Benefits of Polymer Additives in Grease

Functional Products Inc.
www.functionalproducts.com
Benefits of Polymer Additives

- Greater Adhesion
- Reduced Bleeding
- Elevated Tackiness
- Added Yield
- Superior Shear Resistance
- Enhanced Water Resistance
Handling of Polymers

Forms

liquid or gel
powder or pellet

Blending
Dissolving is best accomplished with continuous agitation, at temperatures of at least 200°F (95°C) for 1-3 hours, with the cooling oil.
Polymers Evaluated

- polyisobutylene (PIB),
- ethylene-propylene copolymers (OCP)
- styrene-hydrogenated butadiene (SBR)
- styrene-hydrogenated isoprene (SI)
- radial hydrogenated polyisoprene (Star)
- acid functionalized polymers (FP)
- polyalkylmethacrylate (PMA),
- styrene ester copolymers (SE)
- styrene ethylene butylene copolymers (SEBCP)
<table>
<thead>
<tr>
<th>Polymer</th>
<th>MW Flory</th>
<th>Polydispersity</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCP</td>
<td>200,000</td>
<td>2.50</td>
</tr>
<tr>
<td>PIB</td>
<td>1,000,000</td>
<td>2.00</td>
</tr>
<tr>
<td>STAR</td>
<td>350,000</td>
<td>1.20</td>
</tr>
</tbody>
</table>
Additives and Polymers in Oil

- Additives regulate extreme pressure, wear, rust, corrosion, oxidation, and adhesion.
- Additives affect grease in the same way as lubricant oils.
- Polymers in oil increases the viscosity of base oil and in most cases increases the viscosity index (VI).
Polymers in Grease-Theory

- Changing base oil viscosity no effect on grease mechanical properties.
- Polymers must interact with the three dimensional network of fibers created by thickeners.
- When entangled, augment the mechanical properties.
Which polymers enhance the Network?

- SEBCP due to less soluble styrene blocks
- OCP due to crystalizable ethylene blocks
Enhanced, Bimodal Network Theory

- Network of soap (A)
- Network of polymers with shorter chains between rigid blocks (B)
- Bimodal network of A and B
Bimodal Network-Improves Mechanical Properties

- Improvement in mechanical properties, such as modulus and strength,
- Very limited extensibility of the short polymer chains present in the bimodal network
- An example would be the polybutadiene block of molecules in SEBCP copolymers
Deformation of Thickener Network – A & B

- Elasticity governed by Gaussian, normal distribution (A)
- Deformation from penetration (A)
- Distance is elongated, increased penetration, lower modulus (A)
- New network is bimodal (AB), and non-Gaussian
- Shorter chains restrict the deformation of long chains (AB)
Polymer Affect on Physical Network

- Polymer additives in grease form a bimodal network.
- Bimodal network changes the mechanism of deformation.
- Short chains in bimodal network restrict maximum elongation and increase modulus of elasticity.
- At maximum elongation of bimodal network, short chains cannot increase end-to-end distance by rotation about its skeleton bonds.
- Deformation of bond angles or bond lengths is required for additional elongation, but greater energy needed for this process than for configurational changes.
- Different polymers provide bimodal network: interpenetrated network OCP, SEBCP - entanglement PIB.
Experiment ASTM D 217

- 77 °F, Worked Cone Penetration
- Subjected first to 60 and then to 10,000 doubles strokes
- Three cone penetration measurements were taken using Penetrometer
Experiment ASTM D 4049

Standard Test Method for Determining the Resistance of Lubricating Grease to Water Spray
Experiment- ASTM D-1831

STANDARD ROLL STABILITY TEST

• An approximately 50 g sample was placed in a Roll Stability Tester for 2 hours with a speed of 165 rotations per minute.
• Penetrations of the greases before and after the Roll Stability were measured, compared and the changes recorded.
Experiment- ASTM D-1403

Test Method for Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment” was used with similar procedures as above.
### Polymer Additive Forms, Polymer Type and Treat Levels

**Lithium Grease**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Polymer Additive Form</th>
<th>Polymer Type</th>
<th>Treat Level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li Grease</td>
<td>--</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Li Base + A</td>
<td>Gel</td>
<td>Proprietary</td>
<td>2</td>
</tr>
<tr>
<td>Li Base + A</td>
<td>Gel</td>
<td>Proprietary</td>
<td>3</td>
</tr>
<tr>
<td>Li Base + B</td>
<td>Liquid</td>
<td>Proprietary</td>
<td>2</td>
</tr>
<tr>
<td>Li Base + B</td>
<td>Liquid</td>
<td>Proprietary</td>
<td>3</td>
</tr>
<tr>
<td>Li Base + C</td>
<td>Pellet</td>
<td>Proprietary</td>
<td>1</td>
</tr>
<tr>
<td>Li Base + D</td>
<td>Liquid</td>
<td>PIB</td>
<td>2</td>
</tr>
<tr>
<td>Li Base + E</td>
<td>Liquid</td>
<td>PIB</td>
<td>2</td>
</tr>
<tr>
<td>Li Base + F</td>
<td>Powder</td>
<td>SEBCP</td>
<td>0.5</td>
</tr>
<tr>
<td>Li Base + F</td>
<td>Powder</td>
<td>SEBCP</td>
<td>1</td>
</tr>
<tr>
<td>Li Base + F</td>
<td>Powder</td>
<td>SEBCP</td>
<td>2</td>
</tr>
<tr>
<td>Li Base + G</td>
<td>Pellet</td>
<td>OCP</td>
<td>3</td>
</tr>
<tr>
<td>Li Base + H</td>
<td>Powder</td>
<td>OCP</td>
<td>0.75</td>
</tr>
<tr>
<td>Li Base + H</td>
<td>Powder</td>
<td>OCP</td>
<td>1</td>
</tr>
<tr>
<td>Li Base + I</td>
<td>Liquid</td>
<td>OCP</td>
<td>2</td>
</tr>
</tbody>
</table>
Shear Stability – Proprietary and PIB Polymer Samples

- Polymer A, B, C are proprietary.
- Polymer D, E are PIBs
Shear Stability – SEBC and OCP

- **F** styrene ethylene butylene copolymers
- **G, H, I** ethylene-propylene copolymers
Roll Stability - Proprietary and PIB Polymer Samples

Polymer A, B, C are proprietary.
Polymer D, E are PIBs
Roll Stability – SEBC and OCP

F styrene ethylene butylene copolymers
G, H, I ethylene-propylene copolymers
Water Spray Test - Proprietary Polymer, SEBCP and OCP Additives
### GREASE: IMPROVED SHEAR STABILITY

**ROLL STABILITY - ASTM D1831; 60 and 10,000 STROKES CONE**

**PENETRATION - ASTM D217**

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>Polymer Additive Form</th>
<th>Treat Level, %</th>
<th>60 and 10,000 Strokes Penetration Change</th>
<th>Roll Stability, % Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li Complex Base Grease</td>
<td></td>
<td>0</td>
<td>-24</td>
<td>11.0</td>
</tr>
<tr>
<td>Li Base + <strong>Tackifier A</strong></td>
<td>Liquid</td>
<td>2.0</td>
<td>6</td>
<td>-1.4</td>
</tr>
<tr>
<td>Li Base + <strong>Tackifier B</strong></td>
<td>Liquid</td>
<td>2.0</td>
<td>-3</td>
<td>1.4</td>
</tr>
<tr>
<td>Li Base + <strong>Tackifier C</strong></td>
<td>Liquid</td>
<td>2.0</td>
<td>-3</td>
<td>4.1</td>
</tr>
</tbody>
</table>
**Economic Benefit**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Treat Level (%)</th>
<th>WK 60 Penetration</th>
<th>Oil Adjustment (%)</th>
<th>WK 60 Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Grease</td>
<td>0</td>
<td>296</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li Base + B</td>
<td>3</td>
<td>268</td>
<td>17</td>
<td>294</td>
</tr>
<tr>
<td>Li Base + F</td>
<td>1</td>
<td>278</td>
<td>15</td>
<td>297</td>
</tr>
<tr>
<td>Li Base + H</td>
<td>1</td>
<td>272</td>
<td>16</td>
<td>294</td>
</tr>
</tbody>
</table>

- Yield Increase with Polymer Additives
- B is proprietary, F is SEBCP, and H is OCP
- Increased yield approximately 15%
- Plan for yield increase - increased additives
Summary

- The theory of improvement of grease performance in terms of changing network structure from the addition of polymer was discussed.
- A bimodal network of polymers and grease soap matrix was presented.
- Polymer additives have been shown to provide significant grease performance benefits at low treat levels.
- Polymer additives can improve shear stability and water resistance.
- Select polymer additives may increase yield.