

Experimental Investigation of machining operation under minimum quantity lubrication

Shilpa Sahare

*Department of Mechanical Engineering
Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India*

Prashant Kamble

*Department of Mechanical Engineering
Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India*

Divya N.Dubey

Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India

Abstract- The purpose of this article is to review the relevant literature in machining using minimum quantity lubrication. In this research project an on-going comparative study will be made for tool wear and surface roughness by varying cutting parameters under dry and Minimum Quantity Lubrication (MQL) environment while machining hardened medium carbon steel (hard machining). A mathematical model will also be developed to determine the surface roughness in terms of machining time and cutting tool wear function in terms of the four independent variables: the cutting depth (d), the cutting feed (f), the cutting speed (Vc) and the cutting duration (t). The results application of MQL technique will significantly help to obtain better performance in compare to dry condition. The purpose of cutting fluid in a machining operation is to cool the work piece, reduce friction, and wash away the chips. The cutting fluid contributes significantly toward machining cost and also possesses environmental threats.

Keywords – Minimum Quantity lubrication, hard materials

I. INTRODUCTION

Metal cutting fluids changes the performance of machining operations because of their lubrication, cooling, and chip flushing functions. Typically, in the machining of hardened steel materials, no cutting fluid is applied in the interest of low cutting forces and low environmental impacts. Minimum quantity lubrication (MQL) presents itself as a viable alternative for hard material machining with respect to tool wear, heat dissipation and machined surface quality.

The necessity to machine using less harmful cutting fluids has prompted many researchers to investigate the use of minimum quantity lubrication (MQL). Chalmers(1999) reported that more than 100 million gallons of metalworking fluids are used in the U.S. each year and that 1.2 million employees are exposed to them and to their potential health hazards. The U.S. Occupational Safety and Health Administration (OSHA) (Aronson, 1995) and the U.S. National Institute for Occupational Safety and Health (NIOSH) reported that the permissible exposure level (PEL) for metal working fluid aerosol concentration is 5 mg/m³ and 0.5 mg/m³ respectively (U. S. Department of Health and Human Services, 1998). However, the oil mist level in the U.S. automotive parts manufacturing facilities has been estimated to be 20 – 90 mg/m³ with the use of conventional lubrication by flood coolant (Bennett and Bennett, 1985).

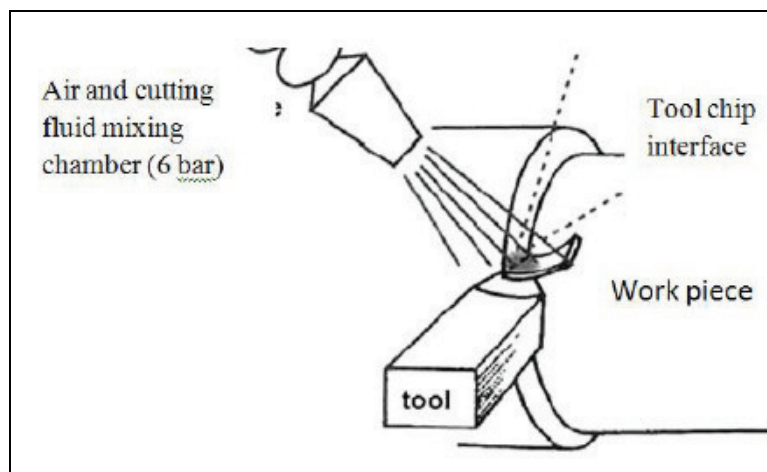
The quality of machined component is evaluated with respect to dimensional accuracy and close tolerances in the time of globalization of manufacturing when working with conventional machining. In metal cutting fluid changes the performance of machining operations in terms of both employee's health and environmental pollution. Hence, use of minimum quantity lubrication system plays an important role in respect of accuracy obtained. Also prevents environmental pollution and hazard to the employee. Use of optimum cutting fluid leads to economical benefits and environmental friendly machining as well.

Minimum quantity lubrication (MQL) is micro lubrication near dry machining, or “spatter” lubrication. It could be considered as the latest method of delivering metalworking fluids to the point of cut, or just the logical continuation of the age old technique of “brushing on” a lubricant where it is needed. This technology recognizes that a little fluid, when properly selected and applied, can make a substantial difference in how effectively a tool performs.

II. MINIMUM QUANTITY LUBRICATION SYSTEM

The conventional system of applying the coolant is flood coolant system, in which a large quantity of coolant is continuously impinged on the rake face of the tool. This system is very inefficient. First of all, a large quantity of the cutting fluid is required. Second, the cutting fluid is not able to reach the cutting zone due to obstruction from chips. A better method is the application of mist lubrication, in which a mixture of air and cutting called aerosol is produced and supplied in the cutting zone with a high pressure

Figure 1. Minimum quantity lubrication



The system uses an atomizer. The atomizer is an ejector where the compressed air is used to atomize the cutting oil. By the air in a low-pressure distribution system to the machining zone. As the compressed air flows through the venturi path, the narrow throat around the discharge nozzle creates a venturi effect in the mixing chamber, i.e., a zone where the static pressure is below the atmospheric pressure (often referred to as a partial vacuum). This partial vacuum draws the oil up from the oil reservoir where the oil is maintained under a constant hydraulic head. The air rushing through the mixing chamber atomizes the oil stream into an aerosol of micron-sized particles. When the aerosol impinges through the jet, it produces a spray of gaseous suspension called mist in the machining zone which works as cooling as well as lubricating medium.

II. ORIGIN OF THE RESEARCH PROBLEM

The metal industries using the cutting fluid has become more problematic in terms of both employee health and environmental pollution. The current trend in metal working industry is to completely eliminate or drastically reduce the cutting fluid use in most machining operations. But the use of cutting fluid cause economy of tools and it becomes easier to keep tight tolerance and to maintain the work piece surface properties without damages. Also Metal cutting fluid changes the performance of machining operation because of their lubrication, cooling and chip flushing function. The growing demands for high productivity machining need use of high cutting speed and high feed rate. This produce high temperature which not only reduce the tool life but also impairs the product quality. Because of this some alternative has been sought to minimize or even avoid the use of cutting fluid in machining operations. One of the alternatives is MQL. The MQL can able to subsidize the heat generated. The saving in cutting fluid and other related costs would be very significant if micro lubrication (MQL) is adopted. An alternative, machining with MQL is gaining acceptances as a cost saving and environmental friendly option.

II. OBJECTIVE OF RESEARCH

The purpose of this research is to investigate and optimize the milling operation under the effects of minimum quantity lubrication. Also investigate the effect of various cutting conditions for surface roughness and find out the factors or variables that mostly affects the surface roughness in machining process.

III. LITERATURE REVIEW

The authors summarize the traditional purposes of cutting fluids and also tried to minimize or even eliminate the concerns associated with cutting fluid usage. Several recent and novel approaches have been proposed and are examined [1]. The experimental investigation is done on the role of MQL on cutting temperature, tool wear, surface roughness and dimensional deviation in turning of AISI-4340 steel at industrial speed-feed combinations by uncoated carbide insert[2],[5]. MQL under pulsed jet mode protects the operator's health and reduces the detrimental effects on the environment [3]. Feasibility study of the minimum quantity lubrication (MQL) in high-speed end milling of hardened steel by coated carbide tool was undertaken. The encouraging results include significant reduction in tool wear rate, dimensional inaccuracy and surface roughness [4]. MQL technique offer better results than by dry cutting in terms of surface roughness. The total length of travel by super cobalt cutting tool in MQL condition is higher than that in dry cutting. The tool life was increased by 43.75 % by MQL than dry cutting [6]. The average chip-tool interface temperature increases with the increases in cutting velocity and feed rate for all three conditions. The chip-tool interface temperature values for MQL are lower than dry and wet conditions [7]. The evolution of the surface finish and tool wear with cutting time has been monitored. Analytical and artificial neural network- models, able to predict the surface roughness under different machining conditions, have been proposed[8]. Author 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[9]. Several grinding fluids, including mineral, vegetable and synthetic esters oil, are compared on the basis of the grinding forces and surface quality properties that would be suitable for MQL grinding applications, to develop a multifunctional fluid having the MQL results such as cooling, lubrication and high ecological and environmental safety performances[10].

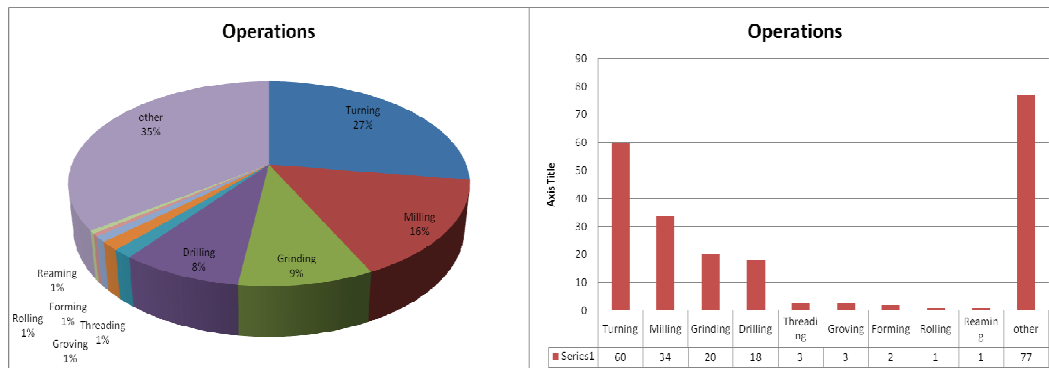


Figure 1. MQL application to various cutting operations

III. EXPERIMENTATION

From the literature review it is seen that most of the work has completed in turning operation with minimum quantity lubrication with a successful results. But still there is a large scope for research for milling operation .Hence the research work is initiated for milling operation. The operation selected is 9kl;p/' [face milling as it is a most important operation done in industries. The Work piece material is AISI1047 with the following chemical composition as given below.

Table -I Chemical composition (wt%):

C	Mn	Si	P	Cu	S	Cr	Ni	Mo	Fe
0.440	0.730	0.190	0.016	0.067	0.015	0.027	0.037	0.014	balance

This material is mostly used in Automotive, naval and building industry. Tool material: coated carbide inserts with TiAlN monolayer. Lubricant selected for this operation is Mobil cut 102.This is having excellent emulsion stability, Excellent

rust protection. This lubricant is water mix cutting fluid suitable for ferrous & non ferrous materials. Taguchi method is used for design of experiments.

Input parameters: Speed, feed, depth of cut, cutting fluid delivery technique.

Output parameters: Surface roughness, tool life

Factors: 4, Levels: 5

Table – 2. Machine specification

Table size	230 x 1067 mm
Travel (x-axis)	682 mm
Cross travel(y-axis)	305mm
Vertical travel (z-axis)	406 mm
Ram travel	390 mm
Spindle column	153-544
Spindle step head	2
Motor	3HP
Spindle taper	NST# 30/R8
Spindle speed	8 STEP , 68-2280RPM

Table -3. Design of Experiments

Parameter	Range	Levels				
		I	II	III	IV	V
Speed (m/min)	100-135	100	110	120	130	135
Feed rate per tooth,(mm/rev)	0.1- 0.15	0.11	0.12	0.13	0.14	0.15
Depth of cut(mm)	1 -3.5	1	1.5	2	3	3.5
Flow rate (ml/hr)		Flood (276,000)	Medium (150,000)	Reduced (15000)	Reduced (10000)	MQL (200)

IV. CONCLUSION

From the discussion presented in this chapter, it is apparent that MQL systems possess many advantages over flood coolant system. However, they also require some modification of machine tools for obtaining the best performance out of them. When the flood coolant system is not present, the machine tools should be equipped with a chip removal system.

REFERENCES

- [1] D. P. Adler, W. W-S Hii, D. J. Michalek, and J. W. Sutherland “Optimization of machining techniques – Examining the Role of Cutting Fluids in Machining and Efforts to Address Associated Environmental/Health Concerns” Sadhana vol. 30, part 6, pp. 699–71, December 2005.
- [2] Nikhil Ranjan Dhar, Sumaiya Islam, Mohammad Kamruzzaman “Effect Minimum Quantity Lubrication (MQL) on Tool Wear, Surface Roughness and Dimensional Deviation in Turning AISI-4340 Steel” G.U. Journal of Science of 20(2): pp 23-32 (2007).
- [3] D.G.Thakur, B. Ramamoorthy, and L. Vijayaraghavan., (2009), “Optimization of Minimum Quantity Lubrication Parameters in High Speed Turning of Super alloy Inconel 718 for Sustainable Development”, World Academy of Science, Engineering and Technology 54 2009.pp224-226.
- [4] Y.S. Liao, H.M. Lin, Y.C. Chen., (2007), “Feasibility study of the minimum quantity lubrication in high-speed end milling of NAK80 hardened steel by coated carbide tool”, International Journal of Machine Tools & Manufacture No.47,pp. 1667–1676(2007).

- [5] N. R. Dhar, M.W. Islam., (2007), "A Study of Effects of MQL on Tool Wear, Job Dimension and Finish in Turning AISI-1040 Steel", *AESEAP Journal of Engineering Education* 2007; Vol. 31, No. 2, pp 16-22.
- [6] S. Thamizhmanii , Rosli, S.Hasan., (2009), " A study of minimum quantity lubrication on Inconel 718 steel", *International Scientific Journal of Materials Science and Engineering* Vol. 39,pp 38-44.
- [7] M. M. Rahman, M. M. A. Khan, N. R Dhar, (2009), "An Experimental Investigation into the Effect of Minimum Quality Lubricant on Cutting Temperature for Machinability of AISI 9310 Steel Alloy, *European Journal of Scientific Research* ISSN 1450-216X Vol.29 No.4 (2009), pp. 502-508.
- [8] C. Bruni, L. d'Apolito, A.Forcellese, F. Gabrielli, M. Simoncini, (2008), "Surface roughness modelling in finish face milling under MQL and dry cutting conditions", *International Journal of Mater Form* (2008) Suppl 1:pp,503–506.
- [9] N.B.Borkar1 ,Dr.S.S.Chaudhari2,A.B.Amale (2010), " Experimental Investigation on the Role of MQL and its Effects on Tool Wear in Turning of mild Steel", *International Journal of Modern Engineering Research (IJMER)* Vol.1, Issue1, pp- 203-209 .
- [10] M. H. Sadeghi & M. J. Hadad & T. Tawakoli & A. Vesali & M. Emami, (2010), "An investigation on surface grinding of AISI 4140 hardened steel using minimum quantity lubrication-MQL technique", *International journal of Mater Form* (2010) 3:pp241–251
- [11] Chalmers, R.E. (1999), "Global Flavor Highlights NAMRC XXVII", *Manufacturing Engineering*, Vol. 123 No.1, pp. 80-88.
- [12] R. B. Aronson. (1995), "Why Dry Machining", *Manufacturing Engineering*, pg 33-36.
- [13] E. O. Bennett and D. L. Bennett, (1985), " Occupational Airways Diseases in the Metal Working Industries", *Tribology International*, 18/3, pg. 169-176, 1985.
- [14] U.S. Department of Health and Human Services. (1998), "Occupational Exposure to Metal Working Fluid", NIOSH Publication No. 98-102.