International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com, Special Issue 42 (AMBALIKA) (March 2017), PP. 84-87

A REVIEW ON MINIMUM QUANTITY LUBRICATION FOR MACHINING OPERATIONS

[1] Hina Nigar,[2]Faizan Hasan
[1] Research Scholar, [2]Assistant Professor,
[1,2] Integral University Lucknow

Abstract— **Minimum quantity lubrication is a possible solution for the optimum lubrication system. This is an alternative between wet and dry machining. In minimum quantity lubrication system, a very small amount of lubricant is used. In this paper, the studies about minimum quantity lubrication was examined. the selection criteria of cutting fluid have been examined. various MQL systems for machining. choosing suitable lubricants for various machining operations have been determined according to cutting tool materials.**

Index Terms— MQL; Machining; Cutting fluid; Lubricant.

I. INTRODUCTION

Machining can be defined as a process which is used techniques 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. With the supply of cutting fluids, friction between tool and work piece is also minimised. Basically cutting fluids are used for effectively cooling and lubrication to reduce the friction between tool and work piece. [1]

There are several functions of cutting fluids

- Cooling and cleaning
- Lubrication
- Improves tool life
- Flushing away the chips
- Improves surface finish
- Prevention of corrosion.

Flood coolant system is the conventional system of applying the coolant. In conventional system a bulk jet of cutting fluid is applied on the cutting zone. Flood system is highly uneconomical.it has also the problems of reachability of cutting fluid. [1]

II. CUTTING FLUIDS CHARACTERISTICS [2]

Basically cutting fluids have three characteristics. These are:

- Cooling effect
- Lubrication effect
- Flushing away chips from the cutting zone.

In machining operation, cooling effect of cutting fluids are considered as a very important parameter [2]. In high speed cutting, the large fluctuation of cutting temp could cause thermal cracks on the cutting edge which leads to failure of cutting tool [3]. By using suitable cutting fluids, temp fluctuations are minimised. Due to less tool, a longer tool life will be obtained. And it will also improve the dimensional accuracy of machined workpiece. [2]

The friction coefficient being low, the lubrication effect can cause easy chip flow on the rake face of cutting tool. Lubrication causes less build-up edge in machining of materials which results in better surface roughness.

Once the chip is formed it is to be quickly flushed away from cutting tool and machined work piece surface. [2]

III. SELECTION CRITERIA OF CUTTING FLUIDS

Selection of suitable cutting fluid is greatly depending on these factors.

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

IV. MINIMUM QUANTITY LUBRICATION

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. It is the process of applying a very small quantity of cutting fluid directly into the cutting zone. This technique is best suited for cutting process like sawing drilling milling turning n tapping etc.

A very small quantity of lubricant is atomised in an air flow towards the cutting zone with a flow rate of 50 to 500 ml/hr. an external supply system with one or more nozzles is used to spray the lubricant to the cutting zone. Very small quantity of lubricant is used in MQL system in comparison of conventional system. It considered as a near dry process with less than 2% of the fluid adhering to the chips. This is not the same as near dry machining where no fluid is used but both share the characteristics of needing no reclamation equipments. This eliminates investment into sump, recyclers containers pump and filtration devices. There is no cost for cleaning and drying the chips before their disposal or cleaning the work piece before to the next process. [4]

In comparison of conventional method, MQL is a total loss lubrication method. This means only new and clean lubricant is used. A good MQL lubricant has a very high viscosity.

For the best implementation of MQL it is vital to have comprehensive information about core elements in advance. That is

- MQL system

- Machining process
- Tool, lubricant
- Machine tool
- Machine operator

Reliable machining is achieved when the lubricant, tool, metering devices and machine all are suitable for MQL and optimally adjusted to each other and these elements are compatible with each other. [4]

V. MQL SYSTEMS

Basically MQL system is used for the supply of an appropriate lubricant to the contact point of the tool and workpiece. Different systems are available for this purpose. The coolant with MQL can be supplied in two different ways:

- External feed system
- Internal feed system

A. External feed system

The external feed system consists of a coolant or reservoir which is connected with the spray nozzles. The system can be assembled near or on the machine and has independently adjustable air and coolant flow for balancing coolant delivery. [4] this system is suitable for retrofitting machine tools, because the required nozzle can be easily fitted on the spindle head. This system is suitable for single process like sawing, turning, drilling etc. [5]

B. Internal feed system

Using internal feed system, the lubricant is supplied through the machine spindle, the tool holding system, and the tool directly on the cutting edge. This allows an optimum moistening of the involved components at the point of application. The group of MQL systems with internal supply is divided into one-channel and two-channel MQL systems. In case of the one-channel systems, the aerosol is mixed outside the spindle, whereby the lubricant of a two channel system is mixed directly inside the spindle. [3]

VI. LUBRICANTS FOR MINIMUM QUANTITY LUBRICATION [5]

When choosing a suitable MQL lubricant, the user should take into account the criteria below.

a. Smell - The smell of the lubricant is not inconsequential. Spraying the lubricant can cause the smell to be intensified.
b. Spray ability - The lubricant should spray easily and, especially with 1-channel systems, be able to produce a stable aerosol (oil-air mixture).
c. Additives - The additives should be adjusted to the processing requirements, particularly when processing non-ferrous metals and difficult-to-cut steels.
d. Residues on machine parts - Despite minimum spray amounts and the use of extraction devices, lubricants may leave residues on work pieces and machine parts. The lubricant should not resinate and should be easy to clean off if necessary.
e. Viscosity range - Practical experience shows that the best results with lubricants (ester or fatty alcohol) are achieved at a viscosity range of 15 to 50 mm2/s and in some cases up to 100mm2/s at 40 °C. Upper viscosity limits should be discussed with the MQL system manufacturer (check device suitability for spray ability). In general, the MQL system and lubricant should be compatible with each other
f. Lubricant change - Before a new lubricant is used, the system should be completely drained and flushed. The flushing process should be performed with the new lubricant.
g. Corrosion protection - A check should be made as to whether the thin MQL residual film on the workpiece after machining offers corrosion protection that meets the requirements or whether additional corrosion protection is necessary.

VII. ADVANTAGES OF MQL: [5]

A. Financial advantages

- Due to the omission of supply and disposal of coolant, high savings are possible.
- After optimization of processes, a higher tool life can be expected.
- Optimized processes reduce the machine cycle time up to 30 %.
- Purchase, warehousing and transportation costs as well as disposal costs of the coolant will be reduced considerably.
- There will be no expenditures for control and care of coolant.
- Depending on the application, extensive follow-up processes for cleaning/washing of the workpieces will be reduced or can be completely eliminated.
- Compared to wet metal chips, which are treated like hazardous waste, dry metal chips can be sold as recycling material.

Ecological advantages

- No used emulsions will accumulate.
- Accidents due to large quantities of leaking coolant are avoided.
- Due to a dry machine, the risk of accidents at work are reduced.
- Airway or skin diseases caused by coolants can be avoided.

Studies on Minimum Quantity Lubrication

- Samantham madhukar et al, 2016: This paper shows that minimum quantity lubrication does generate a significant amount of mist compared to flood cooling. By 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.

- The -Vinh Do et al, 2016: In this study, hard milling operation was performed on AISI H13 Steel. The Taguchi method and ANOVA were applied to optimize minimum

quantity lubrication condition for surface roughness. And best cutting parameters were obtained in order to get improve the surface roughness under MQL condition's optimization. A regression model was established for surface roughness. the value of cutting speed, feed rate, depth of cut was 70 m/min, 0.1 mm/tooth, 0.2mm, respectively. The MQL flow was 50 ml, and the 3 kg/cm2 provided the best results for surface roughness. The lubricant used was the water soluble oil. The linear regression model is considered to be satisfactorily significant.

• A. Cakir et al,2016: this paper shows an experimental study of MQL system, was applied in the turning of AA7075 and AA2024 aluminium alloys. both samples were subjected to four different cutting speeds (150,187.5,240and300m/min), with two different federates (0.1and0.2mm/rev) and four different flow rates(0.25,0.45,0.90and3.25ml/min). the result shows that surface roughness values increases when increasing feed rate and Increasing flow rate decreases surface roughness values and had a positive effect on the surface quality. The effect of the flow rate on the surface quality was greater at a high feed rate. When comparing both alloys the surface quality of AA2024 was found to be better than that of AA7075.

• Mahmood Al Bashir, 2016: This experiment was performed in milling hardened AISI 4140 steel of hardness 40 HRC. The study shows comparison of MQL with dry machining. to ensure that the cutting fluid can be applied in different timed pulses and quantities at critical zones, The MQL was impinged into the form of pulse jet, by using pulse jet attachment. In comparison of dry machining, MQL gives better performance. MQL in high speed milling to increase tool life, reduce tool wear, reduce cutting force generation and promote better surface finish.

• Jeewan Singh, Tarjeet Singh, Aneesh Goyal, 2015: This paper gives a review on the mechanical performance of minimum quantity lubrication compared to completely dry and flood lubrication for various machining operations. These researches shows that MQL system provides better performance than dry machining and flood system can be replaced by the MQL. And due to their environmental friendly characteristics, MQL is found to be alternative for dry n flood machining. Thus minimising pollution and improving health & safety.

• Vishal S. Sharma, Gur Raj Singh & Knut Sorby,2015 This article reviews various MQL methods used by various machining processes like turning, milling, drilling, grinding for different materials. It also highlights the future work directions for research in this area.

• Nourredine Boubekri, Vasim Shaikh,2015: The objective of this paper is to review the state of the art literature in machining using MQL, include its benefits, and focused the adverse health effects of using minimum quantity lubrication. And also highlight areas of relevant future research.

• Hasan M F et al,2014: This paper presents the effects of minimum quantity lubrication (MQL) by vegetable oil based cutting fluid on the turning performance of low alloy steel as compared to completely dry and wet machining in terms of chip–tool interface temperature, chip formation mode, tool wear and surface roughness.

• Sunday Albert Lawal et al, 2013: This paper presents the application of vegetable oil based cutting fluid for the machining of nonferrous metals. Its efficiency based on process parameters of some non-ferrous metal (Titanium alloy, aluminium and copper, brass and aluminium) using different tool matrials.

• Vaibhav Kaushik. A.V, Narendra Shetty.S & Ramprasad.C, 2012: It shows that vegetable oils have become identified world over as a potential source of environmentally favourable metal working fluids due to a combination of biodegradability, renewability and excellent lubrication performance.

• Ali, S.M. Dhar, N.R. & Dey, S.K, 2011: This paper deals with experimental investigation on 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 insert.

• Young Kug Hwang et al, 2010: this paper presents 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 analysing 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. study shows that MQL turning has more advantages than wet turning.

CONCLUSION

These literatures clearly reveal that MQL system provides better performance than dry machining. These researches show that the flood system can be replaced by the MQL system. MQL has reduced the cutting force, provided efficient cooling at the shear zone which reduces temp, provided proper lubrication and retention of tool sharpness for long period of time. Improved Surface finish due to reduction of wear and damage at tool tip by minimum Quantity lubrication.

References

[1] Vishal S. Sharma, Gur Raj Singh & Knut Sorby, December 2015. A Review on Minimum Quantity Lubrication for Machining Processes, Tailor& swift. Materials and Manufacturing Processes, 30: 8,935-953, DOI: 10.1080/10426914.2014.994759, 2015.

[2] O. Çakīr*, A. Yardimeden, T. Ozben, E. Kilickap Selection of cutting fluids in machining processes, JAMME, volume 25 Issue, 2 December 2007.

[3] Jeewan Singh, Tarjeet Singh, Aneesh Goyal, Influence of MQL Technique in Machining Evaluation: A Review and Applications International

journal of Engg Sciences & Research Technology ISSN: 2277-9655(I2OR), Publication Impact Factor: 3.785 ISSN: 2277-9655, 2015.

[4] Tim Walker, The MQL Handbook, A guide to machining with minimum quantity lubrication Units, Inc. V1.0.7,2015.

[5] Samatham Madhukar*, Aitha Shravan, Pakka Vidyanand and G. Sreeram Reddy, A Critical review on Minimum Quantity Lubrication (MQL) Coolant System for Machining Operations International Journal of Current Engineering and Technology Vol.6, No.5, Oct 2016.

[6] Hasan M F, Dwivedi A, Study and Analysis of Natural Oil Based Cutting Fluids Using Minimum Quantity Lubrication System for Alloy Steel, IJPRET, Volume 3 (2): 50-68,2014.

[7] Sunday Albert Lawal, A Review of Application of Vegetable Oil-Based Cutting Fluids in Machining Non-Ferrous Metals, Indian Journal of Science and Technology Vol: 6 Issue: ISSN:0974-6846, 1 January 2013.

[8] Nourredine Boubekri, Vasim Shaikh, Minimum Quantity Lubrication (MQL) in Machining: Benefits and Drawbacks, journal of Industrial and Intelligent Information Vol. 3, No. 3, September 2015.

[9] Vaibhav Kaushik, Narendra Shetty.S & Ramprasad.C, Vegetable Oil Based Cutting Fluids-A Review International Journal on Theoretical and Applied Research in Mechanical Engineering (IJTARME) ISSN (Print): 2319-3182, Volume-1, Issue-1, 2012.

[10] Ali, S.M. Dhar, N.R. & Dey, S.K. Effect of Minimum Quantity Lubrication (MQL) On Cutting Performance in Turning Medium Carbon Steel by Uncoated Carbide Insert At Different Speed-feed Combinations, Advances in Production Engineering & Management, 185-196 ISSN 1854-6250,2011.

[11] L B Abhang and M. Hameedullah, Experimental Investigation of MQL in Alloy Steel Turning, International Journal of Engineering Science and Technology. 2(7), 3045-3053, 2010.

[12] Mahmood Al Bashir, Mozammel Mia1, Nikhil Ranjan Dhar, Investigations on Surface Milling of Hardened AISI 4140 Steel with Pulse Jet MQL Applicator, Springer, DOI 10.1007/s40032-016-0277-2, 2016.