Industrial Lubricants in the new world of Electric Vehicles

2nd Asian Industrial Lubricants ICIS Conference, Singapore

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Electric Vehicle is not Automotive anymore, it is an Industrial machine moving at high power and speed
Sharing a Thought Process..... why paper on EV is being presented in ICIS Industrial Conference

B2B and B2C
There will be a thin line between B2B and B2C for e-fluids.

Industrial lube companies can manufacture e-fluids
And let B2C companies to distribute

Challenges of Automotive fluid for EV not new for Industrial
They have found solutions to overcome most of these challenges

Change in focus for Automotive
Transmission fluids/Gear Oils, Coolants, Greases

Automotive addco and Industrial addco
Again a thin line
Data Points

Critical to know that Asia is going to be a growth engine and ICE to EV transition will take much longer time
3 Asian countries will be in Global Top 5 by 2050....goes to show deeper Motorisation and Industrial activities in this region

Emerging markets will dominate the world’s top 10 economies in 2050 (GDP at PPPs)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>China</td>
<td>1</td>
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<tr>
<td>US</td>
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<td>India</td>
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<td>Japan</td>
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<td>Germany</td>
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<td>UK</td>
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<td>France</td>
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</tbody>
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Sources: IMF for 2016 estimates, PwC analysis for projections to 2050
Global Motorisation accounts only for 14% of total population and Expected to grow to 23% by 2035

Most of the growth will come from Asia, followed by ME & Africa

Source: International Organization of Motor Vehicle Manufacturers
Even with EV penetration going to 30% market share by 2030 (in line with EV30@30 scenario), demand for Industrial Lubricants (for Automotive manufacture application) will remain robust. Engine Oil demand will however come down.
Lubricant demand by sector

Projected annual lubricant demand by sector,¹ million tons

<table>
<thead>
<tr>
<th>Sector</th>
<th>2017</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road transport/automotive</td>
<td>17.2</td>
<td>17.4</td>
<td>17.3</td>
<td>16.9</td>
<td>15.9</td>
</tr>
<tr>
<td>Nontransport/industrial</td>
<td>22.7</td>
<td>23.8</td>
<td>25.6</td>
<td>27.2</td>
<td>28.9</td>
</tr>
<tr>
<td>Other transport (marine, aviation, rail)</td>
<td>2.8</td>
<td>3.0</td>
<td>3.4</td>
<td>3.7</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Compound annual growth rate, %

<table>
<thead>
<tr>
<th>Period</th>
<th>2017–25</th>
<th>2025–35</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017–25</td>
<td>1.5</td>
<td>1.2</td>
</tr>
<tr>
<td>2025–35</td>
<td>2.5</td>
<td>1.6</td>
</tr>
</tbody>
</table>

¹Figures may not sum, because of rounding.

Lubricant consumption for ICE vehicles, hybrid/plug-in hybrid, and battery electric vehicles
Major Applications for Industrial Lubricants and Types of Lubricants...Will continue to dominate in disruptive world

Types of Industrial Lubricants
- Hydraulic Fluids
- Corrosion Preventives
- Gear Oils
- Soluble Cutting Oils
- Neat Cutting Oils
- Forming Oils
- Quenching Oils
- Compressor Oils
- Honing Oils
- Turbine Oils
- Refrigeration Oils
- Marine, railroad, aviation
- Industrial greases
- Way oils
- Cleaners
- Misc.

Automotive manufacturer
Machinery
Metals

Rail, Marine, Aviation
Mining
Compressors
Lubricants Demand by 2030 will undergo change due to ICE to EV transition of 15%(best case) to 25%(worst case) of total vehicle parc.

2030 will have different mix?*

New opportunities for Industrial Lubricant Manufacturers for FF and SF of EV

* Still too early to calculate lubricant mix by 2030, due to lack of clarity of Govt. Policies and journey of Hybrid v/s EV v/s more efficient ICE over next decade.
An opportunity for Industrial Lubricant Players to create a metastory like ‘Intel Inside’
New opportunities for Industrial Manufacturers

.....EV needs high performance fluids and greases

- Gear Oils to lubricate differentials, Chassis and wheels
- Coolants for the battery
- Brake Fluids
- Grease for EV
HEV/BEVs and challenges for e-fluids

- **HEV/BEV**: Likelihood of hybrids being the larger part of EV market in short-term and BEV long term

- **ICE, on average, operates cooler than in a EV**: Risks of significant condensation and fuel dilution of the crankcase lubricant, both of which could lead to sludge and wear

- **Additive Components for consideration**: Corrosion Inhibitor, Demulsifiers, Anti-oxidants, Dispersants, Anti-wear, Friction Modifiers
e-DCT or e-ATF and e-axle - Challenges and solutions by e-fluid formulators

- Excellent oxidation and sludge control
- Should have low electrical conductivity
- Should protect against copper corrosion
- Should have appropriate frictional properties

These fluids will also get hotter than conventional axle fluids. Need to have higher VI, leading to Synthetic base fluids.

Industrial has all the experience and expertise.
Greases...clearly a critical product among e-fluids and Industrial grease makers have already addressed some of the challenges

- The technical challenges for greases will be electrical, thermal and energy-saving
- If current industrial EM greases are considered as a starting point for automotive applications, the voltage issue has already been addressed and the formulating challenge is around the different mechanical environment of the EM
- Industrial EM greases are often based on polyurea or lithium complex thickeners, due to their higher mechanical stability, which ensures the grease stays in the bearings and doesn’t migrate to the windings.

To be contd...
• Electric motors for automotive applications will operate at higher rotational speeds than most industrial applications, leading to higher shear and higher temperatures in the bearings.

• The viscosity of the base fluid will have to be low to reduce energy losses due to friction or drag in all parts of the drivetrain but high enough to maintain an oil film under all anticipated operating conditions.

• All these factors drive formulators towards synthetic and lower-viscosity base fluids.

• Stop-start operation is likely to be more prevalent in EVs than in most industrial applications.

Greases...Some of the challenges in EV are different from Industrial applications and need to be addressed.
References

EV Lubricant Technology...LubesNGreases
International Organization of Motor Vehicle Manufacturers
International Energy Agency – Global EV Outlook

Would like to thank and give credit to Dr. Raj Shah at Koehler Instrument Company in New York and few of my dear friends from the industry for their valuable inputs for this paper
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