www.ijmer.com Vol.1, Issue1, pp- 203-209 ISSN: 2249-6645

Experimental Investigation on the Role of MQL and its Effects on Tool Wear in Turning of mild Steel

N.B.BORKAR[1] ,Dr.S.S.CHAUDHARI[2],A.B.AMALE[3]
*(Department of Mechanical Engg.Yashwantrao Chavan College of Engineering Nagpur, Maharashtra., India).
**(Department of Mechanical Engg. Yashwantrao Chavan College of Engineering Nagpur, Maharashtra. India.)
***(Department of Mechanical Engg. Yashwantrao Chavan College of Engineering Nagpur, Maharashtra ,India.)

ABSTRACT

In present study it has been surveyed that, the metal industries using the cutting fluid has become more problematic in terms of both employee health and environmental pollution. But the use of cutting fluid generally causes economy of tools and it becomes easier to keep tight tolerances and to maintain work piece surface properties without damages. Because of them some alternatives has been sought to minimize or even avoid the use of cutting fluid in machining operations. The preferable alternative selected for the present work is the machining with minimum quantity of lubrication (MQL). The growing demands for high productivity of machining need use of high cutting velocity and feed rate. Such machining inherently produces high cutting temperature, which not only reduces tool life but also impairs the product quality. Metal cutting fluids changes the performance of machining operations because of their lubrication, cooling, and chip flushing functions. Hence some alternatives have been sought to minimize or even avoid the use of cutting fluid in machining operations. Some of these alternatives are dry machining and machining with minimum quantity of lubrication (MQL). There was no formation of built up edge at tool due to reduction in the heat and flushing of the chips away from the tool edge. The MQL can able to subsidize the heat generated. This paper deals with experimental investigation on the role of MQL on cutting temperature, tool wear in turning of mild steel at industrial speed-feed combinations by H.S.S cutting tool. The encouraging results include significant reduction in cutting temperature, tool wears by MQL mainly through favorable chip-tool and work-tool interaction.

Keywords – **Chip-tool ,Dry machining , H.S.S, MQL, Work-tool interface etc.**

1.Introduction

High production machining of steel inherently generates high cutting zone temperature. Such high temperature causes dimensional deviation and serious failure of cutting tools. It also impairs the surface integrity of the product by inducing tensile residual stresses and surface and subsurface micro cracks in addition to rapid oxidation and corrosion [1,3,4]. Currently, this problem is tried to be controlled by reducing heat generation and removing heat from the cutting zone through optimum selection of machining parameters, proper cutting fluid application and using heat resistant cutting tools. For the companies, the costs related to cutting fluids represent a large amount of the total machining costs. Several research workers state that the costs related to cutting fluids are frequently higher than those related to cutting tools. Consequently, elimination on the use of cutting fluids, if possible, can be a significant economic incentive .In machining, conventional cutting fluid application fails to penetrate the chip- tool interface and thus cannot remove heat effectively. The high pressure jet of soluble oil, when applied at the chip-tool interface, could reduce cutting temperature and improve tool life to certain extent [2,3]. MQL is assisting on the economical front. Dry machining operations are now of great interest and, actually, they meet with success in the field of environmentally friendly manufacturing [6]. In reality, however, they are sometimes less effective when higher machining efficiency, better surface finish quality and severe cutting conditions are required. For these situations, semi-dry operations utilizing very small amounts of cutting lubricants are expected to become a powerful tool and, in fact, they already play a significant role in a number of practical applications [7,8]. Minimum quantity lubrication refers to the use of cutting fluids of only a minute amount-typically of a flow rate of 50 to 180 ml/hour which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition, where, for example, up to 10 liters of fluid can be dispensed per minute. The concept of minimum quantity lubrication, sometimes referred to as near dry lubrication [9] or micro-lubrication [10], has been suggested since a decade ago as a means of addressing the issues of environmental intrusiveness and occupational hazards associated with the airborne cutting fluid particles on factory shop floors. The minimization of cutting fluid also leads to economical benefits by way of saving lubricant costs and work -piece/tool/machine cleaning cycle time. The present work experimentally investigates the role of MQL on surface roughness, tool flank wear in turning at different speed combinations by high speed steel tool.

2 .Minimum Quantity Lubrication

2.1 Definition and Concept

The MQL needs to be supplied at high pressure and impinged at high speed through the spray painting gun on the cutting zone. Considering the conditions required for the present work and uninterrupted supply of MQL at a constant pressure of around 6 bar over a reasonably long cut, a MQL delivery system was designed, fabricated and used. The schematic view of the MQL set-up is shown in Fig 1.

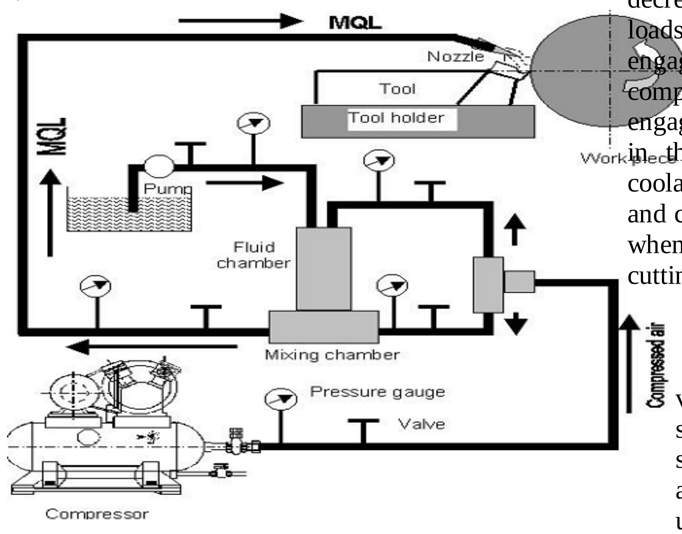

Figure .1Working of MQL system

Several research workers state that the costs related to cutting fluids are frequently higher than those related to cutting tools. Consequently, elimination on the use of cutting fluids, if possible, can be a significant economic incentive. Considering the high cost associated with the use of cutting fluids and projected escalating costs when the stricter environmental laws are enforced, the choice seems obvious. Because of them some alternatives has been sought to minimize or even avoid the use of cutting fluid in machining operations. Some of these alternatives are dry machining and machining with minimum quantity lubrication (MQL).

2.1.2 Working of MQL

High cutting zone temperature is generally tried to be controlled by employing flood cooling by soluble oil. In high speed–feed machining, conventional cutting fluid application fails to penetrate the chip-tool interface and thus cannot remove heat effectively and the use of cutting fluid has become more problematic in terms of both employee health and environmental pollution. Addition of extreme pressure additives in the cutting fluids does not ensure penetration of coolant at the chip–tool interface to provide lubrication and cooling . Minimum quantity lubrication (MQL) is based on the principle that a drop of liquid is split by an air flow, distributed in streaks and transported in the direction of flow of air. The consumptions of oil in industrial applications are in the range of the length of machining was increased wear by the tool increased. MQL consists of a mixture of pressurized air and oil micro- droplets applied directly into the interface between the tool and chips. However, the question of how the lubricants can decrease the friction under very high temperature and loads is still not answered especially for long engagements times. MQL decreased the contact length compared to dry cutting for both short and long engagement time. Addition of extreme pressure additives in the cutting fluids does not ensure penetration of coolant at the chip–tool interface to provide lubrication and cooling . However, high-pressure jet of vegetable oil, when applied at the chip–tool interface, could reduce cutting temperature and improve tool life to some extent.

In MQL machining, a small amount of vegetable oil or biodegradable synthetic ester is sprayed to the tool tip with compressed air. The mild steel work-piece machining with MQL arrangement as shown in fig.2, and fig.3 as the experimental set up.

www.ijmer.com Vol.1, Issue1, pp- 203-209 ISSN: 2249-6645

.

Figure.2 Photographic view of the experimental set-up Figure.3 Photographic view of mixing cup for turning

for turning steel with MQL operation

MQL machining is nearly equal or often better than the traditional wet machining in tool life and surface finish when cutting steels and aluminum alloys . A recent survey conducted on the production of the European automotive industry revealed that the expense of cooling lubricant comprises nearly 20% of the total manufacturing cost is referred in fig .4.

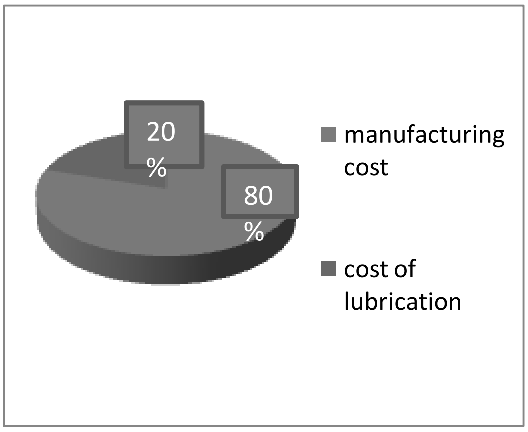

Figure.4 percentage disk for lubrication cost

In comparison to cutting tools, the cooling lubricant cost is significantly higher. As a result, the need to reduce cutting fluids consumption is strong. Furthermore, the permissible exposure level for metal-working fluid aerosol concentration is 5 mg/m3, according to the U.S. Occupational Safety and Health Administration (OSHA) [17], and is 0.5 mg/m3 according to the U.S. National Institute for Occupational Safety and Health (NIOSH) [17]. The oil mist level in U.S. automotive parts manufacturing facilities has been estimated to be generally on the order of 20-90 mg/m3 with the use of traditional flood cooling and lubrication [10]. This suggests an opportunity for improvement of several orders of magnitude. The minimal quantity lubrication (MQL) system is probably the most representative application of semi-dry machining. The purpose of this research work is to experimentally investigate the influence of MQL on cutting tool wear in turning mild steel at industrial speed–feed conditions by H.S.S. tool and compare the effectiveness of MQL with that of dry and wet machining.

3.EXPERIMENTAL CONDITIONS AND PROCEDURE

The present investigation used, mild steel of initial diameter (size: Ø20mm×80 mm) is plain turning, 3hp Lathe HSS (Miranda S-500) at industrial speed-feed combinations under dry, wet and MQL conditions. The experimental conditions are given in Table-1. The ranges of the cutting velocity (Vc) and feed rate (So) were selected based on the tool manufacturer's recommendation and industrial practices. Depth of cut, being a less significant parameter, was kept fixed.

Table1. : Experimental conditions

Machine tool:	3hp Lathe
Work-piece:	Mild Steel (size: Ø20mm× mm)
Cutting tool	HSS ,Miranda S-500
Working tool ometry	8^0, 8^0, 6^0, 6^0, 8^0, 12^0, 0.6 m)
Cutting velocity, Vc	63, 80, 93 m/min
Feed rate, *So*:	0.035,0.050 and 0.820 n/rev
Depth of cut, t:	0.8,0.85 and 1.0 mm
MQL supply:	Air: 6 bar, Lubricant: 200 /h
Environment:	Wet (flood cooling) inimum Quantity lubrication QL)

3.1 Tool Wear

Productivity and economy of manufacturing by machining are significantly influenced by life of the cutting tools. Cutting tools may fail by brittle fracturing, plastic deformation or gradual wear. Turning steel having enough strength, toughness and hot hardness generally fail by gradual wears. With the progress of machining the tools attain crater wear at the rake surface and flank wear at the clearance surfaces, as schematically shown in Fig.3 due to continuous interaction and rubbing with the chips and the work surfaces, respectively.

3.1.1 Crater Wear

The crater wear is usually avoided by selecting a cutting speed and tool material that does not have an affinity to diffusion with the work material . The flank wear, on the other hand, leads to loss of cutting edge, and affects the dimension and surface finish quality. Crater wear occurs on the rake face of the tool where the chip moves under friction and normal loads at elevated temperatures, leading to wear. Since all cutting edges have a finite sharpness, the friction between the flank face of the cutting tool and the freshly cut work surface causes flank wear. The cutting tool wear is well-known affecting the tool life and the surface quality of the finished product. When tool wear is beyond a certain threshold, the tool fails catastrophically due to excessive stresses and rising thermal within the tool edge caused by large friction forces.

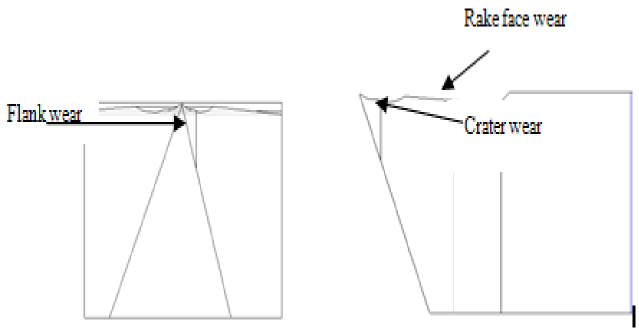

Figure.5 Photographic view of the crater wear

the MQL has reduced tool wear. remarkably in machining mild steel. This is reasonably attributed to extremely lubrication provided by the MQL jet, which could, at least partially, reach the work-tool interfaces, unlike chip-tool interface is shown in fig.4. The deep grooves parallel to the cutting edges of the insert are likely to help entry of larger fraction of the MQL jet at the flank surfaces.

3.1.2 Flank wear

Among the aforesaid wears, the principal flank wear is the most important because it raises the cutting forces and the related problems. The life of carbide tools, which mostly fail by wearing, is assessed by the actual machining time after which the average value (VB) of its principal flank wear reaches a limiting value, like 0.3 mm. Therefore, attempts should be made to reduce the rate of growth of flank wear (VB) in all possible ways without sacrifice in MRR. During the machining process, the cutting tools are loaded with the heavy forces resulting from the deformation process in chip formation and friction between the tool and work-piece. The heat generated at the deformation and friction zones overheats the tool, the chip and partially the work-piece. All the contact surfaces are usually clean and chemically very active; therefore the cutting process is connected with complex physical-chemical processes. Wear on the tool, which occurs as the consequence of such processes, is reflected as progressive wearing of particles from the tool surface.

www.ijmer.com Vol.1, Issue1, pp- 203-209 ISSN: 2249-6645

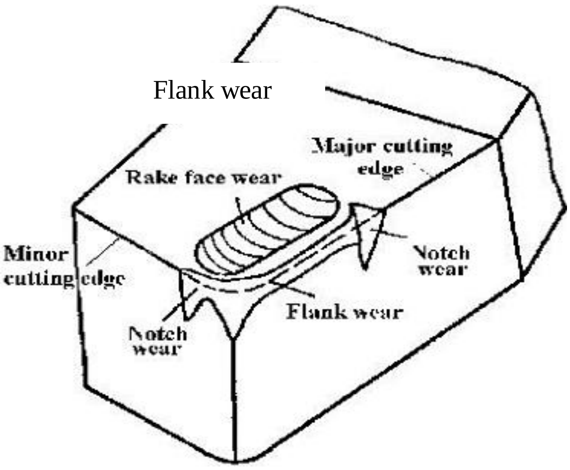

Figure.6 Photographic view of the flank wear

In machining research, a cutting tool is generally said to have failed when its V reaches a specific value, mostly 0.3 mm. It is very important to note in Fig.4 that tool life has improved from 31 min to 48 min, i.e. almost by one and half times increase in tool life have been possible by MQL. Fig.4 also depicts how flank notch wear, V remarkably decreased due to MQL. Deep notching, if forms, not only raises cutting forces but also may cause catastrophic tool failure prematurely and randomly, which is extremely harmful and undesirable for the present days' sophisticated and expensive manufacturing systems. So, proper MQL is expected also to enhance reliability and safely of machining processes and systems.

4.Result and Discussion

MQL in the form of thin but high speed was impinged from a specially designed nozzle along the auxiliary cutting edge of the H.S.S. cutting tool and mild steel round work piece interface . The MQL jet has been used mainly to target the rake surface and flank surface along the auxiliary cutting edge and to protect the auxiliary flank to enable better dimensional accuracy. MQL is expected to provide some favorable effects mainly through reduction in cutting temperature by making the thermal conductive film at work-tool chip interface at experimental trial on wet and MQL condition . With the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted. Finally, a confirmation experiment is conducted to verify the optimal process parameters obtained from the parameter design. In this paper, the cutting parameter design by the Taguchi method is adopted to obtain optimal machining performance in turning. The reliable tool-work minimum quantity lubrication technique with proper combination has been employed to measure the average tool wear, surface roughness during turning of mild steel by the HSS as shown in table.1,table.2,table.3.

4.1.Experimentation results of mild steel turning tool wear dry ,wet , MQL condition.

Table 1. Experimentation results of Dry condition

EX. No.	Cutting Speed (m /min)	Feed ate (mm /rev)	Dept of ut (mm)	Tool wear $V_{B,}$mm
1	63	0.16	0.8	0.2
2	80	0.55	0.85	0.24
3	93	0.24	1.0	0.31

Table 2. Experimentation results of Wet condition

EX. No.	Cutting Speed (m /min)	Feed rate nm /rev)	Dept of :ut (mm)	Tool ear $V_{B,}$mm
	63	0.16	0.8	0.35
2	80	0.55	0.85	0.39
3	93	0.24	1.0	0.43

Table 3. Experimentation results of MQL condition

EX. No.	Cutting Speed (m /min)	Feed rate (mm /rev)	Dept of cut (mm)	Tool ar $V_{B,}$mm
1	63	0.16	0.8	0.21
2	80	0.55	0.85	0.19
3	93	0.24	1.0	0.24

www.ijmer.com Vol.1, Issue1, pp- 203-209 ISSN: 2249-6645

4.2 Graphical representation of an experimental results for dry , wet , MQL machining

The reliable tool-work minimum quantity lubrication technique with proper combination has been employed to measure the average tool wear, surface roughness during turning of mild steel by the HSS as shown in figure.7and figure8.

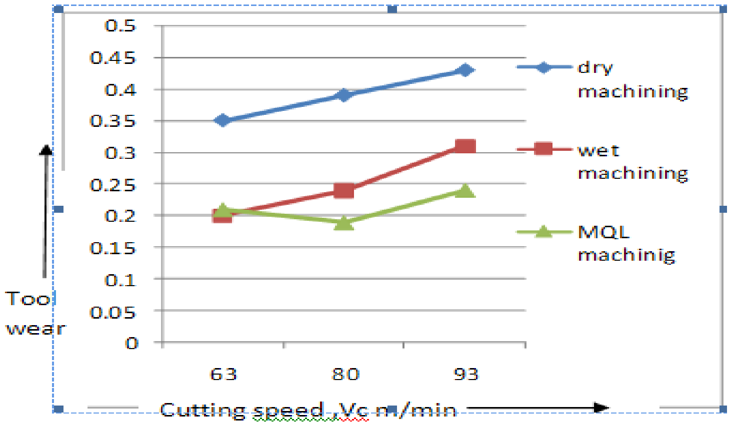

Figure. 7Graphical representation of cutting speed Vs tool wear.

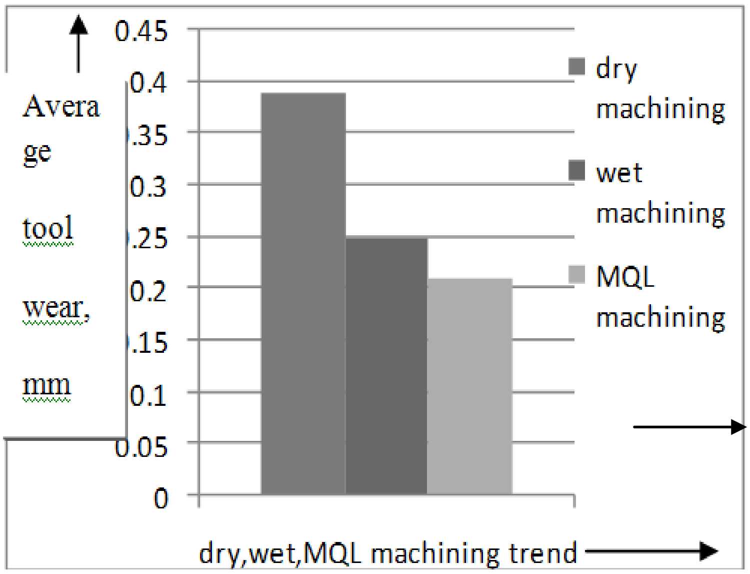

Figure.8 graphical relationship between dry ,wet ,MQL machining.

4. CONCLUSIONS

The present MQL systems enabled reduction in average tool wear for reduction and significant improvement in the major machinability. The most significant contribution of application of MQL in machining the steel by H.S.S tool undertaken has been the high reduction in flank wears, which would enable remarkable improvement in tool life. Such reduction in tool wear might have been possible for retardation of abrasion and notching, decrease or prevention of adhesion and diffusion type thermal sensitive wear at the flanks and reduction of built-up edge (BUE) formation which accelerates wear at the cutting edges by chipping and flaking. Deep notching and grooving, which are very detrimental and may cause premature and catastrophic failure of the cutting tools, are remarkably reduced by MQL.MQL provided better surface finish ultimately increases dimensional accuracy, substantially improved mainly due to significant reduction of wear and damage at the tool tip by the application of MQL. The cutting performance of MQL machining is better than that of conventional machining with flood cutting fluid supply.

References

[1] N. R. Dhar, M.W. Islam
" A Study of Effects of MQL on Tool Wear, Job Dimension and Finish in Turning MILD STEEL Steel" AEESEAP Journal of Engineering Education 2007; Vol. 31, No. 2

[2] S. Thamizhmanii *, Rosli, S.Hasan"study of mql on inconel 718 steel "

[3] Faculty of Mechanical and Manufacturing Engineering, University Tun Hussein Onn Malaysia 86400, Parit Raja, Batu Pahat, Johor, Malaysia, Received 28.01.2009; published in revised form 01.09.2009

[4] P. Leskover and J.Grum, "The Metallurgical Aspect of Machining", Ann. CIRP 35, pp. 537-550, 1986

[5] H.K. Tonshoff and E. Brinkomeier, "Determination of the Mechanical and Thermal Influences on Machined Surface by Microhardness and Residual Stress Analysis", Ann. CIRP 29, pp.519-532, 1986

[6] C. Cassin and G. Boothroyed, "Lubrication Action of Cutting Fluids", J. Mech.Eng. Science, 7(1) pp. 67-81, 1965

F. Klocke and G. Eisenblatter, "Dry Cutting", Annals of the CIRP, 46/2, pp.519-526, 1997

[7] U. Heisel, et al., "Application of Minimum Quantity Cooling Lubrication Technology in Cutting Processes", Prod. Eng, Vol .II/1, pp.49-54, 1994

[8] J. W. Sutherland, et al., "An Experimental Investigation of Air Quality in Wet and Dry Turning", Ann. of CIRP, 49/1, pp.61-64, 2000

[9] J. McCabe and M. A. Ostaraff, "Performance

www.ijmer.com Vol.1, Issue1, pp- 203-209 ISSN: 2249-6645

Experience with Near-Dry Machining of Aluminum", Lubr. Eng., 57/12, pp. 22-27, 2001

[10]. S. Suda, et al., "Evaluation of Machinability with MQL System and Effectiveness in Production Lines", Proceedings of the International Tribology Conference, Nagasaki, pp.203-208, 2001

[11] T. F. MaClure, R. Adams and M. D. Gugger, "Comparison of Flood vs. Micro-lubrication on Machining Performance, website: http://www.unist.com/techsolve.html , 2001.

[12] N. Richard ,D. Aspiwall use of ceramic tool for machining nickel base alloys international journal of engineering and tool manufacturing 296 (1989).

[13] T. Brockhoff and A. Walter, "Fluid Minimization in Cutting and Grinding, Abrasives", pp. 38-42, 1998

[14] R. B. Aronson, "Why Dry Machining", Manufacturing Engineering, pp. 33-36, 1995

[15] U.S. Department of Health and Human Services, "Occupational Exposure to Metalworking Fluids", NIOSH Publication No. 98-102, January 1998

[16] E. O. Bennett and D. L. Bennett, "Occupational Airway Diseases in the Metalworking Industry", Tribology International, 18/3, pp. 169-176, 1998