

US EPA ARCHIVE DOCUMENT



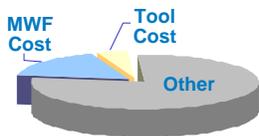
COMPARISON OF VEGETABLE AND PETROLEUM BASE OILS IN METALWORKING FLUIDS

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Background

An Introduction to Metalworking Fluids

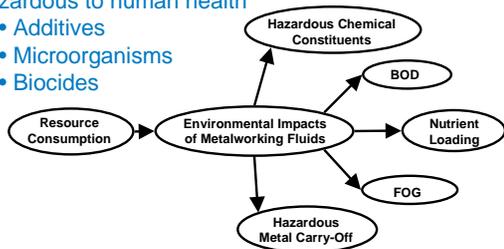
Metalworking Fluids are ubiquitous and necessary. In 2000, approximately 2 billion gallons of metalworking fluids were consumed. Approximately 12% of metals manufacturing costs are due to such large costs?
 Purchase: \$5-\$16/gal
 Maintenance: \$0.20-\$1.20/gal
 Disposal: \$0.25-\$2/gal



Concerns Associated with MWF Use

Serious environmental burden
 Hazardous to human health

- Additives
- Microorganisms
- Biocides



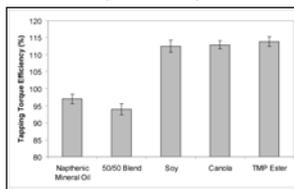
Vegetable Based Metalworking Fluids

Vegetable-based fluids are being researched and developed to possess chemical characteristics that result in:
 Equal or higher performance
 Less bio-deterioration
 Higher stability to field conditions
 More amenable to microfiltration
 Lower total life cycle impact

Approach and Conclusions

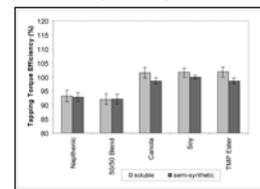
- **Formulation: Different Base Oils**
 - Naphthenic Mineral Oil
 - 50/50 Naphthenic/Paraffinic Mineral Oil
 - Soybean Oil
 - Canola Oil (75% Oleic Content)
 - TMP Ester
- **Evaluation: Tapping Torque Test**
 - Accounts for material variations in work pieces and tools
 - Determine "Tapping Torque Efficiency" relative to a standardized commercial fluid

Performance as Straight Oils (100% wt)



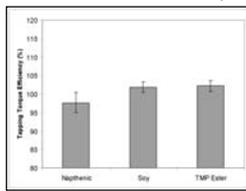
Petroleum Based Vegetable Based

Performance as Emulsions (3.4 % wt) and (0.75% wt)



Petroleum Based Vegetable Based

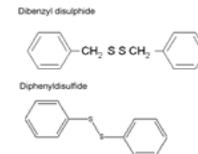
Performance on Harder Steel (4140 vs. 1018)



Petroleum Based Vegetable Based

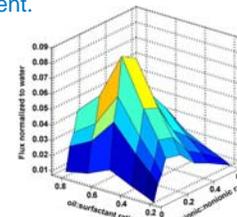
Ongoing Work and Summary

- **Ongoing Work**
 - Our research group is working to develop a fundamental understanding of boundary layer (Extreme Pressure or EP) formation in lubrication. This will allow us to propose alternatives to current compounds which are often toxic and persistent in the environment.



Two widely used EP Additives

- We are developing formulations to be compatible with microfiltration so that fluids can be recycled. Microfiltration of semi-synthetic MWFs increases longevity and quality of a fluid. We are considering parameters such as oil content, surfactant to oil ratio, surfactant structure in MWF design



Optimization of MWF system for microfiltration

- We are looking at alternative delivery mechanisms for MWFs including super critical CO₂ (scCO₂). Vegetable oils dissolved in scCO₂ could be sprayed on work areas to provide lubrication and cooling with greatly decreased environmental impacts.

Summary

- As straight oils, all vegetable based stocks perform significantly better than the mineral oils
- The trend holds, but is less pronounced, after the vegetable oils are emulsified into soluble oil and semi-synthetic MWFs
- Coupled with current work in extreme pressure additives, microfiltration compatibility, and scCO₂ delivery this research in bio-base oils, will yield complete MWF systems that are environmentally preferable to existing options