ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 9(36), DOI: 10.17485/ijst/2016/v9i36/100816, September 2016*

An Investigation in Analysis of Dry Turning in MQL Method for Predicting Tool Wear and to Improve Surface Roughness

G. Ragul[1], S. Naveen Kumar[2], G. Kalivarathan[3], V. Jayakumar[4], C.P. Praveen[3] and Into Jacob[3]

[1]Department of Mechanical Engineering, Budge Budge Institute of Technology, Kolkata, India; ragulme90@gmail.com
[2]Department of Mechanical Engineering, St. Josephs College of Engineering, Chennai, India; Naveen.ap@gmail.com
[3]Department of Mechanical Engineering, Nehru College of Engineering and Research Centre, India; sakthi_eswar@yahoo.com, praveencppalakkad@gmail.com, intopi27@gmail.com
[4]Department of Mechanical Engineering, Saveetha University, Chennai, India; Jkmails2k2@yahoo.com

Abstract

Objectives: To compare the process parameters such as tool performance, surface roughness in turning process under, dry and near-dry conditions. **Methods\Statistical Analysis:** This study deals with the comparative performance of carbide coated tools in conventional dry turning with minimal lubricant application method by varying depth of cut keeping feed and speed as constant. The performance of the tool and the roughness of the work material under different conditions are analyzed. **Findings**: It is found that according to the selected cutting conditions in the model-based comparisons, the predicted tool wear under near dry lubrication are reduced as high as about 30% compared with those in dry cutting while the predicted tool wear land lengths are reduced by 60% compared with those in dry cutting. After the physical behaviors in near dry turning are understood, it is possible to calculate the tool life with given material properties and cutting conditions. **Applications\ Improvements:** This study gives sufficient information about performance of carbide tool with minimum amount of lubrication.

Keywords: Carbide Coated Tools, Dry Turning, Eco Friendly Environment, Minimum Quantity Lubrication (MQL), Surface Roughness

1. Introduction

In this paper work a brief introduction about the comparison between Minimum Quantity Lubrication (MQL) and dry turning in conventional lathe. Machining of titanium alloy is investigated in conventional dry turning and wet turning with minimal fluid methods. In this investigation to predict the tool wears and surface roughness to vary the parameters such as speed and feed, maintaining constant depth of cut. The cutting performances in turning of titanium alloy with pulsed jet coolant. This section includes an introduction about tool wear and surface roughness. It includes environmental safety that has to be in machining environment. Therefore, near dry machining is also recognized as MQL machining. Some advantage of MQL machining is to reduced cost of machining, usage of lubrication is reduced considerably and mainly we improved environmental safety and tool wear also reduced in the

**Author for correspondence*

same time improved better surface roughness. In dry turning of type of conventional machining this includes a direct contact between the tool components and work piece without the application of lubricant. In dry machining process the cutting material is subjected to high temperature which leads to the following difficulties such as reduction of tool life and getting poor surface finish, low machining operation. The cutting material used in dry machining has high hardness, high thermal stability, high chemical resistance, and high toughness.

2. Selection of Work Material

For the comparative study to be conducted, the work material with high strength, low density, and excellent corrosion-resistance which matches titanium alloy is selected. Titanium alloy is used in many parts of aircraft, spacecraft, missiles, and ships which makes our project quiet useful in such kind of manufacturing industries. To select the titanium alloy have good thermal conductivity and also increase the chip formation property. The above mentioned characteristics make the titanium alloy as a best material for our research work.

3. Selection of Cutting Material

For this comparative study, hard work piece say titanium is to be machined and the better one with less wear and improved tool life is to be selected. The cutting material used for machining the work material is carbide SNMG 120412 of H10 23mm a grade insert which has the following property such as increase hardness and also good thermal stability, to increase thermal resistivity and fatigue property it is shown in Figure 1.

Figure 1. Tool holder with cutting insert.

4. Tool Wear

The tool wear that are to be measured in our experiment is flank wear. In order to increase the surface roughness and also to predict tool wear.

4.1 Flank wear

Flank wear is the wear when tool parts in contact with workpiece. Types of flank wear are shown in Figure 2.

- Principle flank wear
- Auxiliary flank wear

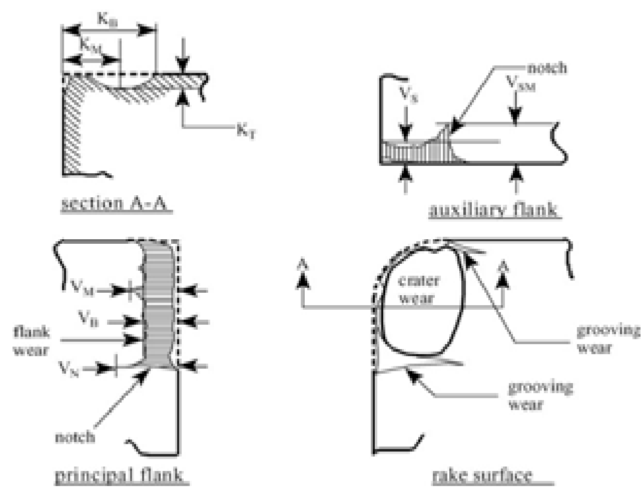

Figure 2. Types of tool wear.

4.1.1. Principle Flank Wear

Principal flank wear is shown in Figure 3.

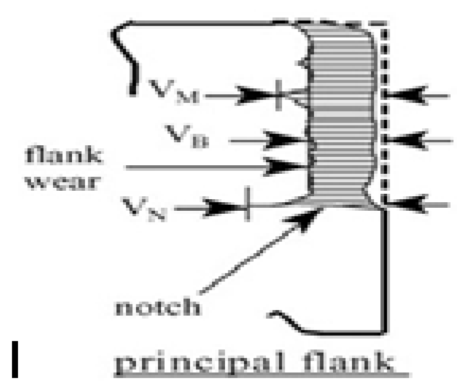

Figure 3. Principal flank wear.

4.1.2 Auxiliary Flank Wear

The wear which occurs on the top of the tool surface is known as auxiliary flank wear and is shown in Figure 4.

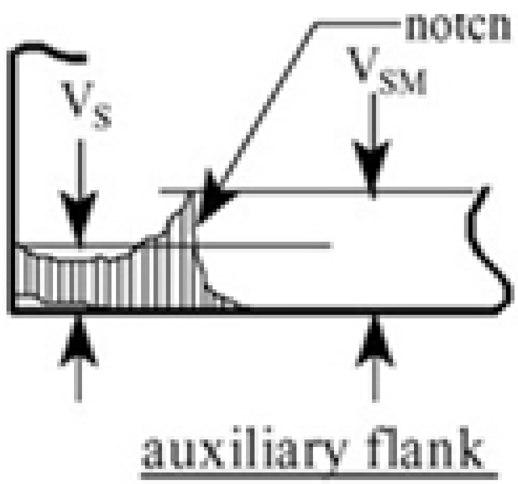

Figure 4. Principal flank wear.

5. Environmental Safety

In this experimental work environment safety is considered as important factor. To reduce the flooding of coolant during turning operation MQL method is implemented to reduce the surface roughness also. According to Occupational Safety and Health Administration (OSHA) and Plant Explosive Level (PEL) also considered.

6. Objective of the Research Work

- To compare dry and MQL cutting conditions.
- Research on tool performance.
- Research on titanium work material.
- Environmental, health impact from the use of cutting fluids.
- To analyze the performance parameters such as surface roughness, tool wear for dry and near dry machining. To control the amount of mist in the working atmosphere using MQL setup.

7. Methodology of Work

The flow chart of research steps is shown as Figure 5.

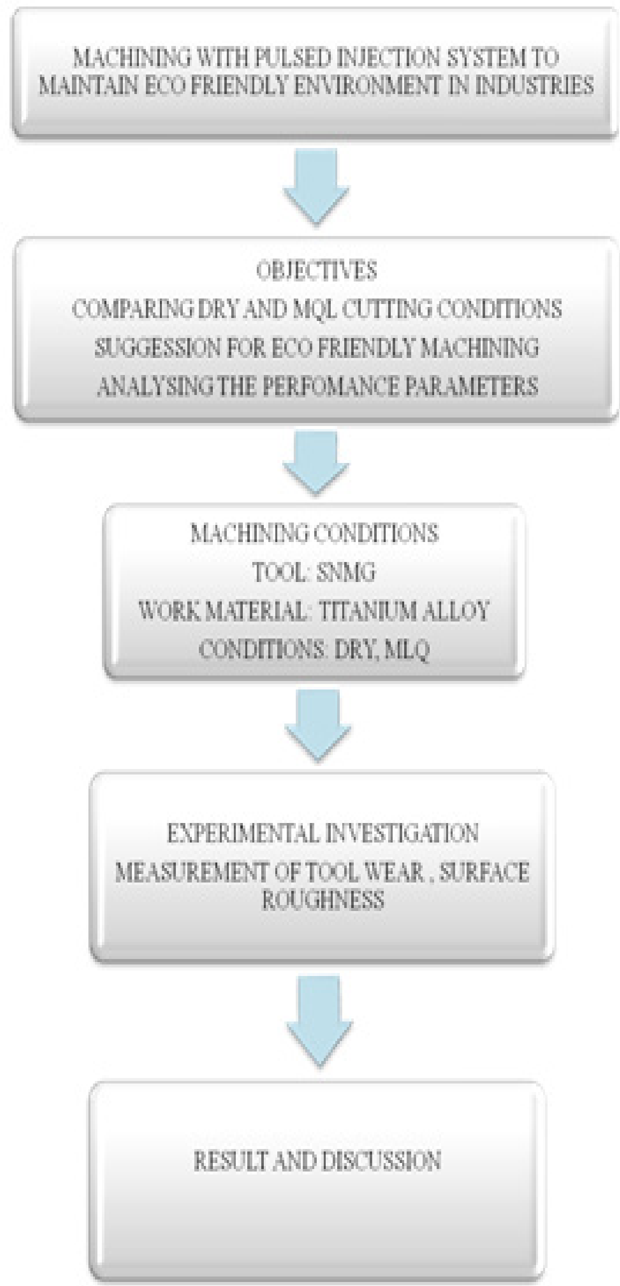

Figure 5. Flowchart shows steps involves in research work.

8. Working Principle OF MQL

In this paper based on the literature review and an examination prior of experimental studies, a methodology was established to study about to improve the surface roughness and also to predict tool wear during machining in dry turning and MQL method. Here to make the comparative study between dry and MQL machining conditions setup. The working of MQL method depend on the principle that atomizing the coolant at desired pressure causes the coolant to break up the droplets into tiny water droplets leading to lubrication with coverage of wide area.

9. Types of MQL Fluid and its Characters

Figure 6 shows MQL fluids and its respectve characters.

9.1 Selection of Lubricant

Table 1 shows the suitable lubricant that can be used for variable operating conditions.

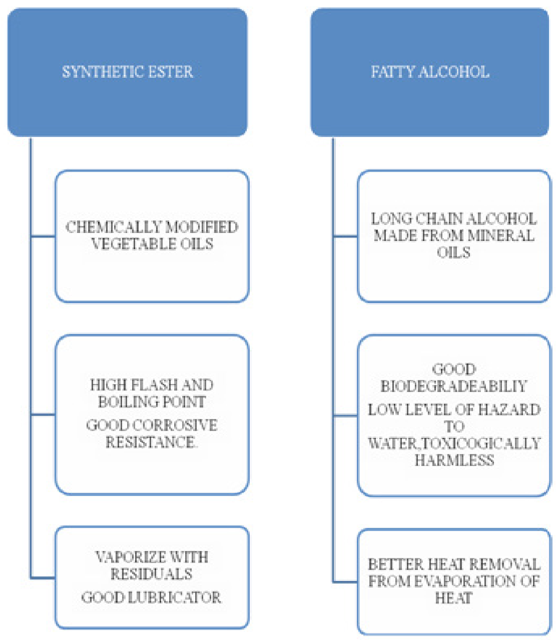

Figure 6. MQL fluids and characters

Table 1. Lubricants and its performance

Medium	Cooling	Lubrication	Chip removal
Emulsion	Excellent	Good	Excellent
Oil	Good	Excellent	Good
Air pressure	Little	No	Little

Table 2 Consists of the various turning parameters are considered to make the comparative study.

Table 2. Machining Conditions of varying turning parameters

Sl. No.	Speed (rpm)	Feed rate (mm/rev)	Depth of cut (mm)
1	180	0.2	0.50
2	180	0.2	1.00
3	180	0.2	1.50

With the tabulated conditions the experiments were conducted and measurements were observed.

9.2 Parameters Affecting the Lubrication

- Parameters Affecting the Lubrication
- Diameter of the nozzle.
- Distance between the nozzle and the work material.
- Pressure of the fuel pump.
- Speed of the motor.
- Power supply.
- Block Diagram of MQL Setup

10. Block Diagram of MQL Setup

The block diagram of MQL setup is shown in Figure 7 and components also shown in Table 3.

Table 3. Showing the components of MQL system

Sl. No.	Components
1	Nozzle
2	P4 Fuel pump
3	Shaft
4	Coupling
5	1 HP motor
6	VARIAC
7	Power supply
8	Coolant tank

11. Working of MQL System

When the power supply is switched on the current from the supply is transferred to the variable transformer (VARIAC). The variable transformer the required constant voltage is supplied to the motor which is coupled with the fuel pump. When the shaft rotates the pump coupled with motor rotates. Meanwhile the fuel pump inlet valve is connected the coolant tank. When the pump reciprocates the coolant from the tank is pumped from the tank using the fuel pump and it is delivered to the nozzle connected to the outlet valve. Now the coolant is pressurized and forced towards the nozzle. At nozzle the

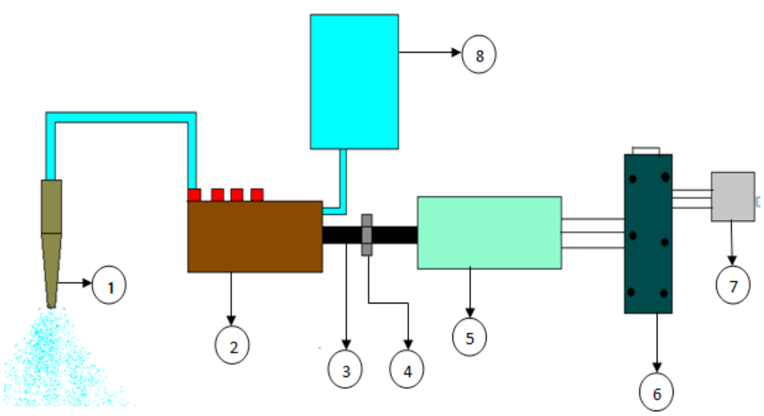

Figure 7. Block diagram of MLQ setup.

pressure of the coolant decreases and its velocity increases causing the coolant to atomize leading to lubrication when allowed to fall on the contact area of the tool and the work piece.

11.1 Advantage of MQL Machining

- Advantage of MQL Machining
- Minimizing the cost of machining
- Less requirement of coolant
- Increased tool life
- Better surface finish
- Environmental safety
- Low initial cost
- Less maintenance cost
- Reliability
- Smooth operation

The above mentioned are some of the application of MQL machining technique which makes it useful for wide range of application.

11.2 Machining of Titanium Alloy using MQL Setup

The conventional lathes in which the parameters are to analyze is now get designed by the MQL system as shown below Figure 8.

Figure 8. MQL setup in conventional lathe.

11.3 Steps of Machining

- The titanium alloy which is to be machined is placed in the chuck of the lathe and the machining is started with the application of lubrication in the form of mist covering the machining area.
- The machining involves turning operation with varying depth of cut for a period of time intervals keeping the feed as constant.
- The stand –off distance is varied according to the requirement.
- The flank wear and surface roughness are noted by time intervals and readings also tabulated and machining of titanium alloy is shown in Figure 9.

Figure 9. Machining of titanium alloy in MQL setup.

12. Dry Machining

Dry machining is the process in which the tool and the work piece are in direct contact to each other without the application of lubrication. In dry machining process the parameters such as tool wear and surface roughness are to be measured same as that of MQL machining but in the absence of the lubricant.

12.1 Steps Involves in Dry Machining

- The titanium alloy is placed in the chuck of the lathe machine as shown in Figure 10.

Figure 10. Dry machining of titanium alloy on conventional lathe machine.

- The machine is started and turning operation is carried out under the same condition followed in MQL machining.

12.2 Advantage of Dry Machining

- Advantage of Dry Machining
- Low initial cost
- Less maintenance
- Less machining cost

12.3 Disadvantage of Dry Machining

- Disadvantage of Dry Machining
- Poor surface finish
- High heat development
- Reduced tool life
- High surface roughness
- Chips get welded to the work piece

Table 4 consists of the various turning parameters considered to make the comparative study.

Table 4. Machining Conditions of varying turning parameters

Sl. No	Speed (rpm)	Feed rate (mm/rev)	Depth of Cut(mm)
1.	180	0.2	0.50
2.	180	0.2	1.00
3.	180	0.2	1.50

With the tabulated conditions the experiments were conducted and measurements were observed.

13. Tool Wear under MQL and Dry Machining

In this work to improve surface roughness and to predict tool wear values are measured with the time interval of 10 minutes with a feed rate of 0.02mm/revolution and with varying depth of cut (DoC) and the values are tabulated as follows in Table 5 and 6.

Table 5. Tool Wear under for MQL Machining

Sl No	Time (min)	Tool Wear(mm)	
		Flank	Auxiliary
1	5	0.01	0.02
2	15	0.1	0.08
3	25	0.15	0.12
4	35	0.17	0.14
5	45	0.24	0.20

Table 6. Tool wears under dry machining

S No	Time (min)	Tool Wear(mm)	
		Flank	Auxiliary
1	5	0.1	0.06
2	15	0.15	0.11
3	25	0.17	0.14
4	35	0.24	0.20
5	45	0.30	0.25

Table 7. Surface roughness for MQL machining

Sl. No.	Time (min)	Surface roughness (μm)
1	5	0.34
2	15	0.56
3	25	0.46
4	35	0.62
5	45	0.93

Table 8. Surface roughness for dry machining

Sl. No.	Time (min)	Surface roughness (μm)
1	5	0.86
2	15	0.74
3	25	0.89
4	35	1.12
5	45	1.45

13.1 Microscopic Image of Tool Wear under MQL Machining and Dry Machining

The image shows in the Figure 11 is observed after the MQL machining with progressive tool wear of different time settings. It was observed that the initial machining shows tool wear tend minimum wear and later on after the 45th minute machining tool gets worn out drastically due to heat created between tool and continues chip flow on the surface of insert. Similarly image shown in Figure 12 after dry machining with progressive of tool wear in different time settings as same above. Also Figure 13 shows auxiliary wear observed during machining.

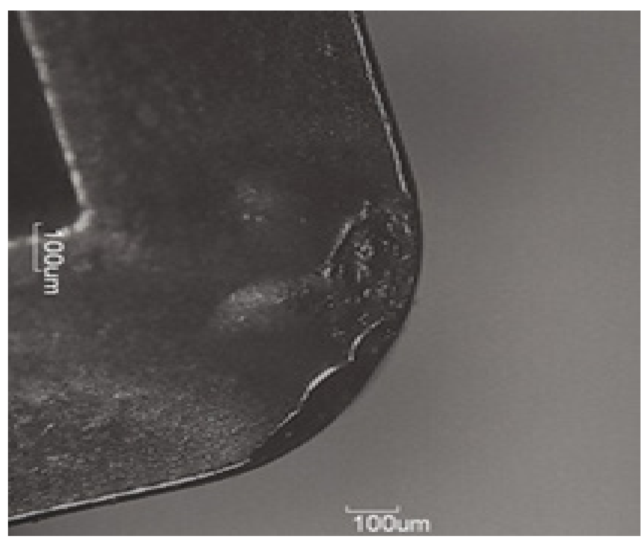

Figure 11. Microscopic image of tool wear machined in MQL system.

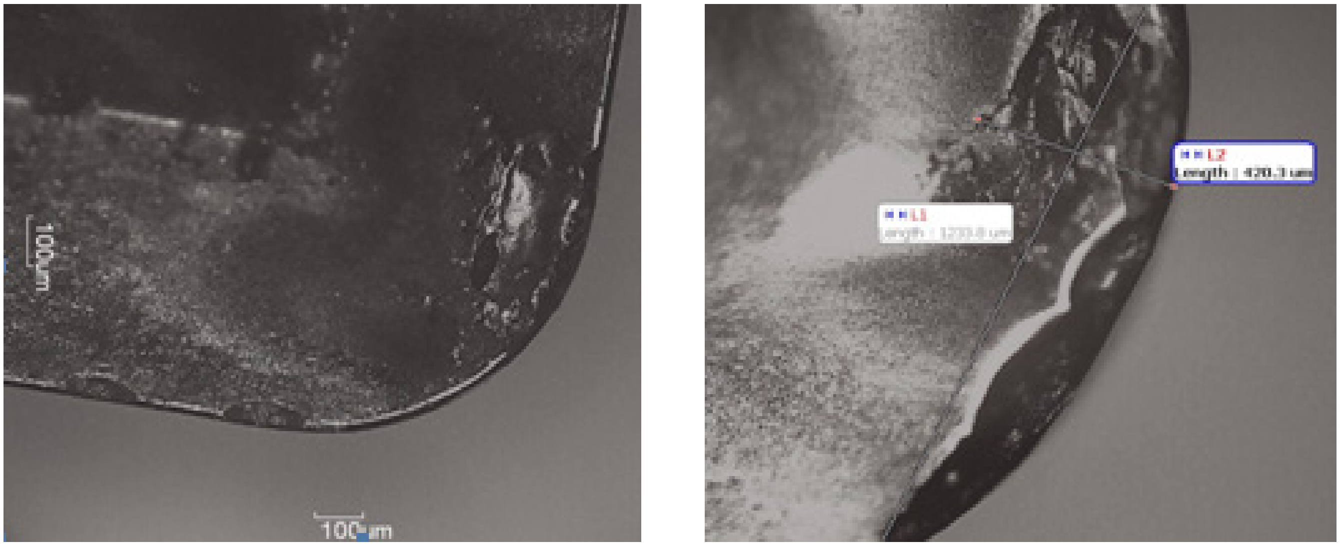

Figure 12. Microscopic image of tool wear in dry machining.

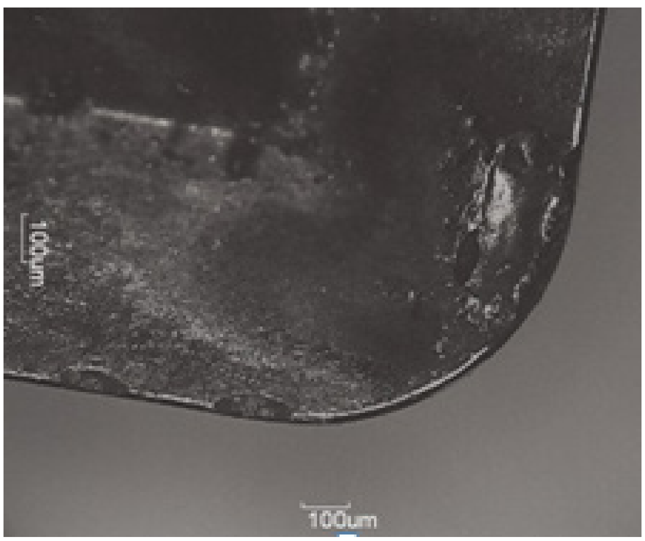

Figure 13. Auxiliary wear observed during machining.

14. Result and Discussion

In this chapter the result of the dry machining and near dry machining is discussed. Charts for both dry and near dry machining showing the difference between the in the case of tool wear and surface roughness.

From the graph it is proved that the amount of auxiliary flank wear for the tool in MQL machining is better when compared to that of dry machining.

The graph as Figure 15 shows that the wear on tool which is machined in MQL setup gives the low wear and increases the tool life comparatively while graph as Figure 14 depicts the difference in auxiliary tool wears.

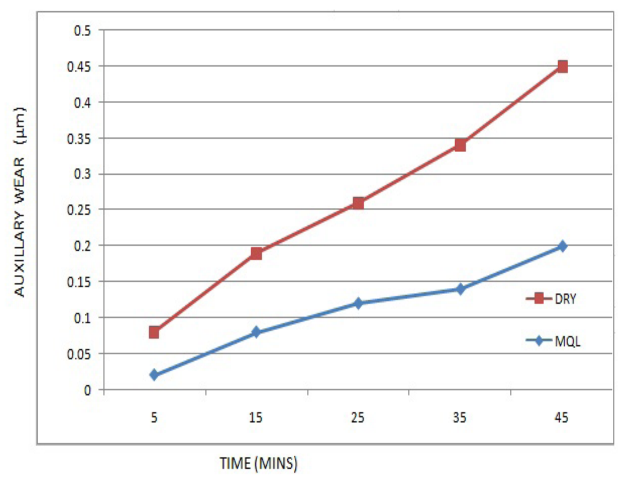

Figure 14. Graph showing the difference in auxiliary tool wears.

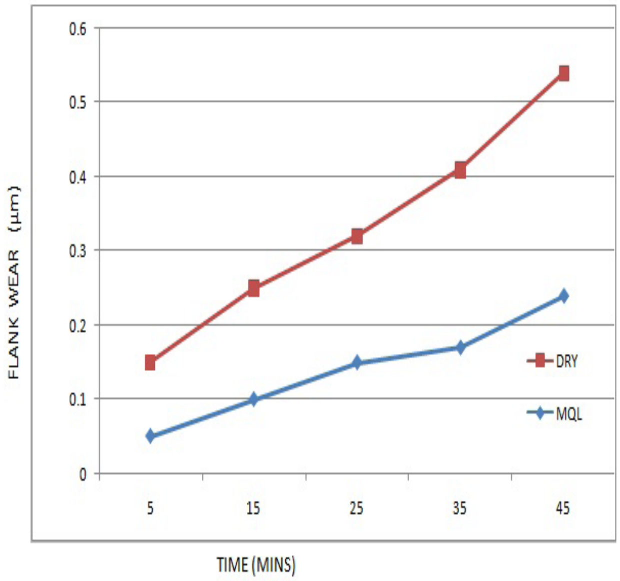

Figure 15. Graph showing the difference in flank tool wears.

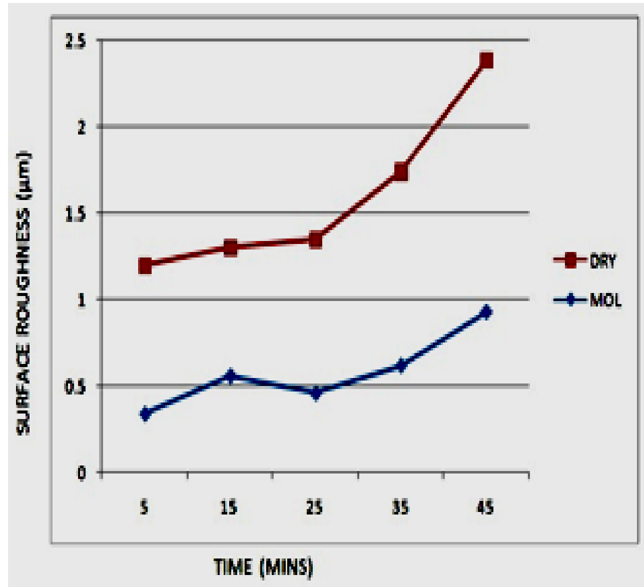

Figure 16. Graph showing the variation of surface roughness.

15. Conclusion

From this experiment in the 10 minutes interval of time readings are manipulated by the dry turning and also MQL based system. In comparison with both system for the surface roughness and also tool wear prediction by the scanning electron microscope under various resolution we found that MQL based system gives better result as the same time it is eco-friendly to reduce the coolant in cost and also worker safety consideration. In the way of reduction the cost as well as improve production rate in automobile and manufacturing industry.

16. References

1. Northcott WH. A Treatise on Lathes and Turning, Longmans Green and Company, London, 1868.
2. Leith D, Thornburg J. Grant Report: Factors that Affect Generation of Coolant Mists, NIOSH Grant No. R01 0H03293-02. University of North Carolina, 1999, p.1-86.
3. US Department of Health and Human Service, of NIOSH: Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids, DHHS (NIOSH) Publication No. 98-102, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1998, p.1-242.
4. Bienkowski K. Coolants and Lubricants: The Truth, Manufacturing Engineering, 1993 March, p 90-96.
5. Shaw MC. Metal Cutting Principles, Clarendon Press, Oxford, 1984.
6. Nachtman ES, Kalpakjain S. Lubricants and Lubrication in Metalworking Operations, Marcel Dekker, Inc., New York. 1985, p.288.
7. Gough PJC. Swarf and Machine Tools: A Guide to the Methods Used in the Handling and Treatment of Swarf and Cutting Fluids, Hutchinson, London, 1970.
8. Woskie SR, Smith TJ, Hammond SK, Hallock MH. Factors Affecting Worker Exposures to Metalworking Fluids during Automotive Component Manufacturing. Applied Occupational and Environmental Hygiene; 1994; 9(9):612-21.
9. Coennett EO, Bennett DL. Minimizing Human Exposure to Chemicals in Metalworking Fluids. Lubrication Engineering. 1987; 43(3):167-75.
10. Brandt RH. Filtration Systems for Metalworking Fluids. In: J. Byers, editor, Metalworking Fluids, Marcel Dekker, New York, 1994, p.1-7.
11. Hoskie SR, Virji MA, Kriebel D, Sama SR, Eberiel D, Milton DK, Hammond SK, Moure-Eraso R. Exposure Assessment

for a Field Investigation of the Acute Respiratory Effects of Metalworking Fluids, I. Summary of Findings. American Industrial Hygiene Association Journal.1996; 57(12):1154-62.

12. Taylor FW. On the Art of Metal Cutting, ASME, New York 1906, p.1-247.
13. Silliman JD. Editor: Cutting and Grinding Fluids: Selection and Application, Society of Manufacturing Engineers, Dearborn Michigan, 1992, p.1-12.
14. Smith GT. CNC Machining Technology, Volume II. Cutting, Fluids and Work holding Technology, Springer-Verlag, London, 1993.