Investigation on Effects of MQL and Flood Cooling on Surface Finish and Tool Wear in Turning of SAE 1018

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ABSTRACT

In the industries, the cutting fluids are used to control the heat generation during machining. The cutting fluids help in minimizing the cutting temperature and to improve the surface quality of products. The use of cutting fluids becomes hazardous to the employ's health and environment. To reduce the effect of cutting fluid on environmental pollution and employ's health much research has been done. The researcher found some alternatives such that dry machining and near dry machining. Dry machining has great impact on it but surface quality has not been maintained due to direct contact of surfaces of work-piece and tool. Near dry machining is the technique in which aerosol consists of small amount of vegetable oils and compressed air at suitable pressure is directly impinged on cutting zone through a nozzle.

In this study, experiments were conducted to analyze the tool wear and surface roughness of SAE 1018 under two different cooling environments i.e. Flood cooling and Minimum Quantity Lubrication (MQL) technique at speed feed combinations with coated carbide bits. The significant results were obtained in terms of reduced nose wear rate and improved surface quality of specimens by using MQL technique.

Keywords :- MQL, Flood Cooling , Near Dry Machining

1. Introduction

Nowadays, Industries seeking to minimize the production cost, energy and resources with improvement in environmental safety. The cost related to cooling and lubrication represents a large amount of total machining. Lot of research work has been done on reduction of cost associated with lubrication. During the machining operations, high cutting forces are produced due to friction between the contact surfaces of tool and work-piece. These forces increase the cutting temperature of cutting zone which results in bad surface quality and high tool wear and also increases the production cost. These cutting forces and interface temperature of cutting zone can be reduced by providing suitable lubrication to the contact surfaces.

1.1 Lubrication

The aim of lubrication in machining process is to provide cooling and lubrication at cutting zone and to minimize the heat produced at tool chip interface.

Lubrication plays significant role during machining operations such as:-

- Lubricant separates the contact surfaces by forming thin film between them.
- Cooling ability of fluid reduces the interface temperature.

- It also helps in removal of chips generated during machining.

1.2 Flood cooling

Flood cooling is commonly known as conventional cooling in which a large quantity lubricant is fed to the tool-tip and work interface. Conventional metal working fluid delivery system provides fluids to work zone in volumes which flood the work area, these fluids are filtered then re-circulated through the system [4]. A metal working fluid may significantly affect the tri-biological conditions at these interfaces by changing the contact temperature, normal and shear stresses and their distributions along the interfaces.[5]

1.3 Minimum Quantity Lubrication (MQL)

MQL is a technique which sprays small amount of cutting fluid (10-100 ml/h) to the cutting zone area with aid of compressed air [7]. Minimum quantity lubrication has been demonstrated to be an effective near dry machining techniques as well as an efficient alternative to completely dry and wet cutting conditions from the viewpoint of cost, ecological and human health issues and machining process performance [8]. MQL is a sustainable manufacturing technique that is safe for the environment and the worker and is cost effective [9]. The MQL needs to be supplied at high pressure and impinged at high speed through a spray painting gun on cutting zone [10]. MQL machining was developed as an alternative to flood and internal high pressure coolant supply to reduce metal working fluid consumption. MQL is an ecologically friendly and cost effective method of fluid delivery [12]. In high speed machining, conventional cutting fluid applications fails to penetrate the chip tool interface and thus cannot remove the heat effectively [13].

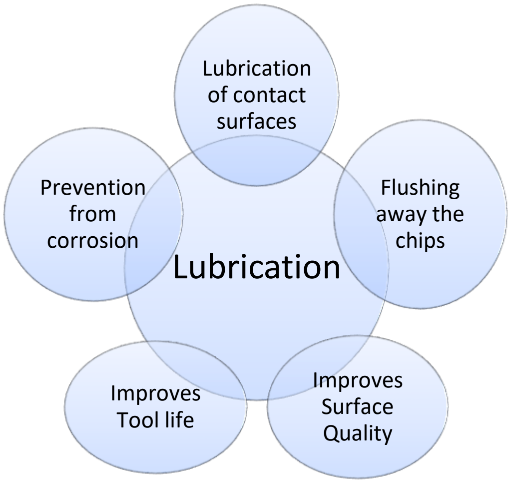

Fig. 1 Functions of Lubrication

2. Experimental Setup

2.1 Machining Parameters

Plain Turning was performed using Panther Lathe Machine of 2 HP in central workshop at Mimit Malout. The lathe Machine equipped with internal flood cooling setup. Experiments were conducted at three different speeds i.e. 288, 394 & 598. The depth of cut kept constant to 0.5 mm.

2.2 Cooling Environment

In the present study two different cooling environments (Flood Cooling and MQL Technique) has been used to compare the effects of different cooling conditions on surface quality and tool wear. In flood cooling, large amount of cutting fluid has been provided to the cutting zone with help of inbuilt setup of Panther lathe machine. The lathe machine was equipped with an external MQL setup. The MQL system supplies the Aerosol (mixture of lubricant & compressed air) at constant pressure of 5 bar to the interface between tool tip and work-piece through a special nozzle fixed on tool post with nominal diameter 2 mm.

2.3 Cutting Tool

The turning operation has been completed by using coated carbide inserts of PS08. Different carbide inserts of same material and geometry were used for each turning operation under both flood and MQL machining. Tool wear was evaluated by measuring the nose wear with Coordinate Measuring Machine (CMM). The microscopic images of carbide bits observed by SEM to examine the nose wear.

2.4 Work-piece Material

The specimen used in plain turning was SAE 1018 with size of 520 mm long rod with diameter of 36 mm. the element concentration in SAE 1018 was measured with Spectro in percentage by weight as shown in table no.1.

Table No.1 Element Concentration in SAE 1018

Element	C	S	P	Si	Mn
Percentage	0.21	0.10	0.016	0.21	0.88

3. Results and discussion

During the turning operation, heat is generated at the contact surfaces of tool and work-piece. This heat majorly affects the tool life and surface quality of the work-piece. Conventional flood cooling system cools and lubricates the tool and work-piece to some extent but could not expected to reduce the tool chip interface where maximum friction generated. It was observed that MQL by vegetable oils effectively reduce the tool chip interface temperature by application of aerosol jet at the point of contact of tool tip and work-piece.

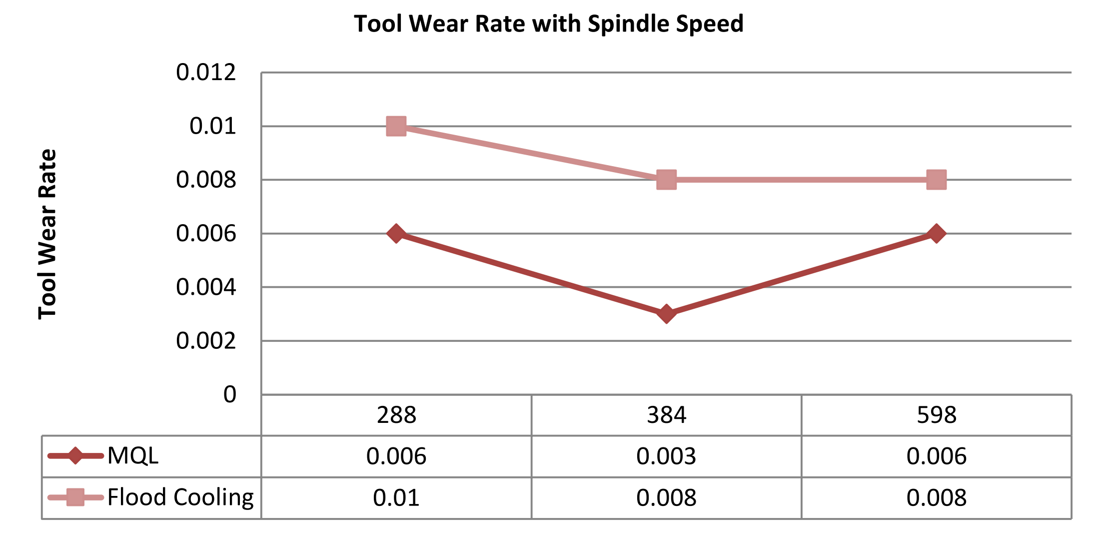

Fig. 2 Variation of Nose Wear with spindle speed

3.1 Nose Wear

Nose wear occurs due to friction between tool tip and work-piece. Nose is the mating part of flank and face which is combination effect of crater wear and flank wear. So it is important factor which affects tool life and surface quality of specimen.

Nose wear is measured with Co-ordinate Measuring Machine (CMM). For the measurement of nose wear coated carbide inserts were removed after each operation. The measured nose wear at three different speeds under both cooling environments is plotted to obtain graphs. The fig. 2 shows that MQL gives very less nose wear at 384 spindle speed as compared to that of flood cooling. It appears that MQL reduces the cutting forces and decreases the cutting temperature.

The SEM views of nose wear of the worn-out insert after the turning of SAE 1018 under flooded and MQL conditions are shown in figs.3 and 4. These figs. shows that abrasive scratch marks appeared at the nose of cutting inserts. Effective interface temperature control with Mustard oil as lubricant in MQL system reduced the growth of nose wear and crater wear. Further fig.2 clearly shows reduces nose wear under MQL by Mustard oil conditions.

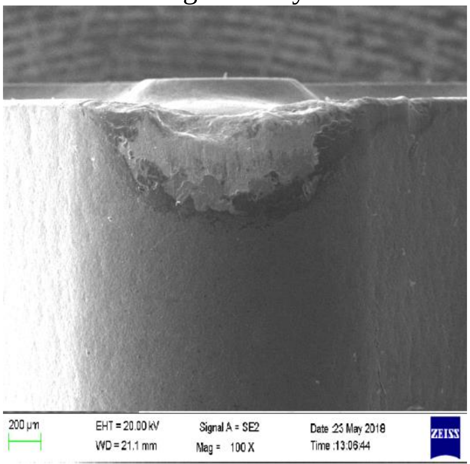

Fig.3 SEM image of Carbide bit under flooded Cooling

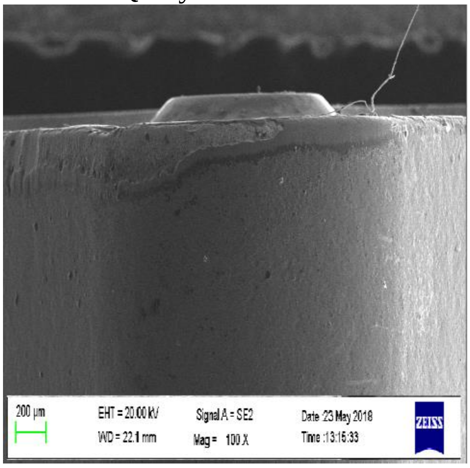

Fig.4 SEM image of Carbide bit under MQL

3.2 Surface Roughness

In order to evaluate the machining performance, Surface roughness were compared under various machining conditions to conventional cooling and MQL system using vegetable oils. The Surface roughnesses of work-pieces after each operation were evaluated to examine the surface quality of job after turning operation. Surface roughness was examined by Mitutoyo SURFTEST-4 at R&D Centre Ludhiana. . During this study Experiment was carried out at different speed and cutting environment and Surface roughness is measured after each operation. Surface roughness values recorded during experiments under MQL environment and flooded cooling are shown in fig. 5. Slightly higher surface roughness values were obtained in flooded environment when compared with MQL technique. From the graph it appears that values of surface roughness varies with change in spindle speed under both cooling conditions but MQL gives improved surface quality as compared to that of flooded. The good surface quality obtained by using MQL system is because of more effective lubrication at tool chip interface. MQL technique allows the chips to slide more easily over the tool surface and results in better surface finish.

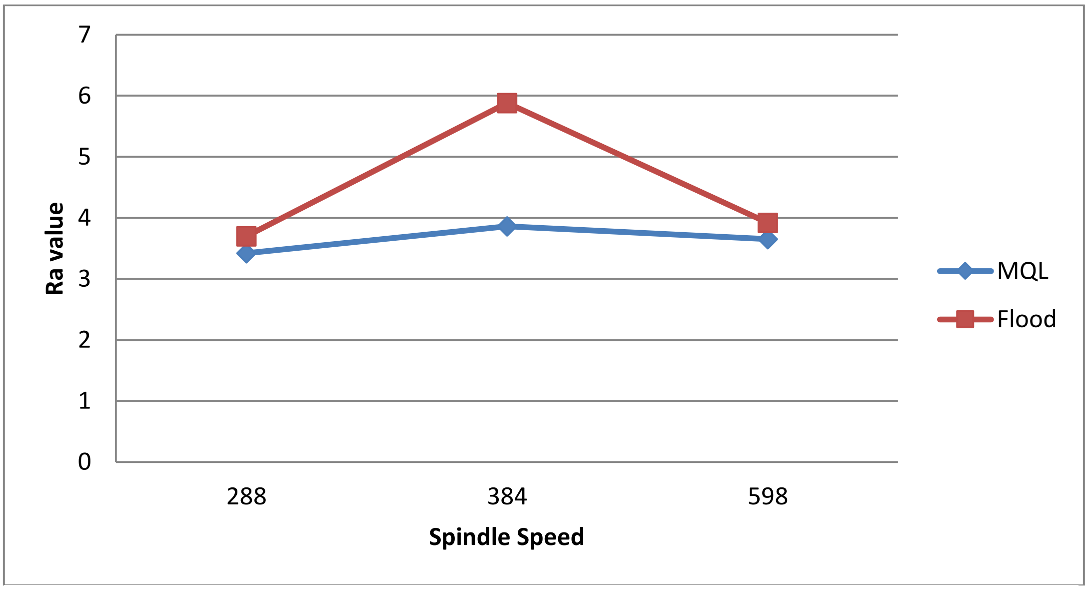

Fig. 5 variations of Ra Values with spindle speed

4. Conclusion

On the basis of results obtained after the turning of SAE 1018 with respect to nose wear and surface roughness under flood cooling and MQL technique with mustard oil, it can be concluded that:-

1. The MQL technique using mustard oil gives better results with respect to nose wear and surface roughness as compared to that of flood cooling.
2. Surface roughness values obtained in MQL system are comparable to that of flood cooling. Whereas MQL system with mustard oil gives better surface quality of work-piece after turning.
3. This study showed that MQL system reduced the nose wear.
4. In comparison with both systems for the surface roughness and tool wear examined by SEM under various conditions we found that MQLbased system gives better results at the same time it is eco-friendly in employee’s health safety consideration.

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