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MQL an Emerging Cooling Technique

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Abstract- Metal cutting fluids changes the performance of machining operations because of their Lubrication, cooling, and chip flushing functions. 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 machining with respect to tool wear, heat dissertation, and machined surface quality. This review paper gives comparison of the mechanical performance of minimum quantity lubrication to completely dry lubrication for the turning of hardened bearing-grade steel materials based on experimental measurement of cutting forces, tool temperature, white layer depth, and part finish. This review paper shows that the use of minimum quantity lubrication leads to reduced surface roughness, delayed tool flank wear, and lower cutting temperature, while also having a minimal effect on the cutting forces.

Keywords- Metal cutting fluids, lubricant, machining processes.

1. INTRODUCTION

To Manufactured any product there must removal of material from it by applying processes like Drilling, Turning, Boring, and Milling etc. on it. And this is known as Machining process.so machining is an important part of any production Industry. During Machining operation large amount amount of heat is generated between contact of tool and work piece and that is not desirable case because it increases power consumption, affects product quality and also result in early failure of cutting tool.

Machining can be done by methods: Dry cutting and flood cutting.-In 1st case we refer to use of lubricant (that reduces temperature of both cutting tool and work piece) as a compressed air. In 2nd case we use Traditional coolant or oil. One of the best option to reduce all effects causes during machining process is cutting fluid. Cutting fluid act as coolant as well as Lubricant and also helps in removal of chips. But cutting fluid may causes negative effects on the operator 'health who is in that working environment.
According to king et al (2001) cost of cutting fluid is near about 7% to 17% of total production cost that is more than cost of cutting tool.so Dry and MQL is an option for it But where high surface finish and greater productivity require there is no use of dry cutting methods. So Minimum Quantity Lubrication is better solution for all problem.

MQL System is used to overcome the disadvantages of Flood and Dry cutting . In MQL system very small quantity of lubricant is used . In India there is unaware of MQL system High cost is major concern of it. So objectives of this study to obtain simple MQL system , reducing cost , making aware of this system to people and investigate its performance in comparison with Dry and Flood cutting.

2. REVIEW OF LITERATURE

A. In 2005 R.Heinemann , S.Hinduja , G.Barrow , G.Petuelli investigated on effect of MQL on tool life of small twist drill in deep hole drilling . He concluded that dry drilling is associated with stongly accelerated tool wear for most of twist drill tested , resulting in significant reduction in tool life.

B. In 2006 Attanasio , M.Gelfi , C.Giradini , C.Remino reported result obtained from turning test and SEM analysis of tool , at two feed rates & 2 cutting length , using MQL on rake and flank of the tool . the results obtained show that when MQL is applied to tool rake , tool life is genrally nodifferant from dry condition , but MQL applied to the tool flank can increase tool life .

C. In 2006 Leonardo Robeto da Silva , Eduardo carlso Bianchi , Ronaldo Yoshinobu fusse , Rodrigo Edurdo catai , Thiago Valle Franca , Paulo Roberto Aguiar was investigated on Analysis of surface integrity for MQL in grinding and performance evaluated based on analysis of surface integrity & commeted technological & ecological gain in grinding process using MQL.

D. In 2007 Y.S.Liao , H.M.Lin was investigated on mechanism of MQL in high speed milling of hardened steel. Tool life can be effectively improved by MQL in HSM of NAK80 hardened steel when cutting parameters are choosen properly.
E. In 2007 Y.S.Liao , H.M.Lin , Y.C.Chen investigated on feasibility study of MQL in high speed end milling of NAK80 hardened steel by coated

carbide tool & resulted MQL improved machined surface finish in high speed milling of die steel.
.F. In 2009 Leonardo De Chiffre , Guido Tosello , Miroslav Piska , Pavel Muller studied on investigate on capability of reaming process using MQL . And resulted in improving quqlity of machined hole , in terma of geometrical characteristics and surface finishing & process quality , w.r.t. to reaming torque & thrust along with their repeatability.

G. In 2009 Domnita Fratila investigated on evaluation of near dry machining effects on gear milling process efficiency on gear milling process efficiency & conclude that MQL is causes of possibility for efficiency increasing reduction in cost improvement of operational environment.

3. NEED OF MQL

(1)Cost related to Cutting fluid is several time larger than cutting tool cost , an overall cost of production. Also handling capacity of lubricant , disposal of it also major problem. Also flood cutting increases causes of health problem to employers and may create problem to environment
(2)In flood cutting, because of lubricant there is problem of disposal and more maintains and it is expensive process.
(3)Internally MQL is a conversion of production process from wet to dry machining help to motivate Personnel; externally it contributes a better corporate image.
()Chip removal also one of the major problem in machining, MQL is solution for it.

4. PRINCIPLE OF MQL

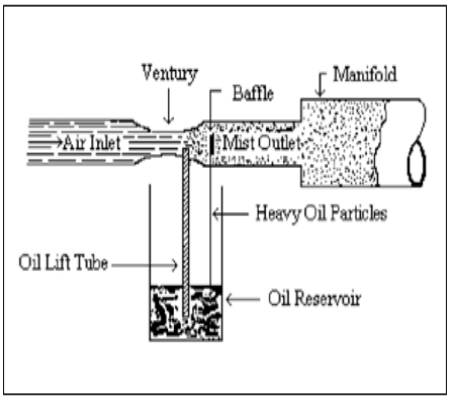

Fig 1: Air oil lubrication system

Developed system based on simple principle shown in fig., Compressed air passed through Ventures , oil siphoned from reservoir by air flow, is atomized into a fine spray .A typical system consist of air filter , Pressure regulator , spray control valve with distributor nozzle , solenoid valve , switches.

5. CONSTRUCTION OF MQL

The MQL system describe here with reference to size and distribution of lubricant drop, generate homogeneous aerosol with drop size approximately 0.5μm. the oil drops are very light because of their small size , which in turns result in very low moment of Inertia. These small drop of oil can be transported over long stretch through lines & deflection without being deposited due to moment of inertia. Additionally transport of aerosol through spindles and tool is unproblematic. MQL system even at very high rotational speed , since effect of centrifugal force an oil drops in very low. The size & distribution of droplets of oil in the aerosol are very homogenous with lubrication MQL system since the aerosol is atomized under controlled condition. In Addition to high degree of surface wetting, extremely fine particle of lubricant also reach poorly accessible or hidden spots on work piece. Difficult through feed task with deflection of kind found in terms of turrets of turning machine can also be handled. Friction and thus the transfer of heat from chip to tool & work piece is reduced. Optimal lubrication during removal of chips in chip groove not only permits higher machining speeds but also results in much better work piece surface finish. A Fine aerosol with homogeneous particle size of 0.5μm is produced in reservoir from a lubricant & compressed air with special nozzle system. Thanks to small particle size , the aerosol passes through the rotating spindle of machining centers ducts of turrets on modern turning centers without any de-mixing taking place route. Aerosol quantity and composition required for respective tool and cutting task are set by valves switched with M or H commands from machine control system. A bypass system can be optionally integrated in aerosol feed to achieve shorter response time .The aerosol is directed is directed 3/2 way ball valve for this purpose
Spray Nozzle: Aerosol required at the process point is produced at nozzle outlet . The lubricant and require atomized air are fed through co-axial line from MQL to spray nozzle. The lubrication mixture is formed at nozzle outlet by venturi principle .the purpose of spray nozzle is to generate tint droplet of lubricant in desired size.
Compressor: by means of compressed air , the aerosol generated inside vessel is transported via one or several connected aerosol lines to supply connection at machine tool Compressed air Requirement valve.
Maximum air admission pressure 8 bar minimum air admission pressure 4 bar .Maximum particle size 40μm , Maximum particle density 10g/m3 , Maximum

pressure dew point temperature 70C , Maximum Lubricant concentration 25g/m3 . Main air valve is closed before connecting MQL system has an NG8 coupling socket for hoses with inside diameter 7.8mm for connection to compressed air supply.

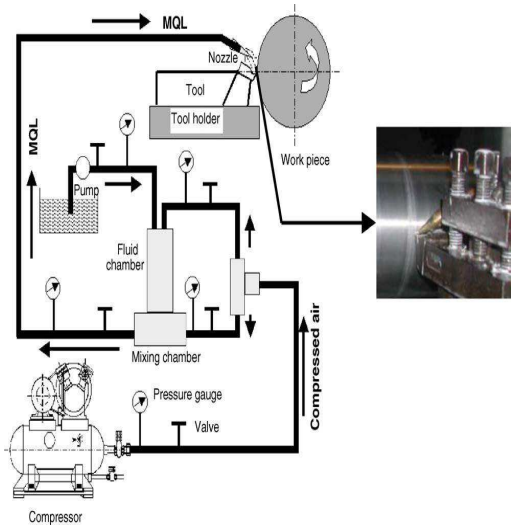

Fig. 2: MQL system

6. TYPE OF MQL

6.1 External Minimum quantity lubrication (MQL):
Metered lubricant is atomized by compressed air in a spray nozzle. That produce micro droplet that make their way together with the carrier air to the friction point without any mist being formed.

6.2 Internal Minimum quantity lubrication (MQL):
An aerosol is generated in MQL equipment reservoir and fed through the rotating spindle turret to the tool with an optimal setting the metered quantity of oil is completely used up without any residue being left.

7. DESIGN DETAILS

Basic design consist of following:

(01) Aerosol generator & lubricant receiver.
(02) Main air valve.
(03) Control Cabinet housing.
(04) Connection for Aerosol lines.
(05) Plug screw for manual filling.
(06) Filling level indicator.
(07) Pressure gauge for interior vessel.
(08) Pressure gauge for primary vessel.
(09) Compressed air connection.
(10) Drain
(11) Reservoir
(12) intake line for automatic lubricant refill.
(13) Glass for display panel of controller.
(14) Controller interface.
(15) Safety valve & fine

8. ADVANTAGES OF MQL

8.1 Cost merit-
No need for cooling lubricant
No cost of disposal chip and cooling lubricant
No need of wash work piece
Not requirement of device like lubricant filter, conditioning system.

8.2 Chip removal-
Chip removal is one of the major problem that should be considered in Construction of mass production
Large quantity of coolant is used to removal of chip
But it is necessary to adopt less lubricant method to remove chip MQL.

8.3 Improve productivity-
Significant reduction of production time (30% to 50%)
Higher efficiency
Tool life increases by 300%
Reliable control of production processes.

8.4 Utilize a Technology Advantages –
Solution for OEM's and retrofilters
Parallel use of wet & dry machining.
No change in design of spindle required.

9. RESULTS:

Temperature measure by thermocouple in MQL, there is lower in temperature by about 20-30^0 C since temperature is an important factor governing thermal damage on tool and life of cutter or tool.
Tests were performed to confirm the dynamic behavior of temperature and force in Response to minimum quantity lubrication. During testing, the total length of cut (8 inches) along the bar specimen was divided into three consecutive sections. The first section was cut completely dry, the minimum quantity lubrication was applied at the start of the second section and at the tool entrance into the third section, the minimum quantity lubrication was turned off so that a dry cutting condition resumes. The steady state temperature drops by about 15% as a result of minimum quantity machining application, while the time it takes to reach such a steady state temperature is on the order of 20 to 30 seconds. The forces exhibit no apparent difference with or without the use of minimum quantity lubrication. These observations are generally consistent with other steady state testing results.
Small amount of cutting fluid in the form of aerosol can reach in cutting zone to produce vital effect on tool life especially for the heat – sensitive , uncoated twist drill.
MQL greatly reduces total mist generation compared to high-pressure through tool

coolant applications, but also reduces the average mist particle size. Mist collection
or filtering equipment may still be required to manage this fine mist. In ferrous
machining sparking and smoking is sometimes observed with MQL. Hence, some filters
may be required to manage smoke if it cannot be eliminated through process or tooling life.

10. SUMMARY

In this review paper an experimental study has been performed to examine the effect of minimum quantity .The resulting surface roughness, no noticeable difference can be concluded with the use of near-dry over completely dry condition. However, the improvement of surface finish can be more obviously felt by near-dry machining under greater depths of cut and feeds. In the context of steady-state cutting temperature, a 10 to 30% reduction is consistently observed when minimum quantity lubrication condition is applied as opposed to completely dry. It is expected to be a result of increase in the evaporative heat transfer at the cutting zone. The cutting forces not changed significantly. The thermal softening effect of work piece in completely dry machining condition is not overwhelming; therefore, the benefit of using completely dry over minimum quantity lubrication is not readily justified. There is a significant increase of tool life – over 30% -- by minimum quantity lubrication over a wide range of cutting conditions. This effect is in close coupling to the reduction of cutting temperature. It can thus be concluded that the use of cutting fluid at minute amounts can potentially protect the tool while holding the cutting forces relatively unchanged in comparison to completely dry cutting. Other machining performance issues in terms of chip flushing and environmental consciousness have not been included in this study. Further research in these directions is suggested.

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