

# Reduced Energy Consumption Using MQL (Minimum Quantity Lubrication)

STLE Presentation

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- Education
  - BSc in Chemistry from the University of Western Ontario
  - CLS, OMA 1, MLT1, SME Metalworking fluid certificate
- Work Experience
  - Regional territory manager for DropsAUSA
  - 30 Years of sales, service, and technical support

# What is Minimum Quantity Lubrication (MQL)?

- Minimum quantity lubrication is the act of providing a controlled and precise amount of lubrication where the cutting tool meets the material.
- Specifically, MQL looks to reduce the friction between the cutting edge of the tool and the work piece.
  - By reducing the friction in machining processes there are several benefits which are achieved



# Origins of MQL



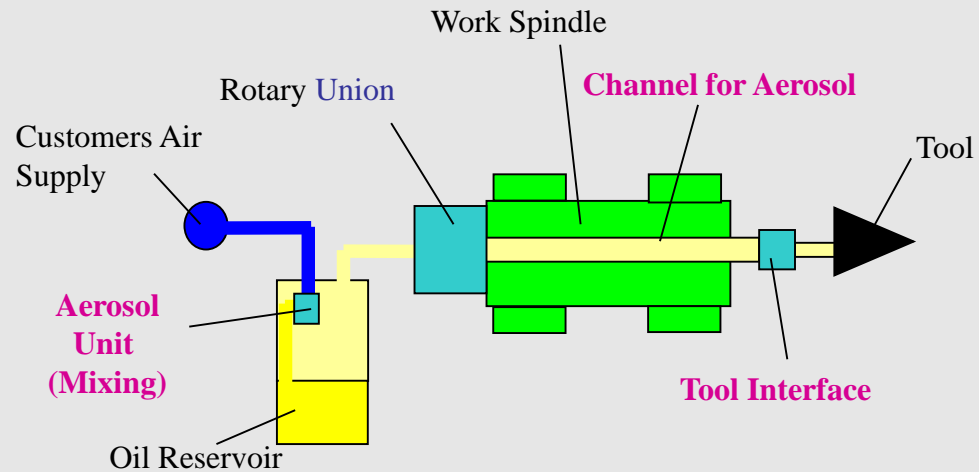
- As time progresses the impact that the machining industry has on the environment is becoming more of a topic in the US.
- In Europe the more strict EPA standards have driven MQL to where it is today.
  - Restrictions on the use of emulsified coolant has made industries seek other options to flood-based coolant
  - With major headways made in fluid technologies new MQL fluids do not have the same negative impacts as emulsified coolant

# Types of MQL Systems

- Due to the different applications of machining, there are several types of MQL solutions. There are benefits to each individual type of system based on size, space, and machine setup (external or through the tool lubrication). In addition production volume is taken into consideration. These systems can be categorized as the following
  - Air Oil
  - Aerosol

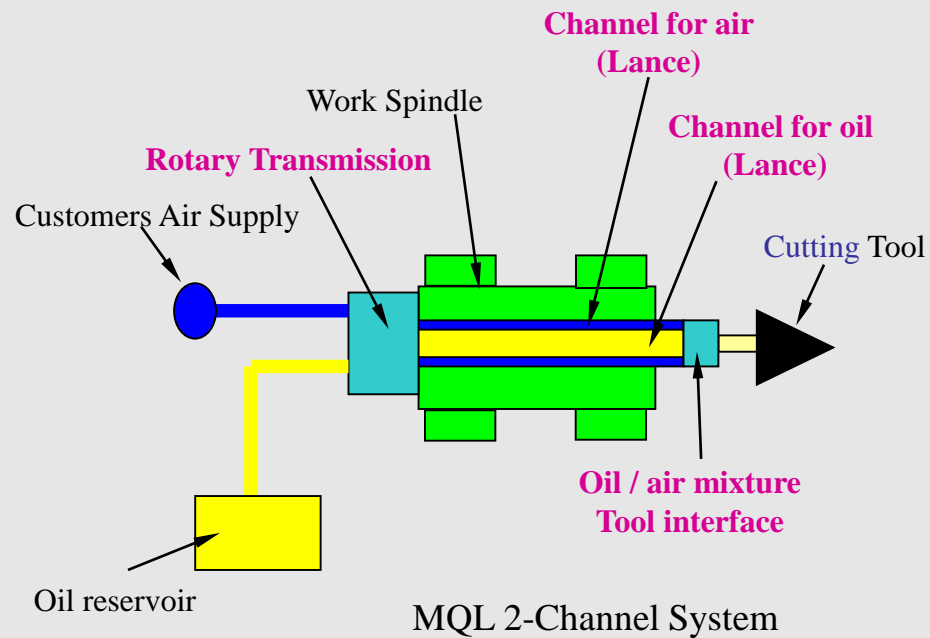


# Single Channel Systems



- In a single channel system, the aerosol is generated before it reaches the machine tool itself. This means that the aerosol is directed through the machine just as coolant would be.
  - Great for lower to medium production rates
  - Complex machinery with restricted space
  - Retrofits

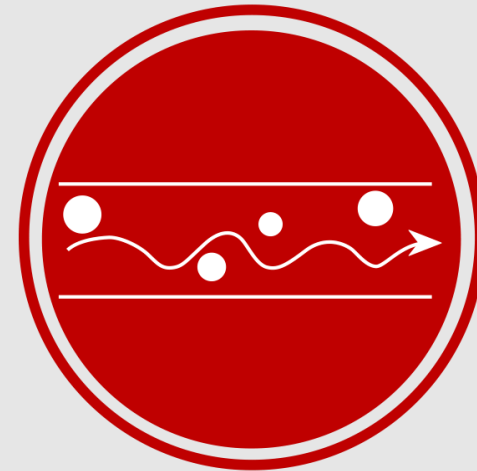
# Dual Channel Systems



- Air and oil is mixed in the tool holder instead of outside of the machine. This means that the oil and air combination is mixed closer to the cutting tool itself. Allowing for a more controlled lubrication.
  - High production rates
  - Flexible manufacturing concepts with several tool changes
  - Environments with cost optimized manufacturing

# Air Oil Systems

- Uses air to transport oil particles to the cutting tool or surface
  - Great for sawing applications
  - Low to medium production
  - Machines with only external lubrication available
  
- A great entry level to near dry machining





# Systems that are applicable for MQL



Nearly all machines that are required to use flood coolant have the possibility to reap the benefits of MQL. These machines include the following but are not limited to.

- Turning Machines
- Milling Machines
- Sawing Applications (Horizontal, Vertical, and Circular)

# Industries

- Many industries use CNC machinery or machinery that requires flood coolant. MQL is applicable but not limited to the following industries.
  - **Medical Industry (MQL is efficient in clean machining environments)**
  - **Aerospace**
  - **Transportation Industry**
  - Oil and Gas Industry
  - Electronic Industry
  - Marine Industry

# Issues with Emulsion Based Lubrication

Emulsion based coolant has been used in industry since the 19<sup>th</sup> century. There are many issues that stem from working with such a fluid.



- Requires daily maintenance



- Can contain hazardous chemicals and may require special care when handling and removing



- Users may rely on a third-party company to handle the disposal of coolant that is no longer applicable



- Parts that are machined need to be thoroughly washed and dried before shipment



- 15% of the overall machining costs are directly coolant related costs



# Health Benefits with MQL



**Lower cost for health protection and reduced cost for sick-leave**



**Decreases Work related diseases**

Several work-related diseases are “Skin diseases”, of which 1/3 are related to inadequate usage of coolant emulsion.

➤(Reference: BIA - Report 4/03)

# Energy Reductions

Cutting creates **Friction**  
at cutting edges of tools



Friction creates an  
**Increase of temperature** within  
tools and parts



**Cooling** of tools and parts  
by MFW medium



**Transportation** of chips out of parts  
By MFW medium (Pressure and flow)



**Cleaning** of tools and parts by  
MFW medium (Velocity)

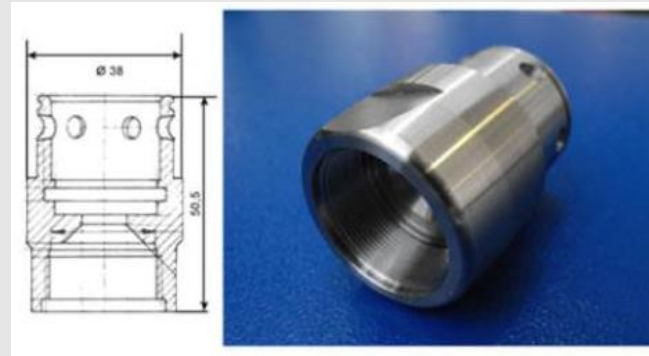
## 1. Fundamental of thermodynamics

$$Q_{12} + W_{R,12} = c_V \cdot m \cdot (T_2 - T_1) + \int_1^2 p \cdot dV + E_{a2} - E_{a1}$$

**Cooling**      **Friction**      **Temperature**      **Work to change volume (Pressure, flow)**      **Outer Energy (Velocity)**

# Energy Reductions in Machining

- Shown is the comparison between a machine running emulsified coolant vs. MQL
  - As shown, there is nearly a minute that is saved from each cycle time. (54 Seconds) Through several cycles this time saved reduces the cost of the product production.



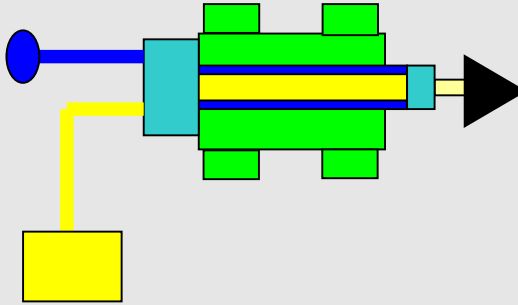
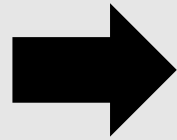
	Coolant Machining			MQL Machining		
Tools	Cutting speed $V_c$ (m/min)	Feed rate $f_s$ (mm/min)	Tool life (Number of Pieces)	Cutting speed $V_c$ (m/min)	Feed rate $f_s$ (mm/min)	Tool life (Number of Pieces)
Esternal drill 10° 10,8	200	200		240	240	
Esternal drill 5° 10,4	200	199		220	220	
Esternal drill Sp. 1,5	100	100		120	186	
Insert drill Ø 23	144	260	-	150	290	
Internal boring Ø 20	145	324		145	396	
Internal Troat boring thickness 3	120	120		160	160	
	Total time 188 seconds			Total time 134 seconds		
	SAVING TIME : 28,7 %					

# Energy Reductions Cont.

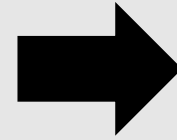


## Example Coolant:

- 7 kW (10 hp)
- 80 bar (1160 psi)
- 30 lpm (8 gpm)
- 60% efficiency



ML 2-Channel System



## Example MQL:

- 0,2 kW (0,026 hp)
- 16 bar (230 psi)
- 10 to 150 ml/h

<b>Advantage from MQL technology</b>	
Energy saving using MQL instead coolant	7 kWh
Number of production hours / Year	5000 h / a
Energy saving per Machine per Year	$7 \text{ kWh} \times 0,1 \text{ USD / kWh} \times 5000 \text{ h / a} = 3500 \text{ USD / a}$

# Elimination of Process Steps

- *Elimination of process steps*
  - In this application the polishing step can be skipped due to the improved surface finish. This is because MQL oil is only used once, not filtered and reused like coolant emulsion. Therefore, you cut with tools not particle fines left in the coolant.

**= Lower cost per piece due to reduction of cycle time and lower tooling costs**







# Reduction of Lubricant Consumption

- *Consumption of lubricant in 5% Emulsion*
  - Emulsion: 1000 to 10 000 Liter per hour
  - Lubricant: 50 to 500 Liter per hour
- *Consumption of MQL oil in mist*
  - Air: 15 m<sup>3</sup> per hour (average)
  - Oil: 0.01 to 0.05 liter per hour

## Reduction in consumption of lubricants



Wet system

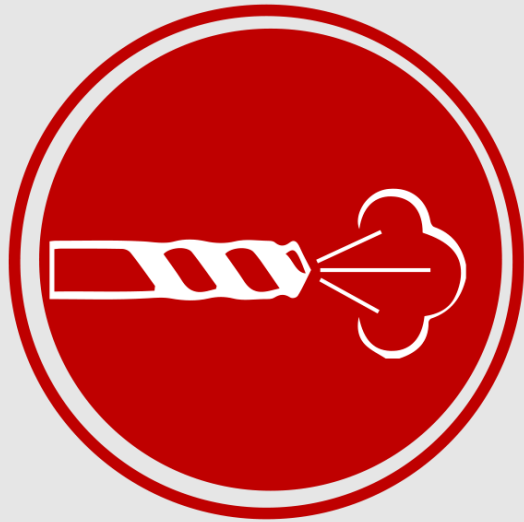


MQL system

Advantage from MQL technology	
Cost per Emulsion Check	25 USD / Hour
Total time for Emulsion Checks	26 Hours / Year
Savings per Machine	25 USD/h x 26 h/a = 650 USD / Year

## Reduction in coolant emulsion checks

# Advantages with MQL



- Reduction of Investment Cost
  - Fewer number of machine components
- Reduction of Hazardousness
  - Lower cost for fire protection in the building
- Reduction of Health Problems
  - Lower cost to prevent skin and respiratory issues
- Reduction of Maintenance Cost
  - No cost for disposal
  - No maintenance cost
  - Less fluid handling
- Reduction of Tooling cost
  - Increase of tooling life
- Increase of Productivity
  - Lower cycle time reduces cost per piece optimized tools increase effect

# MQL Oil Types

- MQL fluids can be broken down into two different categories. Ester Based fluids and Fatty Alcohols.


<b>Ester Based</b>	<b>Fatty Alcohols</b>
Reduction of friction	Higher emissions than Ester
High surface quality	Lower reduction of friction
Low cutting speed with high load	Better heat dissipation
Does not evaporate completely	Higher evaporation

# Comparison of Costs

- Study (Life Cycle Cost) focuses on a 10-year time frame
- Comparison of 2 identical modules (differences are only dedicated to the specifications that are required for the WET or the MQL equipment)
- Capacity : 450.000 units of an aluminum valve body p.a.
- Both scenarios consider the same amount of machine tools from the same machine tool builder

	Wet	MQL
Aquisition costs / Machine	82,48%	73,67%
10 year cost machine downtime / Machine	1,31%	0,15%
10 year Maintenance cost / Machinetool	4,55%	1,93%
10 year cost of operation / Machine	9,31%	6,33%
cost floor space / Machine	2,35%	0,84%
<b>Total 10 year Cycle cost / Machine</b>	<b>100,00%</b>	<b>82,92%</b>

Quelle: MAG IAS GmbH



MQL Impact: Lower operating costs due to less energy consumption and due to other savings – such as less fluid consumption, less tool wear (Longer tool life with MQL)...

# End

- Questions?