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Emerging Technology Investment Opportunities: CleanTech at Michigan

NEXT GENERATION MACHINING FLUIDS

Steven J. Skerlos
Associate Professor of Mechanical Engineering
Director, Environmental and Sustainable Technologies Laboratory
Aqueous Machining Fluids are...

- Essential
- Expensive
- Unstable
- Hazardous
- Polluting
- Unchanged for 50 years
Machining Fluid Improvements

Who cares?
- Workers who get sick
- Environmentalists / U.S. EPA
- Academics

Who doesn’t care?
- Most U.S. Manufacturing Engineers
- Most U.S. Lawmakers (today)
  - The two most important change agents!
Machining Productivity Improvements

Who cares?

- Everyone making a profitable metal product!
- Machining fluids impact: revenue generation rate, tool costs, labor costs, machine tool costs

New Materials = New Machining Challenges

- Ford: Flex-fuel and clean diesel vehicles
- Boeing: 787 aircraft
- Caterpillar: Fuel efficient construction equipment
CO$_2$-Based Machining Fluids are Better than Aqueous:

- Increase productivity
- Increase revenue
- Reduce costs
- Have only 2 components
- Can be retrofit to existing systems
- Eliminate health hazards
- Reduce environmental impact
- Developed @ UM
CO$_2$-Based Machining Fluids are the best ever invented!

25% Increase
Lubrication Performance

Enormous Increase in Tool Life
(4-25x in Titanium Machining)
CO\textsubscript{2}-Based Machining Fluids are CLEAN TECH

- **Lower Life Cycle Greenhouse Gas Emissions**
  - CO\textsubscript{2} is captured from ammonia production waste
  - CO\textsubscript{2} use rate is low
  - Process energy not increased
  - Soybean oil is renewable
- **No aqueous waste**
- **No hazardous chemicals**
- **No biological growth**
- **No need to clean parts afterward**
CO$_2$ fluids are *profitable* for companies that are...

... *production-rate limited*
- defense and aerospace

... *switching to advanced materials*
- automotive and heavy industrial

... *strictly regulated*
- bio-compatible for implants, etc.

... *making very small parts*
- watch making, etc.
Even automakers can profit!

Expected Results from Ford Research (~$5M/yr):

- Valve seat production: (1.5M/yr)
- Cylinder blocks: ($3.5M/yr)
  - Avoided future tool/labor costs
  - 5% of the opportunities

- Profit for Boeing could be much larger
  - 787 starts with 200,000 lbs of titanium
    - Only 25,000 lbs fly away!
Sizable Market; Patent Pending

- Machining Fluid Market: $1B (North America)
- Maintenance and Disposal: $1B
- Metal Fabricated Products Industry: $300B

We are here
## The Supercritical CO₂ Competitive Advantage

<table>
<thead>
<tr>
<th>Customer Needs</th>
<th>Increase/Decrease Flowrate; Change Chemistry</th>
<th>scCO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faster machining</td>
<td>Steady state with only incremental performance gains since 1950</td>
<td>Breakthrough increase in machining speeds (&gt;20%)</td>
</tr>
<tr>
<td>Fewer Tool Changes</td>
<td>1 tool change every 120 min.; change might take 30 min. (Titanium)</td>
<td>Increase tool life above 1000 min.</td>
</tr>
<tr>
<td>Eliminate Disposal &amp; Health Risks</td>
<td>Only modest gains possible</td>
<td>No disposal No health risks</td>
</tr>
</tbody>
</table>
scCO$_2$ in the Competitive Landscape

- Dry Machining
- Minimum Quantity Lubrication
- Liquid Nitrogen
- Flood cooling

Value Add in Challenging Apps.

Maintenance & Disposal Characteristics
We have a business opportunity; We need a business plan

There are many directions this technology could go...

1. Start-up company: sell equipment and consumables

2. License to machine tool builders;
   - Start-up would sell consumables

3. License to fluid suppliers

4. License to OEM on application-specific basis / consult
   - Funding for specific applications needed to expand proven applications outside of automotive.
   - For more: Dan Broderick, Director of Tech Transfer in CoE
     - danbrod@umich.edu, 734-615-5386
Next Generation Machining Fluids

THANK YOU

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