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Review Paper on Oil Mist Lubrication

Ankit Chaurasia*, Junaid**, Naveen Pandey***, Avinash Gupta****
**(Department of Mechanical Engineering, UCEM, Allahabad-211010*
*** (Department of Mechanical Engineering, UCEM, Allahabad-211010*
**** (Department of Mechanical Engineering, UCEM, Allahabad-211010*
***** (Department of Mechanical Engineering, UCEM, Allahabad-211010*
Corresponding Auther: Ankit Chaurasia

ABSTRACT
In any metal cutting operation, the cutting fluids plays a vital role by cooling the surface of the work piece and the cutting tool, removing chips from the cutting zone and by lubricating the tool work piece interface. However misuse of the cutting fluids and wrong methods of its disposal can effect human health and environment badly. Also, it accounts for 16-20% of the total cost of manufacturing in the production industry. In order to minimize the usage of lubricants in machining operations here we use oil mist lubrication system. Oil mist system is the Minimum Quantity Lubrication (MQL) technique. This oil mist system increases the production rate in plant and also enhances various parameters such as surface finishing of work piece, increases tool life, reduces tool wear, etc. The paper explains the mechanism of oil mist lubrication system. Oil mist system proved to be a viable alternatives to the flood lubrication under similar performance parameters.

Keywords - BUE, Built-up-edge; MQL, Minimum Quantity Lubrication; OML, Oil Mist Lubrication.

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I. INTRODUCTION

Now a days machining plays a significant role in the manufacturing industry. It is perhaps the most versatile manufacturing process in which the desired shape, size and surface finish are achieved through the removal of excess materials in the form of small chips. The device which removes the excess materials through direct mechanical contact is known as cutting tool and the machine which provides the necessary relative motion between the work piece and cutting tool is commonly known as machine tool. The material removal processes are a family of shaping operations in which excess material is removed from starting work part so that what remains is the required final geometry. The predominant cutting action in machining involves the shear deformation of the work material to form a chip; as the chip is removed the new surface is exposed. During machining operations (such as shaping, turning, facing, grinding, etc.) the material removed in the form of small chips are gone into the plastic deformation. During such plastic deformation almost 99% energy fed to the machine tool is converted into heat. When ferrous (metals based on Iron) and other high strength materials are machined, the temperature rises with the speed and the tool strength decreases, leading to faster wear and tool failure. The overheating of cutting tool may reduce its sharpness. The use of a blunt tool results in excessive power consumption and poor surface finish.

Cutting fluid is any liquid or gas that is applied directly to the machining operation to improve cutting performance. Cutting fluids address two main problems: (1) heat generation at the shear zone and friction zone, and (2) friction at the tool-chip and the tool work interfaces. Cutting fluids also provide additional benefits, such as washing away chips (especially in grinding and milling), reducing the temperature of the work part for easier handling. But at different aspect cutting fluid also badly affects the environment and human health both during its use as well as during its disposal.

Considering all these aspects, Oil Mist Lubrication (OML) system stands out among others for machining process. Oil Mist was developed in Europe in the early 1900's to replace grease and circulating oil systems on high speed spindle bearings. It was then introduces to US industry in 1948 with steel industry being the first to use. As of December 2012 over 1, 00, 000 process centrifugal pumps are operating with oil mist as the sole bearing lubricant. The estimated number of electric motor on pure oil mist exceeds 10,000. Oil Mist Lubrication is the MQL technique, a very small amount of lubricant/coolant is mixed with air to form aerosol, which is sprayed at a high pressure in the cutting zone with the help of nozzle. The surface finish and tool life attained using OML was found to be better as compared to flood lubrication.

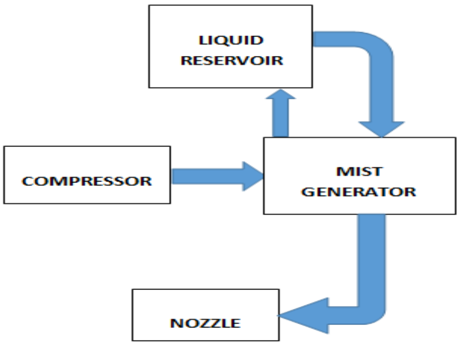


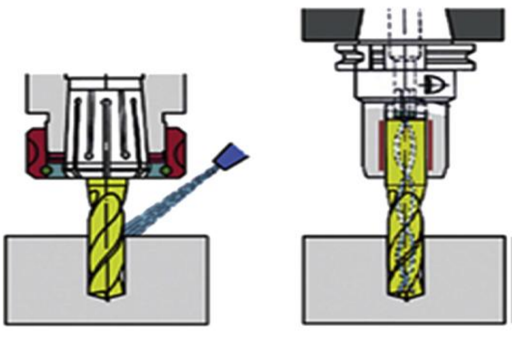
Fig. 1: Block diagram of Oil Mist Lubrication System.

II. OIL MIST SYSTEM TECHNIQUE

In OML technique, a very small amount of lubricant/coolant is mixed with air to form aerosol, which is sprayed at a high pressure in the cutting zone with the help of a nozzle, etc. When this aerosol is sprayed in the cutting zone as mist, it works as coolant as well as lubricant and penetrates deep into the tool-work piece interface.

According to the mode of cutting fluid delivery to the cutting zone, OML technique can be classified into two categories, namely, external delivery and internal delivery. The basic difference between these two can be well explained by Fig. 2. In an external delivery system, the aerosol prepared in atomizer is delivered to the cutting zone by a nozzle placed externally on the machine tool as shown in Fig.2 (a) while in an internal delivery system, the cutting fluid and air is mixed inside the nozzle and sprayed in cutting zone via a channel built in the cutting tool as shown in Fig. 2 (b).

The internal feed OML system has some advantages over the external feed system. The mist delivered at the cutting zone is aerosol at high pressure in which cutting fluid functions as lubricant while the pressurized air performs the cooling action. Oil Mist Lubrication (OML) technique has better surface finish and tool life as compared to dry and wet techniques.



(a) **(b)**

Fig. 2: (a) External and **(b)** Internal Delivery System

Oil mist system can be used with different fluids such as water, vegetable oil, synthetic ester, palm oil, fatty acid, etc. The use of different cutting fluids enhances the parameters of work piece depending upon the temperature of materials and the condition of environment.

III. MAJOR COMPONENTS

In Oil Mist Lubrication system we have used some major components, such as, compressor, mist generator, nozzle, and liquid reservoir which are as follows:

3.1 Compressor

As the name suggests, the compressor is a mechanical device that increases the pressure of a gas by reducing its volume. An air compressor is a specific type of gas compressor. As gases are compressible, the compressor also reduces the volume of the gas. The big advantage of compressor is that each tool doesn't need its own bulky motor. Instead, a single motor on the compressor converts the electrical energy into the kinetic energy. This makes for light, compact, easy-to-handle tools that run quietly and have fewer parts that wear out.

In this section, we have discussed the type of compressor used for oil mist lubrication system according to the conditions required. In this system we have used the Rotary Compressor (Fig. 3) which is defined as the compressor consist of a rotor with number of blades inserted in radial slots in the rotor. The rotor is mounted offset in a larger housing that is either circular or more complex shape. As the rotor turns, blades slide in and out of the slots keeping contact with the outer wall of the housing. Thus, a series of increasing and decreasing volumes is created by the rotating blades.

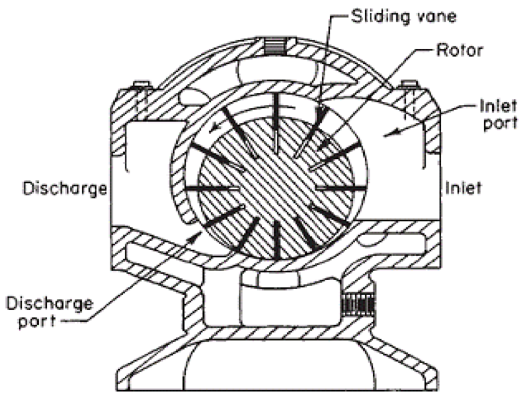


Fig. 3: Schematic diagram of Rotary Compressor

The rotary compressor is light in weight, portable, consumes less power (as compared to other types) and also less costly. The pressure required for generating the mist into the compressor is up to 6.9 bar. The most important part in generating the mist using compressed air is to maintain minimum surface tension.

3.2 Mist Generator

The concept of mist generator basically introduced in generating the mist for various applications. The mist generator (Fig. 4) is not basically a mechanical device, it is the setup in oil mist system in which mist is generated by passing compressed air through a venturi, creates low pressure, causing oil to be siphoned from a small central reservoir and introduced into the high velocity air stream where the oil is atomized (identical to the operation of carburetor)

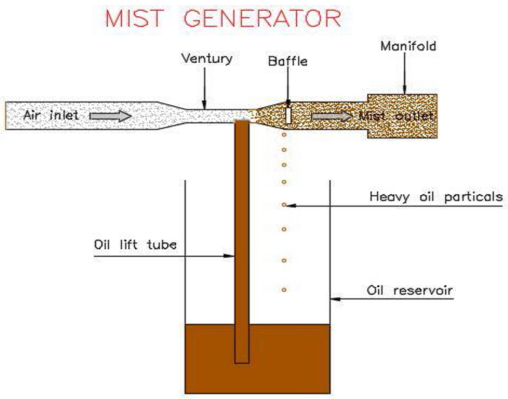


Fig. 4: Schematic diagram showing the mist generation from setup.

Pressure of this inlet air is regulated to properly deliver the oil. Droplets larger than about five to seven microns are not easily transported by the air stream, and are intercepted by a baffle for return to the reservoir. Here are some major points which should be follow while generating the mist. The points are as follows:

- The flow of oil from reservoir must be Laminar (below approximately 24 feet/second),
- Turbulent flow causes oil particles to impact the pipe wall and be removed from air stream.
- Excessively low flow velocities may lead to oil droplet fall out.
- Some level of oil will coalesce in the piping, therefore header piping is sloped to return coalesced oil to the generator.

The mist generator used in oil mist lubrication system is based on venturi principle. Mist generator does not have any moving parts and oil mist visibly resembles light smoke.

3.3 Mist Nozzle

As the name suggests, a mist nozzle (Fig. 5) is a precision device that facilitates dispersion of liquid into mist (in the form of fog). Nozzles are used for three purposes: (1) to distribute a liquid over an area, (2) to increase liquid surface area, (3) create impact force on a solid surface. The mist nozzle utilizes the liquid kinetic energy as the energy source to break the liquid into droplets. The nozzle creates a better and optimum control on the liquid spray. Nozzles are made from several types of materials; the most common are Brass, Plastic, and Nylon, Stainless steel, Hardened stainless steel and Ceramics. Brass nozzles are the least expensive but are soft and rear rapidly. Nylon nozzles resist corrosion, but some chemical cause's thermoplastic to swell. Nozzles are made from harder metals usually cost more but will wear longer.

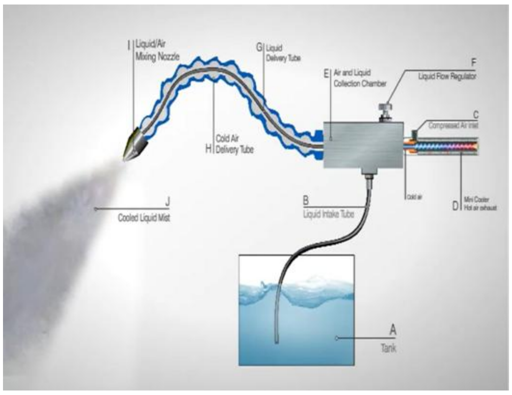


Fig. 5: Model showing the Cooled Liquid Mist coming out from a nozzle.

3.4 Liquid Reservoir

The liquid reservoir/tank used in oil mist lubrication (OML) system varies from manual fill, drums, skid tanks, to large supply tanks. The reservoir/tank should be made of a corrosion-resistant material. Suitable materials used in oil mist system include stainless steel, polyethylene plastic and fiberglass. Care should be taken to avoid incompatible materials. Aluminum, galvanized or steel tanks should not be used. Keep tank clean and free of rust, scale, dirt, and other contaminants which can damage the nozzle. Also, contaminants may collect in the nozzle and restrict the flow of liquid. The tank should be air sealed so the required pressure creates from the compressed air and the cutting fluid siphoned and formation of mist takes place.

IV. OVERVIEW OF THE SYSTEM

We have made our project by using the components, such as, rotary compressor, liquid reservoir (uses a membrane casing of water filter), the arrangements of nozzle, and the piping system (as shown by arrows in Fig. 1)

Fig. 6: Model of Oil Mist Lubrication system.

V. PROPERTIES OF CUTTING FLUID (Vegetable Oil)

There are various major properties of cutting fluids (vegetable oil) are as follows:

- Density: 915 kg/m^3 (Between 15-25ºC)
- Surface Tension: 29.9 mN/m
- Viscosity: 23.58 mPa-s
- Thermal Conductivity: 0.168 W/m K
- Specific Heat: 1.715 kJ/Kg K
- Boiling Point: about 300ºC
- Freezing Point: -16ºC
- Vapour Pressure: 0.2 kPa (At 25ºC)

VI. CONCLUSION

This paper has presented the mechanism of oil mist lubrication system along with its major components details. It has also presented the mechanism of oil mist system. The following conclusions are as follows:

- Due to efficient penetration of oil mist in the contact zone, MQL reduced the friction between the tool-chip interfaces.
- Application of OML reduced the cutting zone temperature resulting in reduction of tool wear.
- A continuous MQL supply showed better results in terms of tool life.
- OML using with vegetable oil performed better dealing with surface defects and surface roughness at all the feed rates and cutting speeds.
- OML also reduced the built-up-edge (BUE) in cutting zone while turning operation performed.

There are also some major advantages which are as follows:

- High production rate
- Reducing energy consumption
- Lower friction, no oil churning, reduced tool-chip interface temperature
- Automated system ensures the right amount of lubricant all the time
- No oil changes, less maintenance

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