Design and Fabrication of Minimum Quantity Lubrication (MQL) Setup

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Abstract—Recent Research in the field of Machining has caused a revolutionary transformation in the machining process. Cutting fluid has various impacts on the work piece and machine components. Due to recent adverse changes in the environmental conditions use of Minimum Quantity Lubrication has become the need of the hour which needs to be addressed with at most concern. This paper focuses on the design and fabrication of the Minimum Quantity Lubrication (MQL) Setup. The various advantages and disadvantages of the MQL Setup has been studied.

Keywords—Minimum Quantity lubrication, Flood Coolant, MQL, Near Dry Machining

I. INTRODUCTION

Minimum Quantity Lubrication (MQL) has increasingly found its way into the area of metal cutting and in many areas, has been established as an alternative of conventional flood coolant method. In contrast to flood lubrication system minimum quantity lubrication uses few droplets of coolant mixed with compressed air in the form of mist.

MQL is the process of applying minute amounts of high-quality lubricant directly to the cutting tool/work piece interface instead of using traditional flood coolants. MQL minimizes your environmental impact by significantly reducing fluid usage and eliminating the need for coolant treatment and disposal. These near-dry machining benefits are multiplied further when using 100% biodegradable lubricants which are formulated from renewable plant-based oils. When considering these facts along with the performance benefits of biodegradable lubricants and MQL, it becomes obvious that this is the future of metal cutting fluid.

The lubricant is sprayed with the help of external supply system which can be one or more nozzles. The amount of coolant used in MQL is about 3-4 order magnitude less than the amount commonly used in flood cooling condition. For example up to 10 liters of coolant is used in flood coolant type lubrication system.

In MQL lubrication is obtained via the lubricant, while a minimum cooling action is achieved by the pressurized air that reaches the cutting surface. When the MQL is applied to the tool rake tool life is no different from dry condition but MQL applied to the tool flank can increase tool life. In machining, excessive heat is generated using flood coolant will reduce thermal shock causing tool failure. Hence MQL will promote tool life as induced thermal shock will be less as compared to flood coolant.

Costs generated by conventional flood lubrication (e.g. maintenance, inspection, preparation and disposal of metalworking fluids) are no longer an issue with minimum quantity lubrication. The average percentages of these costs in the overall cost of wet processing are shown in Figure 1

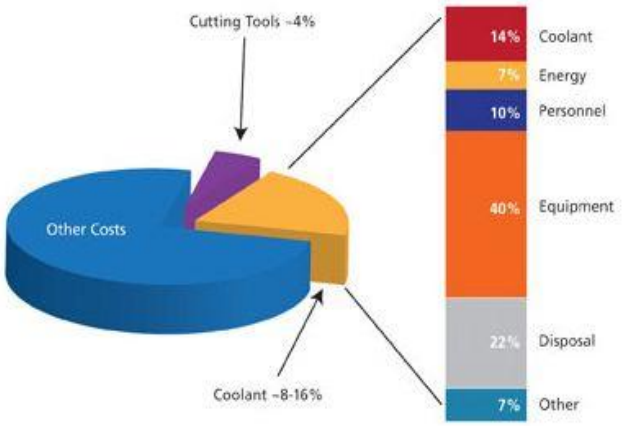
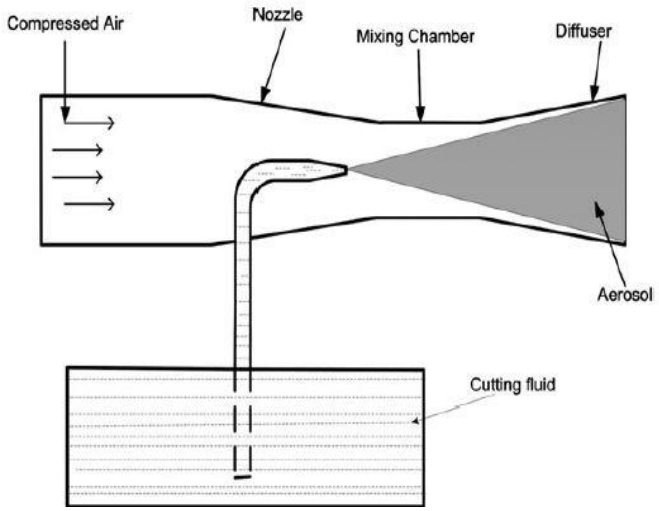


Figure 1

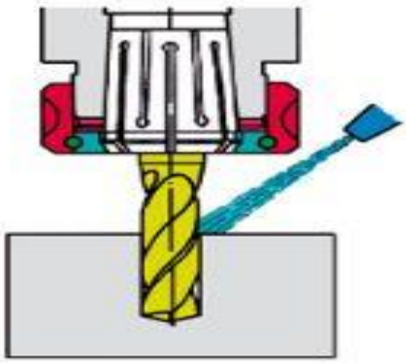
II. WORKING

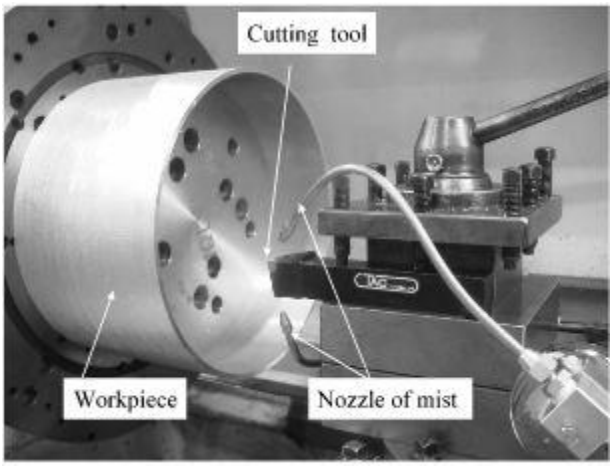


The working of the Minimum Quantity Lubrication setup is based on following components.

- Air Compressor.
- Nozzle.
- Micro Pump.
- Motor.
- Magnetic Stand
- Connecting Pipes

The pictorial representation of MQL Setup is shown below





Their Function are Detailed as Follow

A. Air Compressor

In a single sentence, the function of an air compressor is to compress air and to deliver it for end use. There are three popular types (from the perspective of commercial use).:

- Reciprocating compressor
- Screw compressor
- Centrifugal compressor

The Reciprocating compressor works more or less like an IC engine. It has only two strokes though and also that it is a power consuming device unlike the IC engine which is power generating.

During the intake stroke, the piston moves from the TDC to the BDC. The vacuum created by the suction opens the intake valve on the compressor and socks air into the compression chamber. Once the piston reaches the BDC, the valve closes and the compression stroke starts (from BDC to TDC). In due course, the discharge valve on the other side opens up and the compressed air gets released. Depending on whether it is a single stage or a multistage compression, there can either be an intercooler or it may not be present.

One of the drawbacks of the Reciprocating compressor is that the air supply is intermittent. That is, at the end user your air flow is not continuous. Also, the volume of air that can be handled is limited. As your requirement increases, your compressor size keeps going up.

The next generation of air compressor is the screw compressor. Here the machine consists of a part called the aired, which is the heart of the device. It contains two lobes cut in a particular profile along which the air flows. The airend is generally crowned with an intake valve. The shaft of the aired is coupled to a prime mover (an engine or an electric motor). The prime mover rotates the lobes which creates a vacuum in the aired case. This gives a pulse to the intake valve which opens according to the amount of vacuum created and sucks in air. The air then traverses along the lobes and gets discharged either to a storage tank or for end use. Screw compressors provide a more consistent flow of air than their Reciprocating counterparts and are considered more reliable.

Centrifugal air compressor functions just like a pump. It has a casing which contains a blade profile coupled to a prime mover. Centrifugal compressors generally are used in those applications where the air flow required is huge.

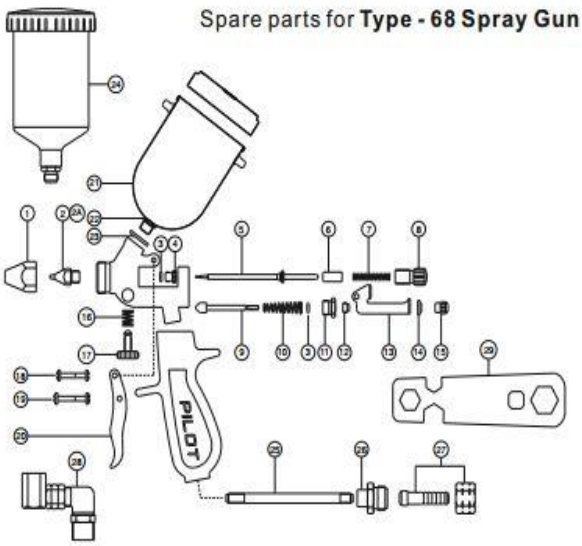
Vane and scroll compressors also exist but they are not commercially viable.

B. Nozzle

A nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe

Pilot Spray Gun Type 68 is used as a nozzle due to the following reasons.

- Exit Diameter of Nozzle : 0.8mm
- Operating pressure : 3bar/ 37 psi
- Superior Spray Pattern
- Fine Atomization
- High Transfer Efficiency



Sr. No.	Description
	Spray Gun Type - 68 with S.S. Top Feed Cup
	Spray Gun Type - 68 with Plastic Top Feed Cup
1	Air Cap
2	Nozzle
2A	S.S Nozzle #
3	Teflon Packing
4	Needle Packing Nut
5	S.S. Needle
6	Needle Spring Box
7	S.S Spring for Needle
8	Needle Adjusting Screw
9	Air Valve Pin
10	S.S. Spring for Air Valve
11	Air Valve Packing Box
12	Air Valve Packing Box Washer
13	Link
14	Air Valve Washer
15	Air Valve Locking Nut
16	S.S. Spring for Air Control

Sr. No.	Description
17	Air Control Valve
18	Fulcrum Screw
19	Trigger & Link Screw
20	Trigger
21	S.S. Top Feed Cup 0.14 Litre Complete
22	Cup Bottom Part
23	Washer For Cup
24	Plastic Top Feed Cup 0.14 Litre Complete
25	Air Intake Tube
26	Air Intake Connector
27	Hose Coupling
28	Adaptor for side Cup Complete #
29	Spanner #
30	Repair kit # *

C. Micro Pump

A Micro pump is used to pump the lubricant.The type of Micro Pump used is Gear Pump. The primary function of Gear pump is to pump the lubricant from the storage tank to the Mixing Chamber where it is mixed with pressurised air. The power supply to the pump is given with the help of motor which is coupled to the pump with the help of a love couple joint.

D. Motor

The primary function of the motor is to supply power to the gear pump. The type of Motor used is Kirloskar Make Three Phase Motor. The Motor is coupled to the gear pump with the help of Love-Couple Joint which is costume Made.

E. Magnetic Stand

A Magnetc Stand is used to attach the Nozzle Setup to the Machine. Switch Type of Magnetic Stand is Used as it can be attached and deattached when ever necessary.

F. Connecting Pipes

Connecting Pipes are used to connect the Pump Output to Nozzle and output from compressor to Nozzle.

III. CALCULATIONS

SPECIFICATIONS:

Output from pump: 500 ml/hr
Volume of Fluid: 500 ml
Time: 3600 sec
Dia. Of Nozzle: 0.8 mm

- Discharge = Volume of Fluid/Time
  = 0.0005/3600
  = $1.3 * 10^{-7}$ m^3/sec.
- Area = 3.14*d2/4
  = 3.14*(0.8*10^-3)2
  = $6.28*10^{-10}$ m^3
- Velocity = Discharge/Area
  = (1.3*10^-7)/(6.28*10^-10)
  = 206.9 m/s.

IV. CONCLUSIONS

- The mach inability of the MQL technique reveals notable improvements over dry and conventional flood cutting fluid supply.
- MQL technique provides reduced tool wear, improved tool life and better surface finish mainly by
- Reducing the friction in the chip tool and work piece tool interfaces, which maintains sharpness of the cutting edge?

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