Mist Application of Cutting Fluid

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***Abstract*--** **During turning operation, high temperature is produced. Such high temperature often leads to several problems like a large heat affected zone, high tool wear, change in hardness and microstructure of the work piece, burning and its consequence and micro cracks. Application of cutting fluids in conventional method reduces the above problems to some extent through cooling and lubricating of the cutting zone. But in this process the cooling rate is low. For this reason mist application technique has become the focus of attention of researchers and technicians in the field of machining as an alternative to traditional flood cooling. The concept of mist application of cutting fluid some time referred to as near dry machining. The minimization of the requirement of cutting fluids leads to economical benefits, and environmental friendly machining.**

In this work, attempts have been made to develop a mist application device to apply cutting fluid for turning operation of medium carbon steels. This experiment is to determining the tool wear and temperature rise during turning operation of medium carbon steel by high speed steel cutting tool at different depth of cuts and spindle speeds as well as cutting speeds. Feed rate has always being constant. The above operation has been done for dry cutting condition, Flood and Mist application of cutting fluids. Mist application of cutting fluid system enabled reduction in average chip-tool interface temperature up to 40% lower than conventional flood cooling cutting system depending upon cutting condition. Mist application system with the present technique has substantially reduced flank wear and hence improves tool life.

***Index Term*--** **Cutting Fluid, Mist Application, Turning Operation, Tool Wear.**

1. INTRODUCTION

A cutting fluid can be defined as any substance which is applied to a tool during a cutting operation to facilitate removal of chips. Cutting fluids have been used extensively in metal cutting operations for the last 200 years. In the beginning, cutting fluids consisted of simple oils applied with brushes to lubricate and cool the machine tool. Occasionally, lard, animal fat or whale oil was added to improve the oil's lubricity. As cutting operations became more severe, cutting fluid formulations became more complex. Today's cutting fluids are special blends of chemical additives, lubricants and water formulated to meet the performance demands of the metalworking industry.

During metal cutting heat generated as a result of work done. Heat is carried away from the tool and work by means of cutting fluids, which at the same time reduced the friction between the tool and chip and between tool and work and facilitates the chip formation. Cutting fluids usually in the form of a liquid are to the formation zone to improve the cutting condition. Cutting fluids is one of the important aids to improve production efficiency.

Cutting fluids play a significant role in machining operations and impact shop productivity, tool life and quality of work. With time and use, fluids degrade in quality and eventually require disposal once their efficiency is lost. Waste management and disposal have become increasingly more complex and expensive. Environmental liability is also a major concern with waste disposal. Many companies are now paying for environmental cleanups or have been fined by regulatory agencies as the result of poor waste disposal practices.

Cutting fluids can be applied in the machining process in a number of different ways. The most common is flood application, where a large volume of fluid is pumped to the metal removal interface. The fluid is collected and then reused many times. Another method, Micro-lubrication, provides fluid to the cutting interface in the form of a mist, providing the lubrication effect. Because of the small volume used, the fluid is not collected for reuse. Also related to the method of fluid application are the concepts of dry (no metal removal fluid used), near-dry, and semi-dry machining. The last two methods are different applications of methods for reducing the volume of fluid used in the machining process. In this study the flood application will be used to compare the performance of the mist application.

In a modern workshop practice or any industry using power, an enormous amount of power is lost either by the generation of heat or by friction between tool surface and work piece. Heat in the cutting process is generated by plastic deformation and by chip or tool friction at the rake and flank faces. It has been seen that the amount of power lost due to generation of heat varies from 20-30 percent and hence to reduce it, the use of cutting fluids came into existence in the field of production technology. Cutting forces can also be considerably reduced by using suitable cutting lubricants when machining metals at speeds bellow 0.7m/sec.
For low speed machining operations, lubrication is a critical function of the cutting fluid. Cooling is not a major function of the cutting fluid as most of the heat generated in low speed machining can be removed by the chip. For high speed machining operations, cooling is the main function of the cutting fluid, as the chip does not have sufficient time to remove the generated heat. The lubrication effects of the cutting fluid in high speed machining operations are also limited. The flow of the cutting fluid to the tool-cutting surface interface is due to capillary flow. In high speed machining, there is insufficient time for the capillary flow of

the fluid to reach the tool-cutting surface interface. Because of the reduced lubrication effects of the cutting fluid, more heat is generated, making the cooling function of the cutting fluid even more critical.

2. CUTTING FLUID AND MIST APPLICATION

Cutting fluids serve several functions in the machining process. For some processes, the primary function is lubrication, while for others, it is cooling. In many processes, cutting fluids are also used for chip removal; in some facilities, a large portion of the cutting fluid pumped throughout the plant is for chip handling. In addition, cutting fluids may also provide corrosion protection for the newly machined surface of the part being produced. All of these functions have an impact on the process, from tool life and power consumption, to part quality and operability.

One of the primary driving forces behind the implementation of micro-lubrication is waste reduction. The fluid is atomized, often with compressed air, and delivered to the cutting interface through a number of nozzles. Because the fluid is applied at such low rates, most or all of the fluid used is carried out with the part. This eliminates the need to collect the fluid while still providing some fluid for lubrication, corrosion prevention, and a limited amount of cooling. Because of the low flow rates, coolant cannot be used to transport chips, meaning alternative methods for chip extraction must be implemented. However, the chips that are extracted should be of higher value since they are not contaminated with large quantities of cutting fluid.

2.1 Working Principle of Mist Application System:

Mist application of cutting fluid refers to the use of cutting fluids of only a minute amount, typically a flow rate of 50 to 500 ml/hr which is about three to four orders of magnitude lower than the amount commonly used in flood cooling condition, where for example, up to 10 liters of fluid can be dispensed per minute.

Mist application requires a high pressure and impinged at high speed through the nozzle at the cutting zone. The mist application system has three components, these are

i. Compressor
ii. Mist generator
iii. Nozzle.

The compressor used in this system acts as air supply unit and the main purpose is to supply air at a pressure, which is used in different components of the mist application system. Mist application system consists of two components (i) fluid chamber and (ii) nozzle.

The fluid chamber has an inlet port and an outlet port at the top and the bottom respectively. It is used only to contain the cutting fluid. It is connected to the compressor by a flexible pipe through the inlet port to keep the fluid inside the chamber under the constant pressure. It is required to maintain the flow into the nozzle over a long period of time during machining operation. The fluid chamber has been designed with larger capacity so as to able to supply fluid continuously during machining.

In the inlet section of nozzle there are two inlet ports through which air and fluid can enter. High pressure air from the compressor enters into the nozzle mixes with the fluid which come from the fluid chamber with high pressure.

Fig. 2.1. Photographic view of the experimental setup.

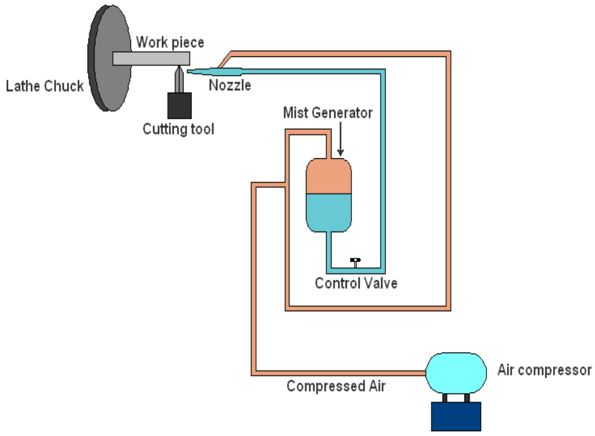

Fig. 2.2. Schematic representation of the experimental setup.

In mist application system a compressor is used to supply air at high pressure. The cutting fluid which is to be used is placed in the mist generator, and there is a connection of high pressure air line from the compressor with the help of flexible pipe at the bottom of the mist generator. When the air at high pressure enters the mist generator it carries a certain amount of cutting fluid along with it, and this cutting fluid coming out from the nozzle with the air coming in another from the compressor as a jet, which is applied to the hot zone. In the mist generator there is a regulating valve by which the flow rate of the cutting fluid can be controlled. The photographic and schematic views of the experimental setup are shown in Fig.2.1 and Fig.2.2 respectively. During the experiment the thin but high velocity stream of mist is to be projected along the work tool interfaces as parallel as possible.

Experimental Cutting Conditions

A. Machine: Lathe machine (Harrison M-250)
B. Work-piece material: Medium Carbon Steel
C. Cutting tool material: High Speed Steel (H.S.S)
D. Cutting Fluid: Diode -so- M (Commercial Name)

E. Cutting Conditions:

- **i.** Spindle speed: 120rpm, 180rpm, 260rpm, 320rpm, 550rpm.
- **ii.** Cutting velocity: 10.38m/min to 48.26 m/min.
- **iii.** Depth of cut: 0.4mm,0.6mm, 0.8mm, 1.0mm, 1.2mm, 1.4mm.
- **iv.** Length of cut: 0.30m.
- **v.** Feed rate: 0.1mm/rev.

F. Measuring tools:

- **i.** Linear scale
- **ii.** Digital slide calipers
- **iii.** Infrared thermometer

3. EXPERIMENTAL INVESTIGATION

I. Turning Zone Temperature

The turning is associated with high temperature rise which is responsible for aggravating several problems like thermal damage of the ground surface, change in hardness, change in surface roughness etc. In present research work the benefits expected out of mist application over dry and wet environment are also based mainly in reduction in turning zone temperature. The temperature of the turning surface has been measured by inferred thermometer.

In present work, the average turning zone temperature could be effectively measured under dry, wet and mist condition very reliably throughout the experimental domain. The evaluated role of mist application on average turning zone temperature in turning the medium carbon steel by single point cutting tool at different feed under dry, wet and mist conditions have been shown in Fig. 3.1 to Fig.3.10.

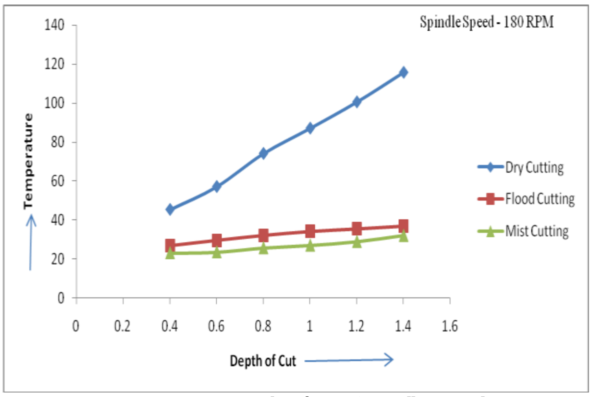

Fig. 3.1. Temperature vs Depth of Cut (Spindle Speed = 180 RPM

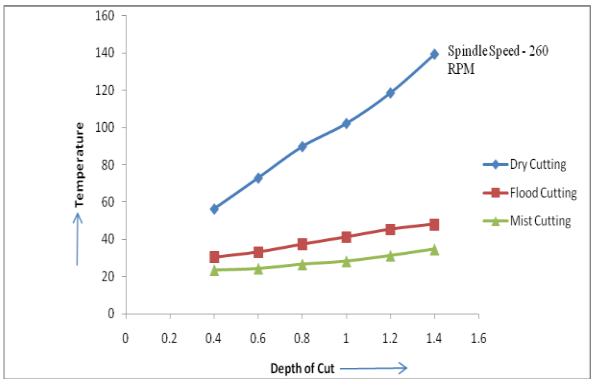

Fig. 3.2. Temperature vs Depth of Cut (Spindle Speed = 260 RPM)

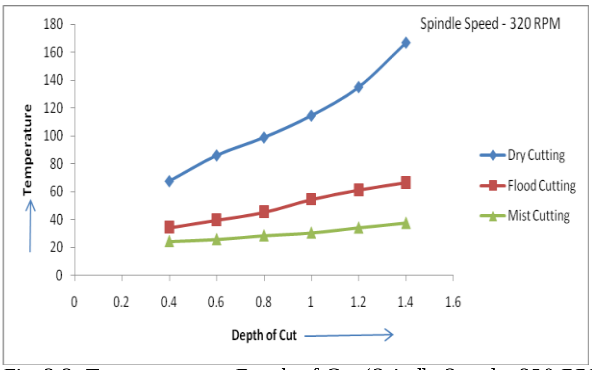

Fig. 3.3. Temperature vs Depth of Cut (Spindle Speed = 320 RPM)

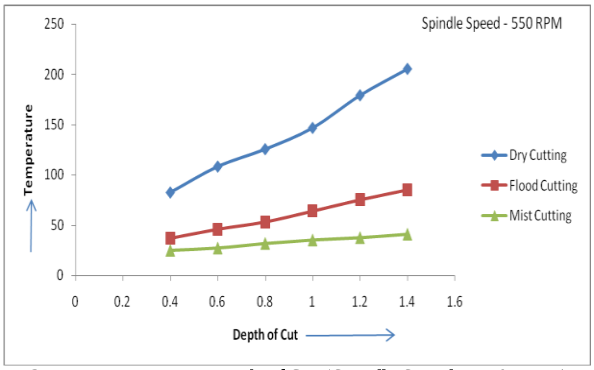

Fig. 3.4. Temperature vs Depth of Cut (Spindle Speed = 550 RPM)

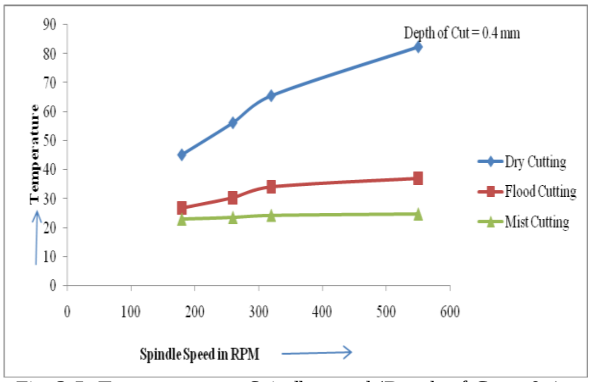

Fig. 3.5. Temperature vs Spindle speed (Depth of Cut = 0.4 mm)

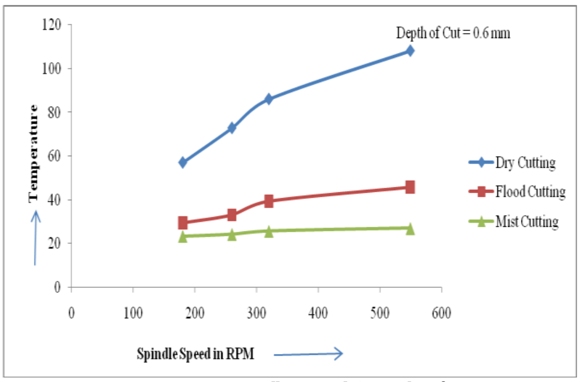

Fig. 3.6. Temperature vs Spindle speed (Depth of Cut = 0.6 mm)

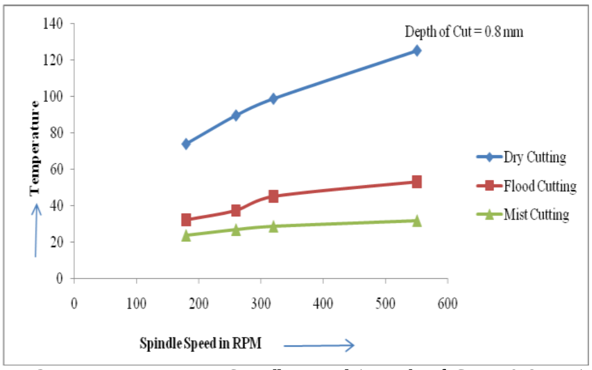

Fig. 3.7. Temperature vs Spindle speed (Depth of Cut = 0.8 mm)

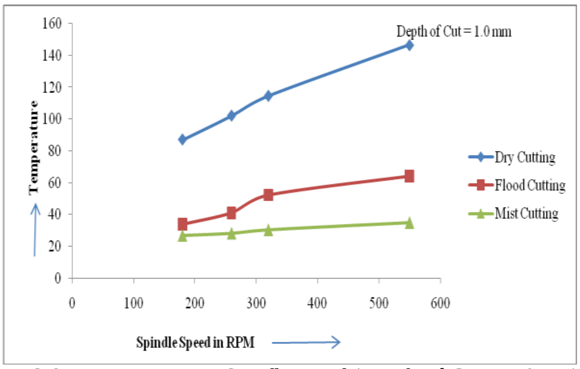

Fig. 3.8. Temperature vs Spindle speed (Depth of Cut = 1.0mm).

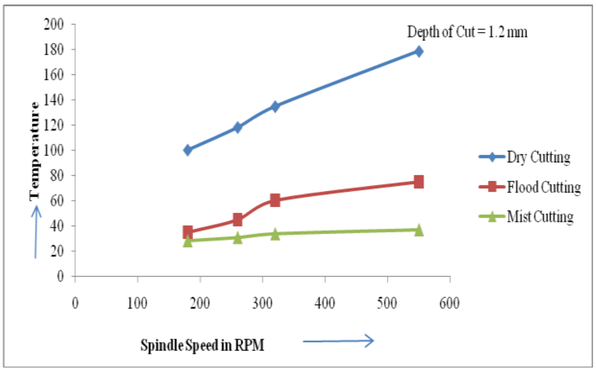

Fig. 3.9. Temperature vs Spindle speed (Depth of Cut = 1.2 mm)

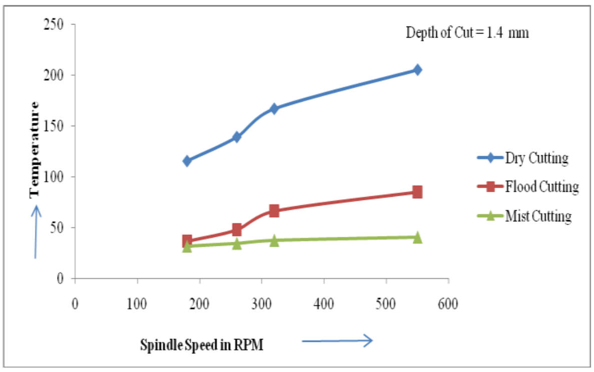

Fig. 3.10. Temperature vs Spindle speed (Depth of Cut = 1.4 mm)

4. DISCUSSION

I. Turning Zone Temperature

The turning zone temperatures have been measured by infrared thermometer. Then turning zone temperature is plotted against spindle speed and depth of cut. The Fig.3.1 to Fig.3.10 are showing the effect of mist application on turning zone temperature under different speed and depth of cut as compared to dry and flood conditions. However from the aforementioned figures it is clear that with the increase in speed and depth of cut the turning temperature increases even under mist condition due to increase in energy consumption and higher material removal rate. But mist application system is still more effective as compared to dry and flood conditions. However it is observed that mist application system in its present way of application enable in reduction of the average cutting temperature by about 10% to 40% more than conventional method depending upon the spindle speed, depth of cut and other process parameter.

II. Tool Wear

The most accurate tool wear measurement technique is the optical measurement technique. As opportunity of this technique is not available so the experiment works has been done manually. The tool wear measured for dry, wet and mist condition increases with the increase in depth of cut and spindle speeds are shown in Fig.3.11. to Fig.3.20.

At dry condition the tool wear is more to other environments. But the tool wear reduces under flood machining compared to dry, which may possible for the lubrication and reducing the cutting zone temperature. However it is evident that for mist condition the tool wear is less than flood and dry conditions.

5. CONCLUSIONS

Based on the present experimental investigation the following conclusions can be drawn:

- The mist application enables reduction of the turning zone temperature up to 10% to 40% more than conventional methods depending on the process parameter. In the present experiment the cutting fluid jet reached perfectly to the tool work interface. Flood cooling by soluble cutting fluid can not control the turning temperature appreciably.
- The wear of high speed steel cutting tool is analyzed for turning operation on the medium carbon steel. The tool wear is measured for dry, flood and mist condition, in which the mist condition provides minimum tool wear.

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