METALWORKING FLUIDS FOAM CONTROL BASED ON NOVEL SURFACTANTS TECHNOLOGY

Enabling manufacturing better, faster, cleaner
Key Messages

• Metalworking Fluids Concept
• Formulations Aspects
• Foam Study and Methods
• Emulsifier Properties
• Results and Conclusions
Metalworking fluids

Metalworking fluids are engineering materials that optimize the metalworking process.

The main types of metalworking fluids can be considered basically as water compatible fluids and straight oils. Where:

**Straight oils:** petroleum or vegetable oil that is used without water as component.

Water-based metalworking fluids classification:

**Soluble Oils:** mineral oil base aqueous emulsions, forming milky emulsion.

**Semi-Synthetic:** mineral oil base emulsions, forming opalescent emulsion.

**Synthetics:** clear and transparent solution. Basically, formulated with polyglycols as the lubricant system. [7]
Product Concept

This study was based on a continuous search for products that demonstrate high performance as emulsifiers and low-foaming characteristics when applied in water-compatible semi-synthetic metalworking fluids.

This proposed molecule maintains properties of an ordinary surfactant with strong capacity to emulsify mineral oil, resulting in a stable concentrate fluid, stable emulsion, high hard water resistance, and low foam formation, compared with other traditional chemical products.
For strong emulsion stability, at least, the use of two surfactants/emulsifier systems makes possible more effective and reliable results.

This study considered non-ionic and anionic surfactants, and the action mechanisms below: [9]

**Anionic:** electrical double layer in oil droplets

**Non-ionic:** steric hindrance
Metalworking Fluid Formulation

Cutting fluids are commonly soluble oil (emulsion) or milky dispersions of mineral oil in water dilution.

In addition to the lubricating oil:

- Emulsifiers
- Corrosion inhibitors
- Surfactants
- Anti-foaming (agents)
- Buffers
- Additives for extreme pressure [1]
Metalworking Fluids Main Properties

✓ Removal of heat
✓ Lubrication
✓ Transport of metal chips produced

Usual condition:
✓ Typical concentration use: 1:10 to 1:100 (depending on the application)
✓ Returns to a tank (central system of cutting fluid)
✓ Susceptible to contamination* [8]

*Longevity of the fluid will depend on intrinsic resistance to deterioration of the product and the microorganisms present.
Foam Formation

Parameters to consider that may result in excessive foam formation:

- Concentration of the cutting fluid mixture
- Level of the cutting fluid in the reservoir
- Crack in the pump housing or intake piping
- High outlet pressure
- High fluid velocities
- Sharp corners in the return system
- Excessive waterfalls
- Water softness
- Contamination [6]
Many formulators concerned about formulation balance can make use of combined appropriate surfactants to result in foam formation prevention.
Experimental Methodology

This study considered factors that influence foam generation, describe mainly quality or water hardness, fluid composition and aging fluid depletion.

Experimental Methods proposed for the study:

- ✓ Hand Shake Test
- ✓ Hi Speed Test (Blender Test)
- ✓ Ross Milles
- ✓ Recirculation Test
Base Formulation

Important points:

- Non silicon anti-foaming addition
- High non-ionic emulsifier rate
- Typical raw-materials for semi-synthetic fluid

<table>
<thead>
<tr>
<th>RAW Material</th>
<th>FUNCTION</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>---</td>
<td>43</td>
</tr>
<tr>
<td>Diacid Mixture</td>
<td>Corrosion Inhibitor</td>
<td>4.5</td>
</tr>
<tr>
<td>Triethanolamine (85%)</td>
<td>Alkaly</td>
<td>8</td>
</tr>
<tr>
<td>Monoethanolamine (99.2%)</td>
<td>Alkaly</td>
<td>4</td>
</tr>
<tr>
<td>Alkyl Aryl Sulfonate (MW=470)</td>
<td>Anionic Emulsifier</td>
<td>8</td>
</tr>
<tr>
<td>Tall Oil Fatty Acid</td>
<td>Corrosion Inhibitor</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Surfactant</strong></td>
<td>Non-ionic Emulsifier</td>
<td>10</td>
</tr>
<tr>
<td>Propylene Glycol n-Butyl Ether</td>
<td>Coupling</td>
<td>2</td>
</tr>
<tr>
<td>Naphtenic Oil</td>
<td>Lubricant</td>
<td>15</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>100</td>
</tr>
</tbody>
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Considering the HLB concept (O/W emulsion), general emulsifier properties and the results of previous laboratorial screening tests with some potential emulsifiers, we selected two emulsifiers for generate final study results:

**Low Foam Emulsifier**
- Liquid non-ionic low foam surfactant
- HLB 12,6

**Reference Emulsifier**
- Liquid Secondary Alcohol Ethoxylate 7 EO
- HLB 13,3
# Low Foam Emulsifier Typical Properties*

<table>
<thead>
<tr>
<th>Active Ingredient, wt%</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLB (calculated)</td>
<td>12.6</td>
</tr>
<tr>
<td>Appearance</td>
<td>Transparent, colorless liquid</td>
</tr>
<tr>
<td>Viscosity at 25°C (77°F), cP</td>
<td>61</td>
</tr>
<tr>
<td>Density at 20°C (68°F), g/mL</td>
<td>0.994</td>
</tr>
<tr>
<td>Flash Pt, Closed Cup, ASTM D93</td>
<td>111°C 231°F</td>
</tr>
<tr>
<td>Pour Point, ASTM D97, °C (°F)</td>
<td>-34 (-20)</td>
</tr>
</tbody>
</table>

*These properties are typical but do not constitute specifications.
Surfactants Technology

Base Technologies
- Mkt Non-ionic Emulsifier (product under use and offering)
- Reference Non-ionic Emulsifier (internal consideration)
- Low foam Non-ionic Emulsifier (internal consideration)

Type of fluids:
- Focus on Semi-synthetic

Base formulation:
Amines, Anionic Emulsifier, Non-ionic Emulsifier, Lubricant (mineral oil), Tall Oil fatty acid, Oxygenated Solvent and Water (~ 70 ppm CaCO3). Did not intend to use biocides and silicone (anti-foam) for this preliminary study.

Main steps:
- Formulation balance an stability
- Hand shake foam test/ High Speed Test (Blender Test)

Preliminary Results:
- Soluble Oil (Paraffinic oil – total amount of 3% Non-ionic Emulsifier)
- Semi synthetic (naphthenic oil base – total amount of 3% Non-ionic Emulsifier)
**Hand Shake Test** (screening tests)

This methodology is based on preparation of a fluid with 1:20 dilution rate and homogenized, and hardly shaking during 1 minute in a closed 100 mL graduated cylinder with total fluid volume of 50 mL. After this time, initial and final foam volume are checked for a related decrease over time.
High-Speed (Blender Test)

This methodology is based on a high speed shaking fluid with a blender. After emulsion preparation, it is stirred for 3 minutes and immediately transferred for a 250 mL graduated cylinder and monitored foam decreasing.

![Semi-synthetic Fluid Graph]

- Reference Emulsifier
- Low Foam Emulsifier
- Mkt Reference

Time(s) vs. Volume (mL) chart showing the decrease in volume over time for different emulsifiers.
Surface Tension

- Water: 98.6°
- Reference Emulsifier: 27.8°
- Low Foam Emulsifier: 27.4°
Hard Water Emulsion Stability

5% (v/v) Semi-synthetic fluids after 14 days stability in high hardness water (distilled water)
Hard Water Emulsion Stability

5% (v/v) Semi-synthetic fluids after 14 days stability in high hardness water (350 ppm CaCO₃)

5% (v/v) Semi-synthetic fluids after 14 days stability in high hardness water (1400 ppm CaCO₃)
1% Volume Emulsifier Dilution (distilled water)

High Speed Blender Test

Hand Shake Test
5% (v/v) Semi-synthetic Fluid (distilled water)

High Speed Blender Test

Hand Shake Test
5% (v/v) Semi-synthetic Fluid (hard water, 700 ppm CaCO$_3$)

**High Speed Blender Test**

![Graph showing volume over time for High Speed Blender Test.]

**Hand Shake Test**

![Graph showing volume over time for Hand Shake Test.]

Reference Emulsifier vs. Low Foam Emulsifier
Oil Compatibility

70% Naphthenic Oil and 30% Surfactants (w/w) - 15 days at 45 °C -
Emulsion Stability (14 days RT)

70% Naphthenic Oil and 30% Surfactants (w/w) at 5% (v/v) emulsion

- Distilled Water
- 350 ppm CaCO₃ Water
- 700 ppm CaCO₃ Water
- 1400 ppm CaCO₃ Water
General Attribution

- Hard water stability
- Oil compatibility
- Emulsion stability
- Formulation compatibility
- Surface tension
- Low foam properties

Reference emulsifier
Low foam emulsifier
CONCLUSION

The related Novel Low Foam Surfactants (Emulsifier) technology demonstrated excellent performance as a low foam surfactant for semi-synthetic metalworking fluids, considering acquired results at the same conditions, and can be considered as a functional product for the proposed application.
REFERENCES


Thank You

we listen. we understand. we deliver.

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