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A REVIEW ON MINIMUM QUANTITY LUBRICATION FOR MACHINING OPERATIONS

Kamaldeep Singh[1] & Dr.Sukhpal Singh Chatha[2]

Abstract: - Minimum quantity lubrication is a possible solution for the optimum lubrication system. The introduction of minimum quantity lubrication (MQL) as an alternative technique can alleviate the pollution and health problems associated with cutting fluids. In minimum quantity lubrication system, a very small amount of lubricant is used. This paper presents a review of some published research works on MQL and MQL with nano-particles and their outcomes on various machining operations. Choosing suitable lubricants for various machining operations have been determined according to cutting tool materials.
Key words: Minimum Quantity Lubrication (MQL), Machining, Nano-fluid.

1. INTRODUCTION

Machining can be defined as a process which is used for producing different components. It is a process of removing material from the work piece in the form of chips with the use of cutting tools. The cutting fluids are very important part of this process. Cutting fluids are used to improve the life of cutting tool and its function [1]. To replace the usage of cutting fluids, several techniques such as, wet machining, cryogenic cooling, Minimum quantity lubrication and solid lubricant assisted machining have been emerge in current years[2]. There are many functions of cutting fluids like cooling and cleaning, lubrication improves tool life, flushing away the chips, improves surface finish and prevention from corrosion. In machining operation, cooling effect of cutting fluids is considered as a very important parameter [3]. By using suitable cutting fluids, temperature fluctuations are minimized. Selection of suitable cutting fluid is greatly depending on these factors:

- Types of machining process
- Types of work material
- Types of cutting tool material

MQL is an alternative to the use of conventional metal working floods. MQL uses very small quantity of fluid to reduce the friction between cutting tool and work piece. In MQL machining, a small vegetable oil or biodegerable synthetic ester is sprayed to the tool tip with compressed air. A very small quantity of lubricant is atomized in an air flow towards the cutting zone with a flow rate of 50 to 500 ml/hr. Minimum quantity lubrication (MQL) techniques can perform cooling and lubrication of grinding zone simultaneously with an extremely low consumption of cutting fluid [2]. Very small quantity of lubricant is used in MQL system in comparison of conventional system. A good MQL lubricant has a very high viscosity [4]. In order to achieve the high cooling and lubricating capability with the MQL, a fluid with high thermal conductivity must be utilized [3,4]. The schematic view of the MQL setup is shown in Fig. 1.1

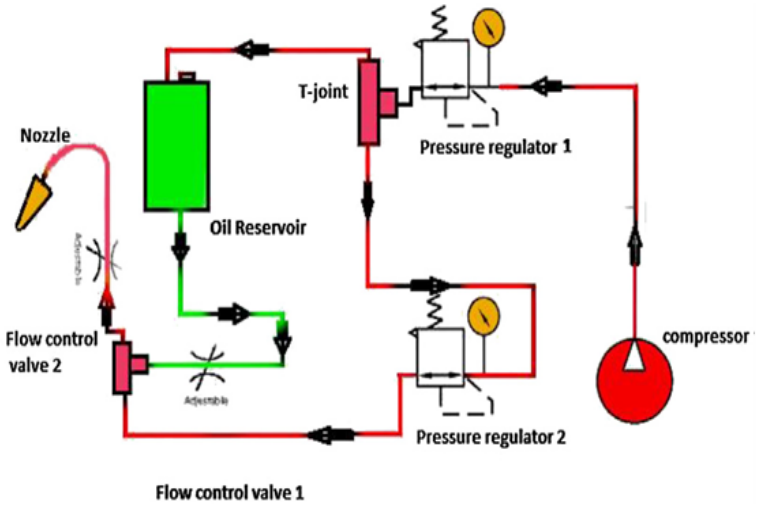

Fig. 1.1Schematic view of MQL unit [5]

[1] Yadavindra College of Engineering, Punjabi University Guru Kashi Campus, Talwandi Sabo, Punjab, India-151302
[2] Yadavindra College of Engineering, Punjabi University Guru Kashi Campus, Talwandi Sabo, Punjab, India-151302

There are two basic types of MQL delivery systems: external spray and through tool. The external spray system consists of a coolant tank or reservoir which is connected with tubes fitted with one or more nozzles [2]. The system can be assembled near or on the machine and has independently adjustable air and coolant flow for balancing coolant delivery. It is inexpensive, portable, and suited for almost all machining operations. Through-tool MQL systems are available in two configurations; based on the method of creating the air-oil mist. The first is the external mixing or one-channel system. Here, the oil and air are mixed externally, and piped through the spindle and tool to the cutting zone [3].
The previous researchers have designed and developed nano-fluids, which consist of nano-particles and a base liquid. Nano-particles are basically in the form of metals and oxides and base oils are usually various vegetable oils. MQL grinding with use of nano-fluids significantly reduces grinding forces and improve ground surface quality of workpiece, compared to commercial metal working fluids [6]. Nano-fluids can be supply to the cutting zone in a machining process through nozzles like the flooded machining systems, but the larger wastage during the machining application and higher manufacturing costs of nano- fluids have urged researchers to study nano-fluids along with the minimum quantity lubrication system [7]. The aim of this paper is to understand the mechanism of MQL. This may be helpful in the selection of appropriate nano-particles type among different available nano-particles for any specific machining process.

2. LITERATURE REVIEW

Boubekri & Shaikh, 2015 [1] reported that MQL provides environment friendliness (maintaining neat, clean and dry working area, avoiding inconvenience and health hazards due to heat, smoke, fumes, gases, etc. and preventing pollution of the surroundings) and improves the machinability characteristics. The application of MQL based synthetic ester as the cutting fluid was more efficient for the machining process as it reduced the cutting temperature, cutting force, tool-chip contact length and produced better chip thickness compared to dry machining technique. Madhukar et al, 2016 [2] studied about the minimum quantity lubrication and reported that MQL does generate a significant amount of mist compared to flood cooling. However, minimum quantity lubrication, machining is safe for both operators and environment, particularly when vegetable oil based lubricants are used. Use of minimum quantity lubrication also decreases production cost by reducing coolant cost. This study shows that adaptation of minimum quantity lubrication system in comparison of flood system yields significant advantages like reduction in cost, providing good environmental working condition etc. Boswell Islam, 2012 [3] Concluded that air cooling with the use of small amount of vegetable oils is not a totally dry process it is quite close and therefore is a sustainable. It also studied the effects of three parameters like cutting speed, feed and depth of cut upon surface finish during milling operation and found that the surface finish was improved by 27% and also showed that MQL may be considered to be an economical and environmentally compatible lubrication technique. Hasan & Dwivedi, 2014 [4] investigated that MQL systems enabled reduction in average chip tool interface temperature up to 10% as compared to wet machining depending upon the cutting conditions. MQL machining was performed much superior compared to the dry and wet machining due to substantial reduction in cutting zone temperature enabling favorable chip formation and chip–tool interaction. It was also seen from the results that the substantial reduction in tool wears resulted in enhanced the tool life and surface finish. Goyal et al, 2015 [6] examined the mechanical performance of minimum quantity lubrication and compared it with completely dry and flood lubrication for various machining operations. This research shows that MQL system provides better performance than dry machining and flood. System can be replaced by the MQL due to their environmental friendly characteristics, MQL is found to be alternative for dry and flood machining. Thus it generate minimizes pollution and improving health & safety. Dhar et al, 2009 [11]studied the effects of minimum quantity lubrication (MQL) by vegetable oil based cutting fluid on the turning performance of low alloy steel AISI 9310 as compared to completely dry and wet machining in terms of chip–tool interface temperature, chip formation mode, tool wear and surface roughness. It was observed that the MQL machining was performed much superior compared to the dry and wet machining. Dhar et al., 2011 [12] investigated the role of MQL by cutting oil on chip thickness ratio, cutting temperature, cutting forces, tool wear and surface roughness in turning medium carbon steel at industrial speed- feed combinations by uncoated carbide. For MQL flow rate of fluid was maintained at 60 ml/hr and compressed air pressure at 7 bar. The fluid has been used for lubrication was soluble oil. From the study it was concluded that MQL provide advantage mainly by decreasing the cutting temperature which leads to maintain sharpness of the tool. Dimensional accuracy improved mainly due to reduction of wear at the tool tip with the help of MQL. Lawal et al, 2013 [13] studied about the applications of vegetable oil based cutting fluid for the machining of nonferrous metals. From this study it was concluded that use of cutting fluids in machining processes can reduce the cutting temperature and provides lubrication to tool and work piece, which increases tool life and improves the surface quality. They used vegetable oil as cutting fluid because of its superior lubrication and high-pressure performance and found that MQL can be a good technique for turning hardened stainless steel using coated carbide cutting tools for cutting parameters. Tim walker, 2015 [14] investigate the comparison of MQL and wet turning of AISI1045 work material by selecting the optimal cutting parameters, in order to predict the cutting force and surface roughness and analyzing the effect of cutting parameters on machinability. In this experiment cutting speed and depth of cut showed opposite effects on cutting force and surface roughness. This study shows that MQL turning has more advantages than wet turning. Further investigated the evaluation of near dry machining effects on gear milling process efficiency & conclude that MQL is causes of possibility for efficiency increasing reduction in cost improvement of operational environment.

3. CONCLUSION

Minimum Quantity Lubrication (MQL) and Near Dry Metalworking (NDMW) is the most recent and quickly advancing technology in metalworking fluid systems. MQL technique not only significantly reduced amount of metal cutting fluids (MCFs), but also generated lower forces than conventional flood grinding and dry grinding. This technology was originally developed in the aerospace industry because the dry machining is not possible due to the scale of the work amplified the negative attributes of the traditional flood type coolant and surface quality requirements. Literatures clearly reveal that MQL system provides better performance than dry maching. Flood system can be replaced by the MQL system. MQL can reduce the cutting force, provide efficient cooling at the shear zone which reduces temperature, provide proper lubrication and retention of tool sharpness for long period of time. Minimum Quantity lubrication Improves surface finish due to reduction of wear and damage at tool tip.

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