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Review Article

A REVIEW ON MQL IN REAMING

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Modern era of mass production of holes with good surface finish and geometrical accuracy (cylindricity, roundness) is the basic requirement for precise assembly of different machined components. Even in today's industrial era, most of the machining operations are performed using flood lubrication but flood lubrication contributes to adverse health effect and safety issues, including toxicity, lung diseases to operator and air pollution, etc. Because of this mentioned issues the use of cutting fluid needs to be minimized and hence the Minimal Quantity Lubrication (MQL) technology was introduced. MQL is the process to apply minute amount of lubrication to the tool tip during machining. The lubricant is mixed with compressed air and forms aerosol mixture called as MQL. Conventional cutting fluids (flood lubrication) eliminate such problems as higher cutting temperature, tool wear and greater dimensional deviation. But, they possess a significant portion of the total machining cost. Thus machining under Minimum Quantity Lubrication (MQL) condition has drawn the attention of researchers as an alternative to the traditionally used flood lubrication with a view to minimizing the cooling and lubricating cost as well as reducing cutting zone temperature, tool wear, surface roughness and dimensional deviation. It was observed that the use of MQL technology resulted in decrease of overall cost by about 13% and it is possible to achieve effective lubrication of cutting process with extremely small quantity of oil. The result is not only high productivity but also longer tool life and cost saving.

Keywords: Reaming, Minimum Quantity Lubrication (MQL)

INTRODUCTION

Cutting fluids applied in machining provide lubrication and cooling, minimizing the heat produced between the surface of the workpiece and the tool and the contact area between tool and chip. However, during the last decade, a significant research has been undertaken with the aim of diminishing the quantity of cutting fluids applied in production, due to the fact that the use of large amounts of

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cutting fluids brings several drawbacks. Cutting fluids can be difficult and expensive to recycle; they can cause skin and lung diseases to the operator and cause air pollution.

Other reasons for decreasing the quantity of cutting fluids are the costs related to the fluids, which have been evaluated to be in the range 7-17% of the overall manufacturing costs (De Chiffre *et al.*, 2009).

The necessity to machine using less harmful cutting fluids has prompted many researchers to investigate the use of minimum quantity lubrication. In order to minimize the use of cutting fluids and to fulfill the demands concerning health work environment, the Minimal Quantity Lubrication (MQL) technology was introduced (Nourredine Boubekri and Vasim Shaikh, 2012).

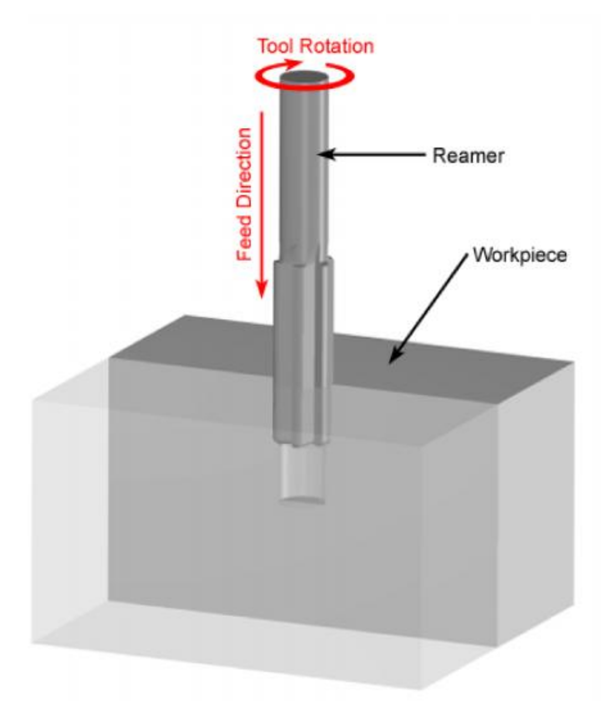
MQL is a machining method that delivers a precise amount of lubrication to the tool tip. The lubricant is mixed with compressed air and forms the desired air/oil aerosol mixture. By using MQL it is possible to achieve effective lubrication of the cutting process with extremely small quantities of oil. The result is not only higher productivity due to faster cutting speeds but also longer tool life and cost savings on cooling lubricants. By abandoning conventional cooling lubricants and taking into account only the use of this new technology, costs can be reduced significantly.

REAMING OPERATION

Reaming is a common machining process with the characteristic property of enlarging, smoothing and accurately sizing existing holes to tight tolerances. The quality of the hole depends on reamer geometry, cutting conditions, application, stock removal, lubrication and the quality of the holes to be reamed. Reaming is a finishing operation which normally follows drilling or core drilling. Since stock removal is small and must be uniform in reaming, the starting holes (drilled or otherwise produced) must have relatively good roundness, straightness, and surface finish.

Reamers tend to follow the existing centerline of the hole being reamed. If insufficient stock removal is left in the hole before reaming, the reamer can wear faster than normally and result in loss of diameter accuracy. In general applications, average surface roughness for reaming is expected to be in range between 0.8 mm and 3.2 mm but high-accuracy reaming can produce average surface roughness as low as 0.4 mm (De Chiffre *et al.*, 2009). Currently, there is a wide scale evaluation of the use of Metal Working

Figure 1: Reaming Operation

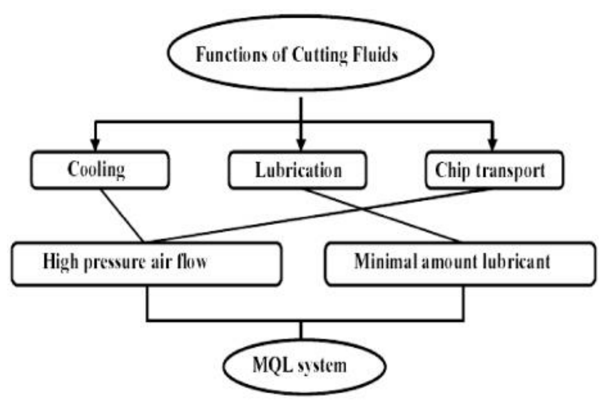


Fluids (MWFs) in machining. Industries are looking for ways to reduce the amount of lubricants in metal removing operations due to the ecological, economical and most importantly occupational pressure (Khan *et al.*, 2009). Cutting fluids, especially fluids containing oil, have become a huge problem due to the health and environmental hazards they pose. Driven by an increased awareness of environmental and health issues, industry has made efforts to eliminate or reduce their consumption of these fluids. This can be achieved by implementing near-dry machining or a Minimal Quantity of Lubrication (MQL) approach. In dry machining, increased friction and adhesion occur at the tool-workpiece interface which results in a high tool wear rate. In contrast, the MQL technique involves the application of a small quantity of lubricant that is dispensed to the tool-workpiece interface by a compressed air flow. It has been found that MQL reduces the friction coefficient and cutting temperature compared to dry and flood conditions.

CONCEPT OF MQL

Minimum Quantity Lubrication (MQL) is a machining method that delivers a precise amount of lubrication to the tool tip. The lubricant is mixed with compressed air and forms the desired air/oil aerosol mixture. MQL, 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 on the basis of their contributions to cutting performance. In MQL however, secondary characteristics are important. These include their safety properties, (environment pollution and human contact), 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 workpiece surface integrity in situations of high tool pressure (Nourredine Boubekri and Vasim Shaikh, 2012).

Figure 2: Cutting with Minimal Quantity Lubrication



A classification of lubrication based on oil usage per time unit is given in Table 1 (De Chiffre *et al.*, 2009).

Table 1: Lubrication Types in Terms of Flow Rate

Flow Rate (ml/h)	Lubrication Type
0	Dry
<80	Minimal quantity lubrication
80-2000	Minimal flow lubrication
>2000	Flood lubrication

Types of MQL Systems

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 drop outs, 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 (Nourredine Boubekri and Vasim Shaikh, 2012).

MQL Working Principle

The figure below shows a two-channel MQL system for through spindle (Internal) lubrication.

Figure 3: Through Spindle Internal Lubrication

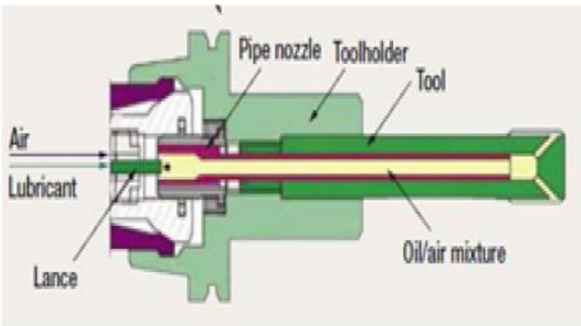
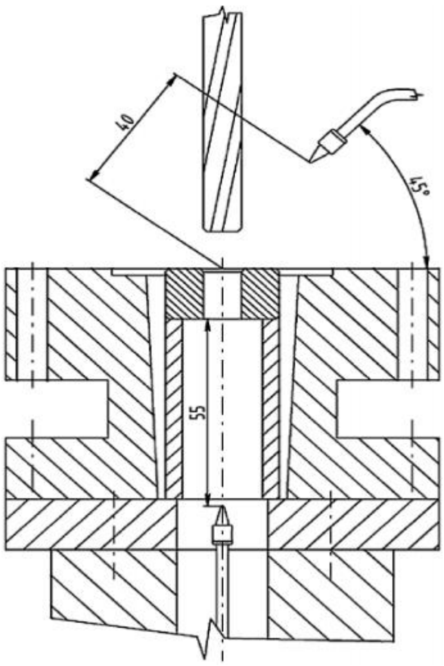


Figure 4: MQL Application Strategy TB



In a two-channel system, the precise amount of oil is transported through a lance to a pipe nozzle located at the tool holder's base. As lubricant moves through the lance and into the pipe nozzle, air supplied through the rotary transmission travels down the spindle coolant tube that encapsulates the lance to the mixing chamber of the pipe nozzle, where it combines with fluid to form an aerosol.

LITERATURE REVIEW

Leonardo De Chiffre and S. Muller (2009) investigated the capability of reaming process using minimal quantity lubrication. He studied the influence of some parameters on the hole quality (diameter, roundness, cylindricity and surface roughness) and cutting forces (reaming thrust and torque) in reaming of austenitic stainless steel. These parameters include reamer diameter (i.e., depth of cut of 0.10 and 0.05 mm), cutting speed at 5 and 6 m/min, feed (i.e., feed rate at 49.7 and 33.1 mm/min), type of feed (return of the tool after machining completion, i.e., slow and rapid) and Minimal Quantity Lubrication application. It was observed that a higher feed rate leads to higher process repeatability in terms of Ra. A rapid reverse feed rate is not producing a worse surface finish and it is therefore preferable in order to decrease machining time and enhance productivity. In particular, it was observed that smaller depth-of-cut 0.05 mm, TT application strategy (both nozzles delivering from the top of the workpiece being reamed) and higher cutting speed at 6 m/min lead to a less even surface of the hole, especially on the bottom position. MQL in reaming leads to high quality results in terms of hole dimensions and surface finish (De Chiffre *et al.*, 2009).

Nazmul Ahsan evaluated the performance of Minimum Quantity Lubrication (MQL) in drilling operation. He experimentally observed the performance of MQL in drilling AISI 1040 steel by HSS drill and concluded that roundness deviation was smaller under MQL condition compared to dry and wet conditions. When high depth of cut was employed, the drilling with dry condition was not possible because of poor cooling and lubrication action. MQL may be attributed to effective lubricating action, which prevented chip sticking on the tool and made the cut favorable (Nazmul Ahsan and Md. Golam Kibria, 2010).

Nourredine Boubekri and Vasim Shaikh (2012) reviewed different literatures available on MQL and commented on different physical phenomenon related to MQL. He concluded that the process of mist particles generation and their physical characteristics are yet to be determined for a whole class of machining processes and machining conditions (Nourredine Boubekri and Vasim Shaikh, 2012).

Khan performed experiments on alloy steel with vegetable oil based cutting fluid and found that the present MQL system enabled reduction in the average chip-tool interface temperature up to 10% as compared to wet machining depending upon the cutting conditions and even such apparently small reduction, unlike common belief, enabled significant improvement in the major machinability indices. The chips produced under both dry and wet condition are of ribbon type continuous chips at lower feed rates and more or less tubular type continuous chips at higher feed rates. When machined with MQL the form of these ductile chips did not change appreciably but their back surface appeared much brighter and smoother. This indicates that the amount of reduction of temperature and presence of MQL application enabled favorable chip-tool interaction and elimination of even trace of built up edge formation. Surface finish also improved mainly due to reduction of wear and damage at the tool-tip by the application of MQL (Khan *et al.*, 2009).

Bezerra (2001) focused on the effect of machining parameters when reaming Aluminum-Silicon (SAE 322) alloy on dimensional stability and surface roughness of reamed cylindrical holes using K10 cemented carbide welded blade reamer. The input parameters depth of cut, cutting speed, feed rate, helix angle, number of blades, margin size and rake face finishing of reamer were individually varied. The test result shows that satisfactory hole quality can be achieved during reaming by employing smaller depth of cut 0.2 and 0.3 mm, lower cutting speed of 25 mm/min, higher feed rates between 0.20 and 0.40 mm/rev as well as straight flute reamers with many blades and small margins (0.20 mm). Reaming at higher feed conditions improves the accuracy of holes produced at the expense of an increase in power consumption and deterioration in the surface finish generated (Bezerra *et al.*, 2001).

Ali focused on effect of MQL on cutting performance in turning medium carbon steel by uncoated carbide insert at different speed feed combinations. He found that the MQL system enable the significant improvement in productivity, product quality and overall machining economy. It also increases the dimensional accuracy and surface finish (Ali, 2011).

Thakur *et al.* (2009) investigated the optimization of minimum quantity lubrication parameters in high speed turning of Superalloy Inconel 718 for sustainable development. Minimum Quantity Lubrication (MQL) under pulsed jet mode proved to be an effective approach for low thermal conductivity and specific heat difficult-to-cut material superalloy Inconel 718 material. Also MQL under pulsed jet mode protects the operator's health and reduces the detrimental effects on the environment (Thakur *et al.*, 2009).

CONCLUSION

High costing and environmentally hazardous nature of conventional methods of lubrication (flood lubrication) resulted in development of new technique of lubrication known as Minimum Quantity Lubrication. Although the technique of MQL resulted in significant advantages related to cost and environment friendly nature of machining operations, the processes of lubrication and cooling in MQL are yet to be well understood. The effect of MQL parameters on the surface quality, power consumption and nature of tool wear needs to be explored in a wide manner. According to the various literatures, the use of MQL resulted in cost savings on cooling lubricants along with the longer tool life and high productivity.

REFERENCES

1. Ali S M (2011), "Effect of MQL on Cutting Performance in Turning Medium Carbon Steel by Uncoated Carbide Insert at Different Speed Feed Combinations", *Advances in Production Engineering and Management*, Vol. 3, pp. 185-196.
2. Bezerra A A, Machado A R, Souza A M and Ezugwu E O (2001), "Effect of

Machining Parameters When Reaming Aluminium-Silicon (SAE 322) Alloy", *Journal of Materials Processing Technology*, Vol. 112, pp. 185-198.

3. De Chiffre L, Tosello M and Muller P (2009), "Investigation on Capability of Reaming Process Using Minimal Quantity Lubrication", *CIRP Journal of Manufacturing Science and Technology*, Vol. 2, pp. 47-54.
4. Khan M M M, Mithu M A H and Dhar N R (2009), "Effect of Minimum Quantity Lubrication on Turning AISI 9310 Alloy Steel Using Vegetable Oil-Based Cutting Fluid", *Journal of Material Processing Technology*, Vol. 209, pp. 5573-5583.
5. Nazmul Ahsan A M M and Md. Golam Kibria (2010), "Performance Evaluation of Minimum Quantity Lubrication (MQL) in Drilling Operation" International Conference on Mechanical, Industrial and Energy Engineering.
6. Nourredine Boubekri and Vasim Shaikh (2012), "Machining Using Minimum Quantity Lubrication: A Technology Sustainability", *International Journal of Applied Science & Technology*, Vol. 1, pp. 111-115.
7. Thakur D G, Ramamoorthy B and Vijayaraghavan L (2009), "Optimization of Minimum Quantity Lubrication Parameters in High Speed Turning of Superalloy Inconel 718 for Sustainable Development", *World Academy of Science, Engineering and Technology*, Vol. 54.