

Minimum Quantity Lubrication

An emerging technology for sustainable development

Rupesh M Parthe

Assistant Professor, Vidyalkar Institute of Technology, Mumbai 400037

rupeshparthe21@gmail.com

Abstract — The machining of metals has traditionally involved the use of large quantities of water and oils for dissipating the cutting tool temperature, improving the surface finish of parts and increasing tool life. Invariably, the cutting fluid has become contaminated with use, has required being environmentally disposed and has accounted for approximately 17% of the total production cost of parts. The purpose of this article is to review the relevant literature in machining using minimum quantity lubrication particularly as it pertains to environmental and health issues and outline future potential research in this technology. The findings of this study show that MQL may be an economical and environmentally compatible lubrication technique.

Keywords—MQL, cutting fluid, sustainability.

I. INTRODUCTION

In recent years, major changes in the laws against pollution have been enacted. In particular, the aerospace industry is looking for new engines to meet the increasingly stringent environmental regulations that provide, by 2020, the reduction of fuel consumption, polluting emissions, and noises. To accomplish such objectives, new materials have been developed for the application of the most stressed parts of the power train. However, these intermetallic alloys appear to be difficult-to-cut excessive tool wear, heat and forces affect the cutting processes, together with the poor surface quality of the produced parts. When machining difficult-to-cut materials, one of the key phenomena is the excessive generation of heat in the cutting zone, which has a controlling influence on the wear rate of the tool. Research reports have proved that a reduction in cutting temperature increases tool life. Hence, cutting fluids are profusely used for cooling and lubrication purposes, and wet cutting is de facto a standard for industrial production. The primary functions of coolants are to cool and to lubricate.

The cooling effect increases tool life by retaining the cutting temperatures below the thermal softening temperature of tool material, decreasing thermally induced tool wear mechanisms such as diffusion and adhesion. The lubricating effect reduces the mechanical wear, such as the abrasion on the tool rake face. In addition, coolants are responsible for secondary functions, as the conveyance of chips and the cleaning of tools/work pieces. Emulsions possess excellent heat transfer characteristics because of their high-water content, whilst oils excel when a high degree of lubricity is required.

II. MINIMUM QUANTITY LUBRICATION

Minimum Quantity Lubrication, also known as “Micro-lubrication”, and “Near-Dry Machining”, is the latest technique of delivering metal cutting fluid to the tool/work interface. Using this technology, a little fluid, when properly selected and applied, can make a substantial difference in how effectively a tool performs. In conventional operations utilizing flood coolant, cutting fluids are selected mainly based on their contributions to cutting performance. In MQL however, secondary characteristics are important. These include their safety properties, biodegradability, oxidation and storage stability. This is important because the lubricant must be compatible with the environment and resistant to long term usage caused by low consumption. In MQL, lubrication is obtained via the lubricant, while a minimum cooling action is achieved by the pressurized air that reaches the tool/work interface. Further, MQL reduces induced thermal shock and helps to increase the work piece surface integrity in situations of high tool pressure.

1. Types of MQL

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. 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. The advantages of such systems are simplicity and low cost; they are suited to be retrofitted to existing machines with high-pressure, through the tool coolant capability. They are easy to service; no critical parts are located inside the spindle. The disadvantage is that the oil-mist is subjected to dispersion and separation during its travel from the nozzle. To minimize oil dropouts, a mist of relatively fine particles is used, which often limits the amount of lubrication that can be supplied to the cutting zone and consequently affects the performance of the cutting process. The second configuration is the internal mixing or two channel systems. Most commonly in a two-channel system, two parallel tubes are routed through the spindle to bring oil and air to an external mixing device near the tool holder where the mist is created. This approach requires a specially designed spindle. Such systems have less dispersion and dropouts and can deliver mist with larger droplet sizes than external mixing devices. They also have less lag time when changing tools between cuts or oil delivery rate during a cut. However, the systems are more difficult to maintain; critical parts are located inside the spindle.

III. LITERATURE REVIEW

Paolo C. Priarone [1] concluded that, MQL appears to be an advantageous solution for milling, while in turning wet cutting is the best choice for reducing the tool wear, since the higher process temperatures require the higher cooling effect of the emulsion. The experimental tests show that dry machining requires a sensible reduction of process parameters to preserve a stable process, although limiting the energy consumption and reducing to zero the lubricant consumption.

Bruce L. Tai [2] review the use of MQL in automotive powertrains. MQL has revolutionized the traditional wet automotive powertrain machining owing to its significant cost-saving in manufacturing. This paper summarized the development history at Ford, advantages, technical challenges, and advancements of MQL technologies based on industrial and academic experiences in the past decades.

Mohamad Syahmi Shahrom [3] presents an investigation into Minimum Quantity Lubricant (MQL) and wet machining in milling processes of AISI 1060 Aluminum work material with the main objective is to determine the effect of lubrication conditions on the surface roughness. It

was found that MQL produced better surface finish as compared to wet machining. The result can significantly reduce cost and environmental pollution.

D.V. Lohar and C.R. Nanavaty [4] concluded that the cutting force in hard turning of hardened AISI 4340 is less as compared to dry and wet turning. There is a 40% decrease in cutting forces during MQL. While for wet flood condition it was about 26% more than MQL and 19% less than dry condition. It is observed that the cutting temperature in hard turning of hardened AISI 4340 is less as compared to dry and wet turning. It gives a 36 % decrease in cutting temperature. There is a 30% improvement in surface finish using MQL.

Md. Imran Ansari [5] gave the experimental result that feed was the major significant factor followed by speed whereas depth of cut played an insignificant role in affecting surface roughness.

Kedare S. B. [6] concluded that surface finish was found to be improved by 27%. The findings of this study show that MQL may be an economical and environmentally compatible lubrication technique.

Ibrahim Deiab [7] investigated the effect of six different strategies on the flank tool wear, surface roughness and energy consumption during turning of titanium Ti-6Al-4V using uncoated carbide tool at certain speed and feed. The use of rapeseed vegetable oil in MQL and MQCL configuration turns out to be an overall sustainable alternative. Thus, confirming the promise predicted in the use of vegetable oil as a lubricant for machining.

D. Biermann [8] concluded that the cooling effect of the MQL in the effective cutting area leads to a temperature increase within the coolant and sequel to the heating effect at the borehole wall. To reduce the production costs the deep hole drilling with twist drills and MQL becomes more and more interesting for the metal working industry. The increased thermal load when substituting the emulsion coolant concept by MQL can cause lower process reliability and thermally induced workpiece deviations.

IV. CONCLUSION

After having review of various research available for minimum quantity lubrication. It is concluded that, cost of cutting fluid contains major part of cost of production. To be in global marketing, cost of manufacturing must be minimum as possible. Again water and air pollution is major issue in current situation. Hence there must be an alternative solution for the wet machining. MQL is best option for the same. Minimum use of cutting fluid, saves the cost of purchasing, cost of storing and cost of disposal also. Minimum disposal of fluid minimizes the water contamination. Thorough study and experimentation should be carried out on MQL with all machining types and various materials. The findings of this study show that MQL may be

considered to be an economical and environmentally compatible lubrication technique.

References

- [1] Paolo C. Priarone, 2014 "Milling and turning of titanium aluminates by using minimum quantity lubrication", *Procedia CIRP* 24.
- [2] Bruce L. Tai, 2014 "Minimum Quantity Lubrication (MQL) in Automotive Powertrain Machining", 6th CIRP International Conference on High Performance Cutting.
- [3] Mohamad Syahmi Shahrom, 2012 "Taguchi Method Approach on Effect of Lubrication Condition on Surface Roughness in Milling Operation", Malaysian Technical Universities Conference on Engineering & Technology.
- [4] D.V. Lohar and C.R. Nanavaty, 2013 "Performance Evaluation of Minimum Quantity Lubrication (MQL) using CBN Tool during Hard Turning of AISI 4340 and its Comparison with Dry and Wet Turning", *Bonfring International Journal of Industrial Engineering and Management Science*.
- [5] Md. Imran Ansari, 2013 "Study of the Effect of Minimum Quantity Lubrication on the Surface Roughness of Incoloy 800 during Turning Operation", *International Journal of Mechanical Engineering and Research*.
- [6] Kedare S. B, 2014 "Effect of Minimum Quantity Lubrication (MQL) on Surface Roughness of Mild Steel of 15HRC on Universal Milling Machine", *Procedia Materials Science* 6.
- [7] Ibrahim Deiab, 2014 "Analysis of Lubrication Strategies for Sustainable Machining during Turning of Titanium Ti-6Al-4V alloy", *Procedia CIRP* 17.
- [8] D. Biermann, 2012, "Thermal Aspects in Deep Hole Drilling of Aluminum Cast Alloy Using Twist Drills and MQL", 45th CIRP Conference on Manufacturing Systems.
- [9] E. A. Rahim, 2015 "Experimental Investigation of Minimum Quantity Lubrication (MQL) as a Sustainable Cooling Technique", 12th Global Conference on Sustainable Manufacturing.
- [10] Jagadish, 2014, "Cutting Fluid Selection for Sustainable Design for Manufacturing: an Integrated Theory", 3rd International Conference on Materials Processing and Characterization.
- [11] Parash Kalita, 2012 "Study of specific energy and friction coefficient in minimum quantity lubrication grinding using oil-based nano lubricants", *Journal of Manufacturing Processes*.
- [12] Y. R. Ginting, 2015, "Investigation into alternative cooling methods for achieving environmentally friendly machining process", The 22nd CIRP conference on Life Cycle Engineering.