OPEN ACCESS
ISSN: 2249-6645
International
Journal
Of Modern Engineering Research (IJMER)

Effect of Minimum Quantity Lubrication on Tool Wear and Temperature in Turning EN8 Steel by ANOVA

T. Nikitha[1], Dr. M. V. R. D. Prasad[2]
Department of Mechanical Engineering, VNR VJIET, Hyderabad, India
[1]E-mail: tnikitha1625@gmail.com
[2]E-mail: dpmandava.vnr@vnrvjiet.in

ABSTRACT: *In all machining processes, tool wear is a natural phenomenon and it leads to tool failure. Metal cutting fluids changes the performance of machining operations because of their lubrication, cooling, and chip flushing functions but the use of cutting fluid has become more problematic in terms of both employee health and environmental pollution. It is found that MQL condition will be a very good alternative to flooded lubricant condition and dry condition machining which is presently employed in most of the metal cutting industries there by not only the machining will be environmentally friendly but also will improve the machinability characteristics. A cutting fluid for minimum quantity lubrication should be selected not only on the basis of primary characteristics that is cutting performance, but also of its secondary characteristics, such as biodegradability, oxidation stability and storage stability. In this experimental investigation KARANJA OIL is used as lubricant, which is focused on the issues related to environmental problems, toxicity, fluid disposal, its cost. Therefore, in addition to environmental and health concerns and to reduce the production cost, this is the experimental investigation to achieve longer tool life, enhanced tool wear and temperature. Then the analysis of the results was carried out by using the ANOVA in synthesis 9 to find which Process parameter has significant effect on output parameter.*
Keywords: *MQL (Minimum quantity lubrication), karanja oil, ANOVA, Tool wear.*

I. INTRODUCTION

Machining can be defined as the process of removing material from a work piece in the form of chips. Machining contains removal of material from work piece, it covers several processes like Turning, Milling, Drilling, Grinding etc. The machinability of the material depends on the properties of materials, speed, feed, depth of cut, cutting temperature, tool wear, tool life etc. During the machining, lot of heat is generated which increases with a subsequent increase in the cutting speed. This heat generated, if not dissipated successfully, may affect the finished surface quality, and reduce the tool life and hence overall performance of the process. Thus, although high speed machining is desirable in many cases for higher productivity, the consequences of heat generation needs to be minimized. Due to the economic and environmental/ecological costs, as well as health hazards associated in machining process there is a need to identify ways to simultaneously improve machining technology, by reducing the environmental pollution, which requires a technological innovation. Researchers have focused their attention on issues related to environmental problems, fluid disposal, toxicity, filterability, misting, staining, surface cleanliness and indirect cost involved while using coolant/lubricants and have tried to find out ways to improve the current techniques of cooling during turning in order to reduce the temperature at the cutting zone and to eliminate/minimize these problems. Because of these problems some alternatives have been suggested. They are dry machining, minimum quantity lubrication. As a result, minimum quantity lubrication (MQL) is the good alternative than compared to that of dry condition and flooded lubricant condition. Minimum quantity lubrication (MQL) is a technique that uses a spray of small oil droplets in a compressed air jet. The lubricant is sprayed directly into the cutting zone, avoiding the huge flows of conventional flood coolant methods. . In MQL, a very small lubricant flow is used. MQL refers to the use of cutting fluids of only a minute amount, typically of a flow rate of 50-250 ml/h. The lubricant/cutting fluid used in machining is KARANJA oil under flooded and MQL conditions. Machining with this oil is suggested by Indian institute of chemical technology from vizag, due to its extreme lubricant properties.

II. OBJECTIVE

To turn EN8 steel with uncoated carbide insert by varying input parameters. Such as cutting speed, feed rate, and depth of cut under dry, flooded and MQL conditions. To determine the tool wear values and temperature values for under all the machining conditions at different intervals of time. To analyze the experimental results using a statistical tool MINITAB. The main objective of the present work is to experimentally investigate the role of minimum quantity lubrication(MQL) on tool wear in turning EN8 steel by uncoated carbide inserts and compare the effectiveness of MQL with that of dry and wet machining. MQL droplets provides reduced tool wear, improved tool life, better surface finish, reduce damage at the tool tip as compared to dry and wet machining. KARANJA oil which used in this experiment ensures that it does not become problematic in terms of both employee health and environmental pollution. Comparison of dry, flooded and MQL type of lubricating systems. Make use of KARANJA OIL (bio seed oil) as cutting fluid. To find tool wear, tool life and temperature on varying the parameter depth of cut 0.2 mm, 0.4 mm, 0.6 mm. Procedure to increase the tool life.

III. METHODOLOGY

Experiments have been carried out by a work piece material EN8 steel of 450mm length and 70mm diameter. The cutting tools used are uncoated carbide inserts (CNMG 120408), for which machining is done at different depth of cuts and at constant cutting speed and feed under dry, flooded and minimum quantity lubrication (MQL) machining conditions. The working of an oil mist lubricator is shown in Figure 1.

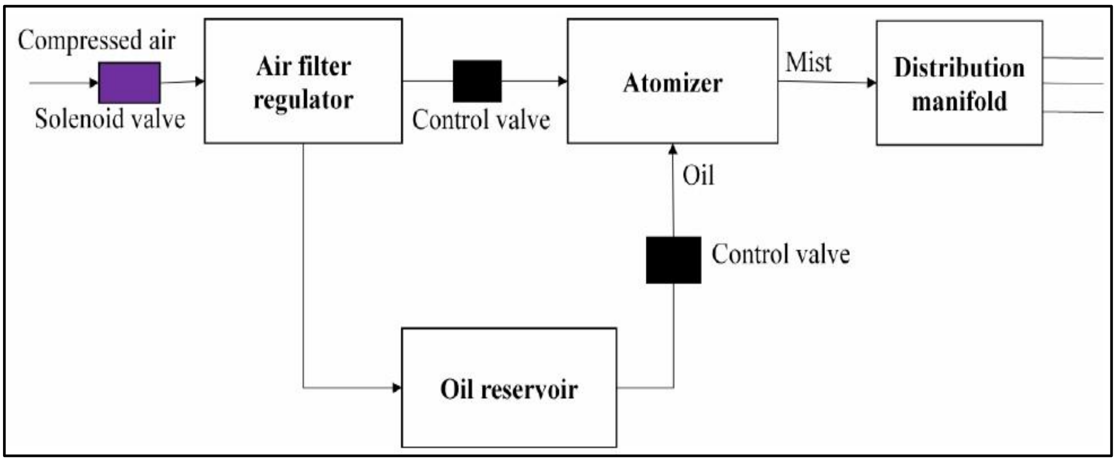


Fig. 1 Flowchart Depicting The Working Of Oil Mist Lubricator

IV. PROCESS DESCRIPTION

The machinability characteristics of the work material mainly with respect of tool wear, temperature have been investigated to study the role of MQL. Depth of cut is significant parameter in this experiment. The different depths of cuts were used are 0.2mm, 0.4mm, and 0.6mm. In present case, tool wear and temperature are considered for studying the role of minimum quantity lubrication. Lubricant used in this experimental investigation is karanja oil. The following are experimental conditions. The cutting insert was withdrawn at regular intervals to study the pattern and extent of Flank wear for all the trials. The average widths of the principle flank wear were measured using tool maker's microscope. By the same time, the machining temperature at the cutting zone is an important index of machinability and needs to be controlled as far as possible. MQL is expected to provide some favorable effects mainly through reduction in cutting temperature. The temperature at the tool tip for every turning operation done in the CNC machine is recorded using digital temperature indicator, which is connected to the thermocouple. Finally the results were tabulated according to the design of experiments. The tool wear and temperature are obtained from the experimentation table. In the present work, performance character namely tool wear and temperature is to be minimize and hence the "smaller values is the better results".

V. EXPRIMENTATION

Table 1 Specification of Machine, Work Piece Material, Tool

Super Jobber 500 CNC Lathe Machine	
Work piece Materials	EN8 steel (C=0.3-0.44%, Si = 0.1-0.4%, Mn = 0.6-1%,S=0.05%, P= 0.05%, Cr = 0.3%, Ni = 0.4%, Mo = 0.15%)
Size	7 0mm diameter and 450mm length rod
Cutting tool	uncoated carbide inserts
Cutting tool specification	CNMG120408

Table 2 Process Parameters

Depth of cut	0.2, 0.4, 0.6mm
Feed	0.16mm/rev
Cutting speed	110m/min
MQL supply	Air pressure-5bar, lubricant used : 60ml/hr
Lubricant	Karanja Oil

Table 3 Lubricant Properties

Viscosity	40.2 mm2/sec
Boiling point	316 °C
Environmental conditions	Dry, flooded and minimum quantity lubrication (MQL)

5.1 MQL Set Up

The flow rate of lubricant was adjusted as 60ml/hour with the help of lubricator as shown in Figure. The cutting fluid needed to be supplied using minimum quantity lubrication technique. Therefore, an MQL setup was developed for creating the required oil-mist to be supplied onto the cutting zone. The setup used for MQL application is shown in Figure and the conditions under which MQL is carried out is shown in Table

Table 4 Conditions Under Minimum Quantity Lubrication Machining

Quantity of Lubricant Used	60 ml/hr
Maintained Air pressure	5 bar
Distance of Mql nozzle from contact zone	20 mm

The main principle of lubricator is to mist out the lubricant in the form of spray, where it requires an air compressor and the air pressure is maintained at 5bar.

Fig. 2 Photographic view of MQL setup

In the MQL setup, the air compressor is connected to lubricator and the lubricant is poured in the upper chamber of lubricator. The lubricant mixes with the air and comes out of the nozzle whose diameter is 0.2mm in the form of spray which is arranged near the tool and work piece zone. In this set up, the compress used is ElgiVayu portable compressor which is shown in below figure.

Fig. 3 Minimum Quantity Lubrication Setup with a Compressor

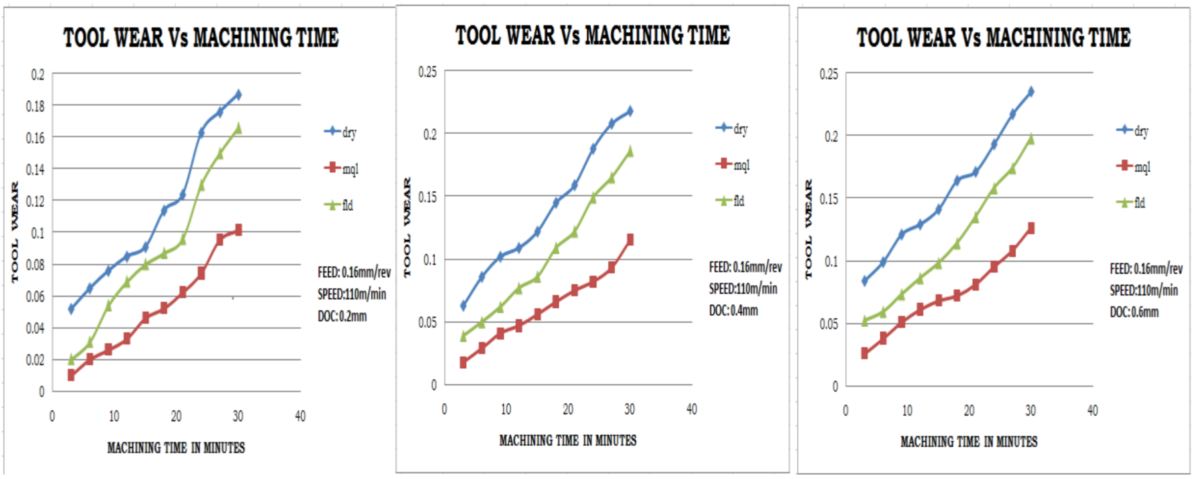
VI. RESULTS

In the present work, the tool wear and tool temperature is measured under Dry, Flooded and MQL conditions by using tool maker's microscope and digital temperature indicator. According to design of experiments the following table is shows response with certain parameters and factors. The tool wear and temperature values are obtained in the below Table

Table 5 Arrangements of Experiments and their Response

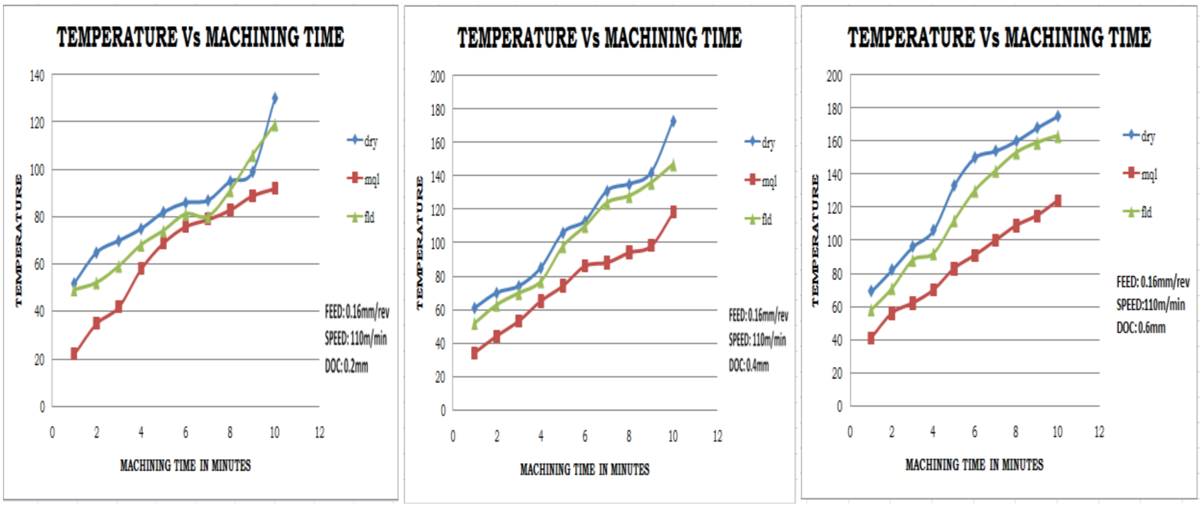
Number of experiments	Factor-1 (Machining)	Factor-2 (DOC)	Response-1 (Tool wear)	Response-2 (Temperature)
1	Dry	0.2	0.187	130
2	Dry	0.4	0.218	173
3	Dry	0.6	0.235	175
4	MQL	0.2	0.101	92
5	MQL	0.4	0.115	118
6	MQL	0.6	0.126	124
7	FLOODED	0.2	0.166	119
8	FLOODED	0.4	0.186	147
9	FLOODED	0.6	0.198	163

The values of tool wear obtained after each machining are taken and graphs are plotted for tool wear v/s. machining time, and temperature v/s. machining time.



Graphs are plotted for tool wear vs. machining time for different depth of cuts 0.2 mm, 0.4 mm, 0.6 mm. it can be interpreted that the tool wear for MQL and flooded conditions are nearly equal and is low in comparison with dry machining condition for all the depth of cuts.

Graphs are plotted for temperature vs. machining time for different depth of cuts 0.2 mm, 0.4 mm, 0.6 mm.



Graphs clearly show that flank wear, particularly its rate of growth decreased by MQL. The cause behind reduction in flank wear observed may reasonably be attributed to reduction in the flank temperature by MQL, which helped in reducing abrasion wear by retaining tool hardness and also adhesion and diffusion types of wear which are highly sensitive to temperature. Because of such reduction in rate of growth of flank wear the tool life would be much higher if MQL is properly applied.
The above graphs indicates the variation of tool wear and temperature along the machining time and compares all the three (dry, wet, MQL) systems. The tool wear and temperature are less in case of MQL system than that of wet and dry systems.

VII. ANALYSIS

7.1 TOOL WEARS UNDER DRY CONDITION, FLOODED CONDITION, MQL CONDITION

The tool wear under dry condition, flooded, MQL condition for a depth of cut of 0.2mm, 0.4mm, 0.6mm and a feed rate of 0.16mm are shown in Fig respectively. Fig shows the tool wear under dry condition at a constant feed rate of 0.16mm/rev and speed of 110m/min at the end of 30 minutes, Which gives the maximum wears by this the tool gets damage.

Fig. 4 Tool Wears For Dry Condition

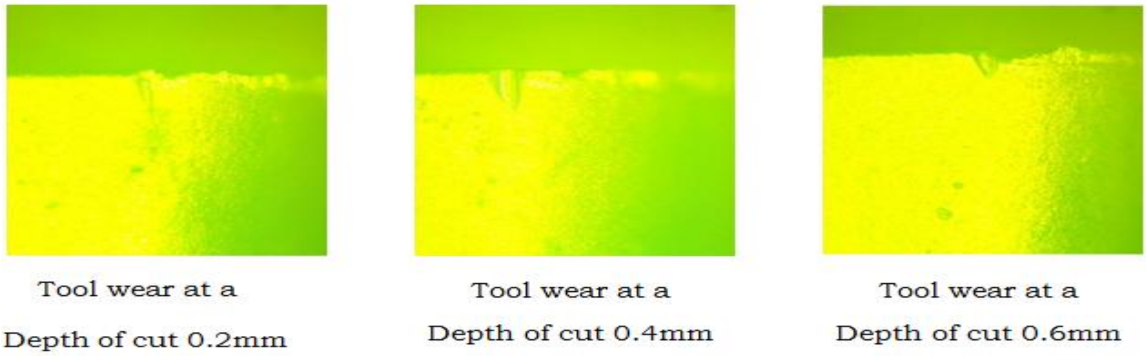


Fig. 5 Tool Wears For Flooded Condition

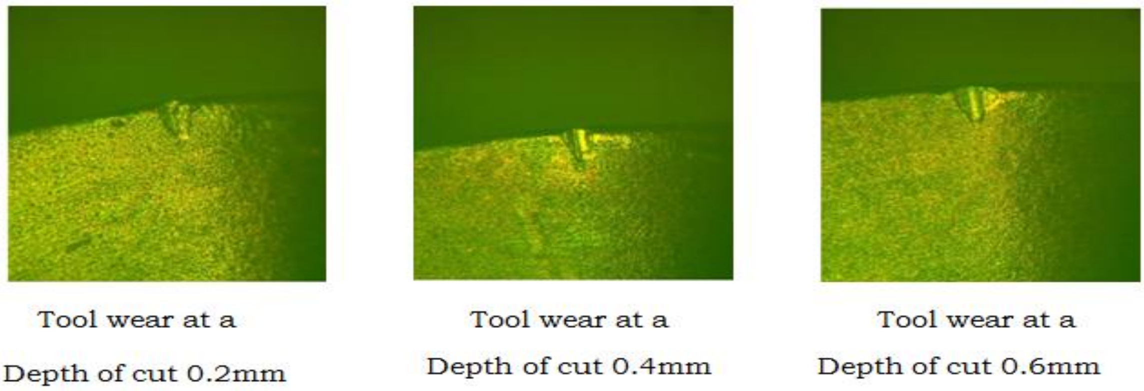
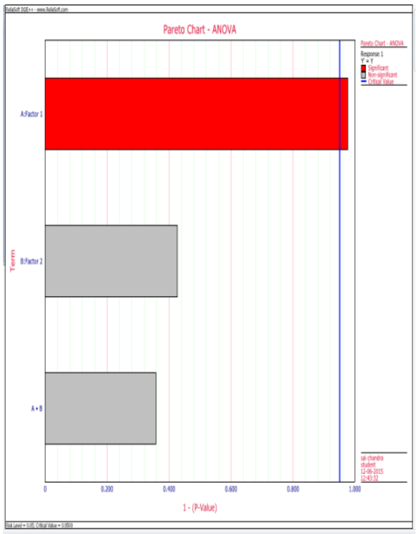


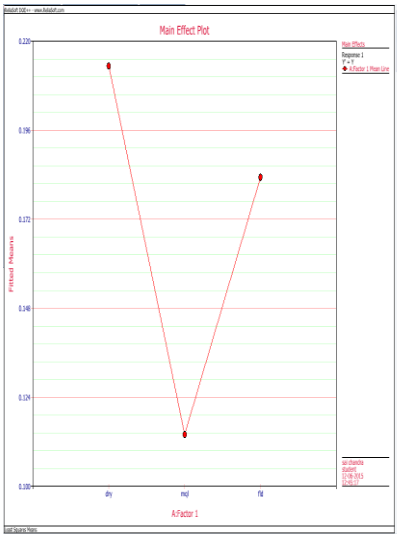
Fig. 6 Tool Wears For MQL Condition

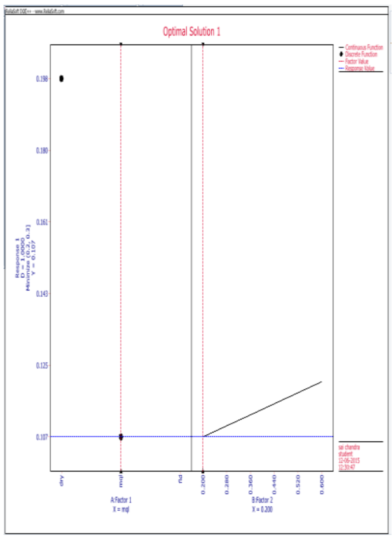
The snap shot of tool wear clearly shows that there is increase in wear of tool with the time and also increases when depth of cut increases. Large wear is formed for dry type and least wear is formed for MQL type of arrangement. In wet type of arrangements there is a pressure which tries to remove the chips at faster rate and results in more wear of the tool than MQL system.

7.2 ANOVA RESULTS

The analysis of the results was carried out by using the ANOVA in synthesis-9 to find which Process parameter has significant effect on output parameter. It is necessary to check the assumptions of ANOVA before drawing conclusions. There are three assumptions in ANOVA analysis: normality, constant variance, and independence.







Hence From the above graphs it is found that the optimal solution which gives the ultimate results that, MQL machining condition with depth of cut i.e. 0.2mm gives the reduced tool wear, improved tool life and better surface finish as compared to dry and wet machining of EN8 steel.

VIII. CONCLUSIONS

- The cutting performance of MQL machining is better than that of dry and conventional machining with flood cutting fluid supply because MQL provides the benefits mainly by reducing the cutting temperature, which improves the chip-tool interaction and maintains sharpness of the cutting edges.
- MQL jet provided reduced tool wear, improved tool life and better surface finish as compared to dry and wet machining of EN8 steel.
- Temperature is reduced in case of MQL system as compared to that of dry and flooded conditions by which, tool life can be improved.
- It is observed that when machining at a speed of 110m/mm with a feed rate of 0.16mm/rev, the tool wear for MQL is less when compared to that of Flooded and Dry machining for all depth of cuts.
- It is found that when machining at 110m/min with a feed rate of 0.16mm/rev, the tool wear and temperature for 0.2mm depth of cut is less compared to others under same cutting parameters.
- In the present experiment, it is observed that the increase in depth of cut increases the tool wear.
- Lesser tool wear and temperature indicates higher tool life. Hence tool life when machining under MQL condition is more compared to Flooded and Dry condition.
- Karanja oil can be used as lubricant in machining conditions.

REFERENCES

[1]. N.R. Dhar, M.T. Ahmed, S. Islam "An experimental investigation on effect of minimum quantity lubrication in machining AISI 1040 steel" International Journal of Machine Tools & Manufacture, Vol. 47, 2007, pp. 748-753.

[2]. Ali, S.M , Dhar, N.R & Der, 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 and management, Vol. 6, 2011, pp. 185-196.

[3]. S. Suda, T. Wakabayashi, I. Inasaki, H. Yokota "Multifunctional Application of a Synthetic Ester to Machine Tool Lubrication Based on MQL Machining Lubricants", Vol. 3, 2001, pp. 6-24.

[4]. M. H. Sadeghi, M. J. Haddad, T. Tawakoli, M. Emami "Minimal quantity lubrication-MQL in grinding of Ti-6Al-4V titanium alloy", Vol. 44, Issue 5-6, pp. 487-500.

[5]. C. Bruni, A. Forcellese, F. Gabriella, M. Simoncini "Effect of the lubrication- cooling technique, insert technology and machine bed material on the work part surface finish and tool wear in finish turning of AISI 420B" International Journal of Machine Tools & Manufacture, Vol. 46, 2006, pp. 47-54.

[6]. T. Obikawa, Y. Kamata, J. Shinozuka, "Analysis of Mist Flow in MQL Cutting", Key Engineering Materials, Vol. 257-258, pp. 339-344, Feb. 2004 Satish Chinchanikar, S.K. Choudhury "Hard turning using HiPIMS-coated carbide tools: Wear behavior under dry and minimum quantity lubrication (MQL)" .

[7]. Zhiqiang Liu, Qing long An a, Jinyang Xu a, Ming Chen, Shu Han "Wear performance of coating and coating in high-speed machining of titanium alloys under dry and minimum quantity lubrication (MQL) conditions", Vol. 36, 2011, pp. 46-59.

[8]. Attanasio, M. Gelfi, C. Giardini, C. Remino "Minimal quantity lubrication in turning: Effect on tool wear" Wear, Vol. 260, 2006, pp. 333-338.