rates with palm oil and fatty alcohol coolant. They also reported highest tool life with palm oil lubricant.

Abdulla *et.al.* [17]developed cutting oils from coconut, sunflower, rapeseed, palm olive, rapeseed and used them for machining aerospace grade titanium. They conducted tests on thrust force. They reported that low cutting forces were obtained from the vegetable oils which had naturally derived additives. Many researchers report a significant improvement in surface quality by using vegetable oil based cutting fluid instead of mineral oil based fluid {18-20]

Recent researches focus on use of nano particles in m*et.al.* working fluids. Nano particles offer higher het carrying away capacity. It is also reported in literature that the nano fluids decrease the tool wear thereby increasing the tool life. The base oil is usually vegetable oil in these formulations. Many different nano particles have been used in the formulation of cutting fluids [21,22]. Krishna *et.al.* [26] reported the performance of a suspension containing nanoboric\ acid in coconut oil done at different cutting conditions. They reported an increased cooling action of the formulated cutting fluid.

Vegetable oils have a polar charge as opposed to the mineral oils. Mineral oils do not carry any charge. Owing to this inherent property of the vegetable oils, they have more affinity to sticking to the surface of the metals [23, 24]. Another advantage of vegetable oils is that they are readily biodegradable whereas mineral oils are not biodegradable. Though there are many advantages of vegetable oil to be used as an alternate to the mineral oil based cutting fluids, they have some disadvantages also. They have limited oxidative and thermal stability. But the advantages outweigh the shortcomings of the vegetable oil based cutting fluids.

2. CONCLUSION

It has been proved that vegetable oils have much superior inherent lubricity characteristics as compared to the mineral oil based cutting oils. Properly formulated vegetable oil based cutting oils can be a potential candidate for alternates to mineral oil based cutting oils. Researches can be done on formulating blends of different oils and testing long term emulsion stability of these oils and further testing the performance of these oils before their commercialization. Vegetable oil based cutting fluids also help in reducing the carbon foot print and are a step towards a clean manufacturing.

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