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Sustainable Manufacturing: Performance Evalution of a Non-conventional Cutting Fluid

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ABSTRACT: Conventional cutting fluids pose serious risk to the environment. The carcinogenic additives in the cutting fluids have a negative health effect on the workers as well. These can infiltrate inside through nasal passage fumes and through contact and thereby causing various types of skin and respiratory diseases. Skin irritation is commonly reported by workers working in such environments where such cutting fluids are used. In order to find an alternate to the conventional cutting fluid, an attempt was done to develop a new cutting fluid which would be safe for human, environment and which would perform at par with the conventional cutting fluid. Tool tip temperature and surface roughness were studied at constant cutting parameters and different cutting fluids.

Keywords: Vegetable based cutting fluid; Surface roughness; Tool life; Tool wear and Temperature.

INTRODUCTION: Manufacturing industries are the backbone and an essential part for the prosperity of a nation. Every manufacturing industry involves metal removing process. Each material removal or finishing process requires the application of either straight oils or soluble cutting fluids. Heat is generated due to the surfaces coming in contact and friction and it has a negative impact on the cutting tool and can also deform the workpiece dimensions and also the form of the workpiece dimensionally [1-3]. So, a cutting fluid has to be used in order to keep the temperature under control.

There are different categories of cutting fluids viz straight oil, soluble, synthetic and semi-synthetic. Different class of cutting fluid finds applications in different areas of machining or material removal process. High speed machining requires the use of soluble oils. Soluble oils are water soluble. These are mixed up with water and then sprayed directly on the cutting zone. This helps in lowering the temperature and keeping it under limit [3].

This increases the cutting tool life and thus increases the production rate and minimizes the losses [9-12]. Application of cutting fluid also helps in subsiding the friction between the rubbing surfaces i.e. the tool and workpiece. [10-15]

Better surface is achieved by the use of cutting fluids as compared to dry machining [12-15, 17-19]. Studies done by many researchers have shown that use of cutting fluids reduces tool wear, increases surface finish and hence increases tool life [5-7, 14-16, 19].

The conventional cutting fluids have additives which are added to increase their life and cutting performance. These additives are carcinogenic and unsafe for humans and environment. A substitute to these is vegetable oil based cutting fluid. Vegetable oil based cutting fluids have high inherent viscosity and hence there is no need of adding additives to improve their performance. These have high lubricity also.

Another problem is the disposal of the conventional cutting fluids. These require thorough neutralization before being disposed into water bodies. This adds up to the cost of the cutting fluid. Whereas, vegetable oil based cutting fluids do not require such neutralization because they are not toxic and do not have any carcinogenic additive like the ones in the conventional cutting fluid.

To make oil soluble in water an emulsifier is required. Most emulsifiers are petroleum based. So we need to find an emulsifier which is not petroleum based and is safe for human use.

R. Srikant reported better results with edible oil and a biodegradable emulsifier. The biodegradable cutting fluid performed better than the conventional cutting fluid and an increased tool life was reported [19]. Other researchers have reported a significant increase the tool life of the cutting tool. [7-16]. Many researches done by using these edible vegetable oil have performed better than the conventional cutting fluids. Researchers have reported better surface finish, reduced tool wear and reduced cutting forces as compared to the conventional petroleum based cutting fluids. Also after use, the disposal does not require any kind of neutralization as these are readily biodegradable. So the biodegradable cutting fluids must be used.

MATERIALS AND METHOD: In the present work unfiltered neem oil was mixed with a biodegradable surfactant in different concentrations of 5%, 10%, 15%, 20%, 25% and 30%. The concentrate was then diluted to 10% and the flow rate was varied. The results were compared with dry machining and a conventional cutting fluid. The workpiece chosen was AISI 1045 and machining was done with CNMG120408 and PCLNR2525M12 tool holder. Cutting speed was maintained at 110m/min, 0.5mm/rev feed rate and 0.5 mm depth of cut and fluid flow rate of 0.5 litre/min, 1 litre/min and 1.5 litre/min was set and maintained using a pump. The tool tip temperature was measured using Thermal imaging camera (make: FLUKE) and the surface roughness was measured using a portable roughness tester TESA 4G with least count of 1micron.After every pass the machining was stopped and surface roughness was measured using the portable surface roughness tester.

RESULT AND DISCUSSION:

Temperature: Average temperature was noted during every pass of the cutting tool for all three rates of flow. The temperatures are noted and shown as below (Figures 1-3).

As is evident from the experiment, Neem 5% surfactant performs the best among all the other cutting fluids in AISI 1040 machining at all flow rates. This even performs better than the conventional cutting fluids.

Surface Roughness: Average surface roughness was taken for every cutting condition at every pass and the results plotted as below (Figures 4-6).

As can be seen from the observations mineral oil based cutting fluid gives the lowest surface finish followed closely by Neem 5% surfactant cutting fluid at all the flow rates. So Neem 5% surfactant can safely be used as an alternate to the mineral oil based cutting fluid for mild steel machining.

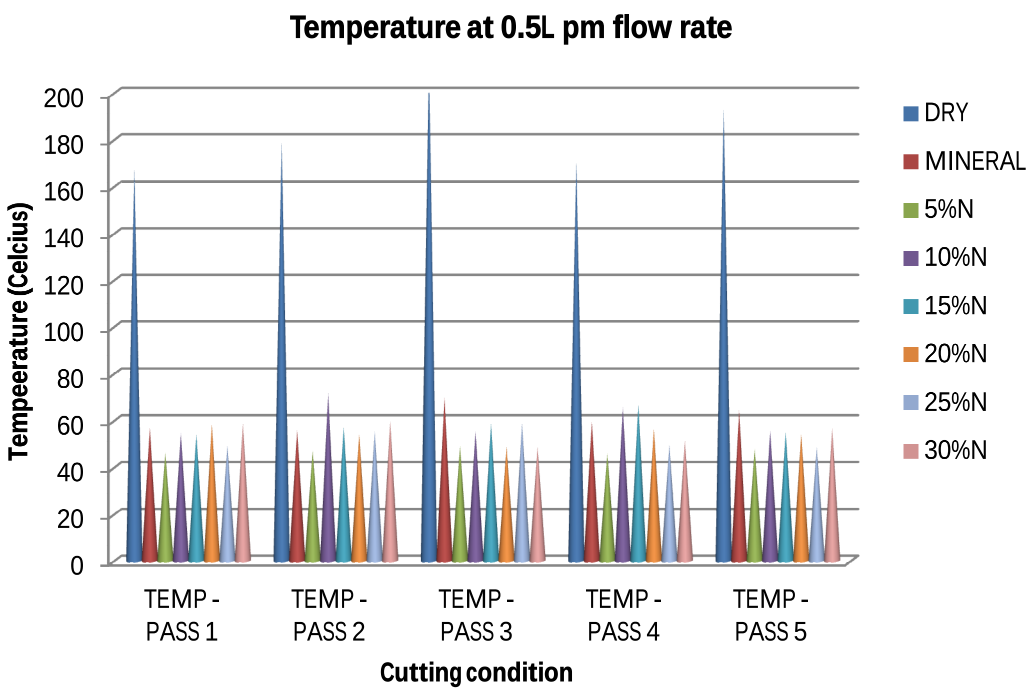

Figure 1: Temperature in degree Celsius at different passes and with different cutting fluids at 0.5Lpm flow rate.

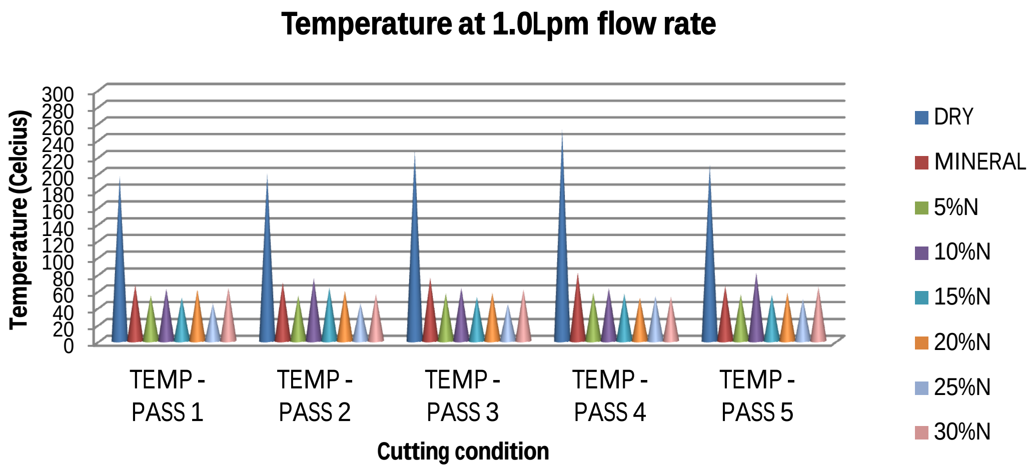

Figure 2: Temperature in degree Celsius at different passes and with different cutting fluids at 1.0Lpm flow rate.

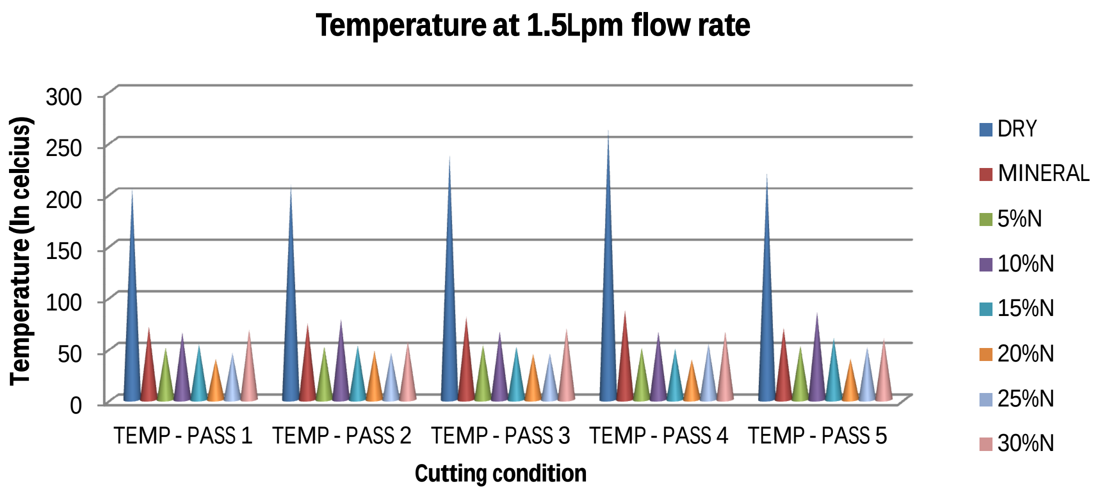

Figure 3: Temperature in degree Celsius at different passes and with different cutting fluids at 1.5 Lpm flow rate.

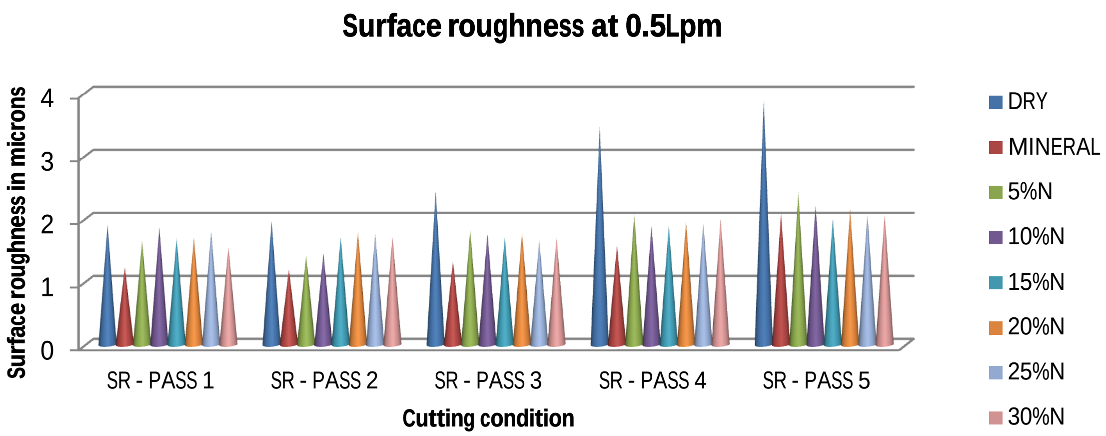

Figure 4: Surface roughness in microns at different passes and with different cutting fluids at 0.5Lpm.

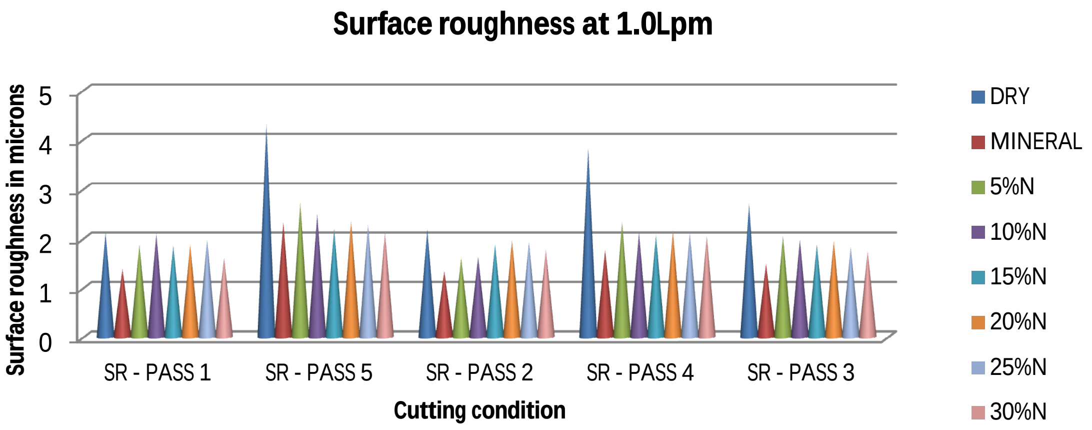

Figure 5: Surface roughness in microns at different passes and with different cutting fluids at 1.0Lpm.

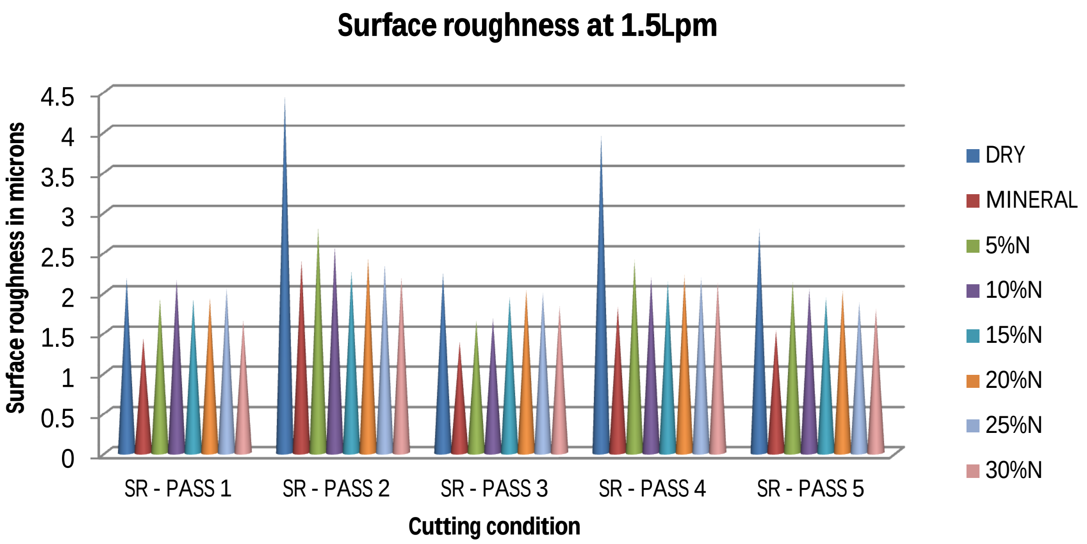

Figure 6: Surface roughness in microns at different passes and with different cutting fluids at 1.5Lpm.

CONCLUSION: The results indicate that the newly formulated cutting fluids can be used as an alternative to the conventional mineral oil based cutting fluid as these perform better in terms of temperature reduction and almost similar results in reducing the surface roughness. Also these do not have any carcinogenic additive and thus saves cost of neutralization and easy disposal.

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