Lubricating Base Oil Production
- Technology Overview

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Introduction

Conventional Lube Base Oil Refining Technologies

Advanced Lube Base Oil Refining Technologies

GTL Lube Base Oil Production Technology

Used Oil Re-refining Technology

Conclusions
Lubricant

- Lubricant is an essential component for any machinery
- Finished Lubricant is a blend of base oil(s) and additives
- Base oil is a major constituent of any lubricant
- Additives (e.g. VI improvers, PPT depressant, antioxidant, detergent, dispersant etc) are chemical compounds used to enhance lubricant’s properties
- Lubricants are formulated for variety of applications by selecting proper ‘base oils’ of required viscosity/VI and ‘additive packages’
# Lube Base Oil Terminology

<table>
<thead>
<tr>
<th>Lube Base Oils</th>
<th>Lube Product that meets certain specs (Viscosity, Pour point, VI etc) &amp; is suitable for blending</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lube Slate</td>
<td>Set of lube base oils usually 3 to 5 (Spindle, LN, IN, HN &amp; BS)</td>
</tr>
<tr>
<td>Neutral Lube Distillates</td>
<td>Produced from side out of the VDU (100N, 150N, 500N, 800N, 1300N)</td>
</tr>
<tr>
<td>Bright Stock</td>
<td>Produced from Deasphalted oil from VR (2500N)</td>
</tr>
</tbody>
</table>
American Petroleum Institute (API) introduced a broad classification for all types of Lube Base Oils.

5 Groups indicate performance level of base oils.

Helps to minimize lengthy testing for blending and substitution purposes.

<table>
<thead>
<tr>
<th>API Group</th>
<th>Sats</th>
<th>Sulfur</th>
<th>VI</th>
<th>Typical Manufacturing Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>&lt;90%</td>
<td>&gt;0.03%</td>
<td>80-119</td>
<td>Solvent Processing</td>
</tr>
<tr>
<td>II</td>
<td>&gt;90%</td>
<td>&lt;0.03%</td>
<td>80-119</td>
<td>Hydroprocessing</td>
</tr>
<tr>
<td>III</td>
<td>&gt;90%</td>
<td>&lt;0.03%</td>
<td>120+</td>
<td>Wax Isomerisation, GTL</td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>N.A</td>
<td></td>
<td>Poly Alpha Olefins (PAO)</td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
<td></td>
<td>All other Base Stocks</td>
</tr>
</tbody>
</table>
## Global Base Oils Production and API Group Percentage Distribution

<table>
<thead>
<tr>
<th>Year</th>
<th>Bbl/ d</th>
<th>Group – I</th>
<th>Group - II</th>
<th>Group – III, IV &amp; V</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>6,80,000</td>
<td>91</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>2015*</td>
<td>8,31,500</td>
<td>69</td>
<td>21</td>
<td>10</td>
</tr>
</tbody>
</table>

*Projected

*Quality of Base oil increases from Group – I base oil to Group – V base oil*
Feed Stocks for Group-I Lube Base Oil

- Gas: 4%
- Naphtha: 20%
- Kerosene: 4%
- Gas oil: 23%
- Vacuum distillates for base oil production: 23%
- Vacuum residue: 26%

Light distillates lead to:

- Lube base oils
- Aromatic extracts
- Paraffin wax
- Vacuum residue
Feed Stocks for Group-I Lube Base Oil

- **Vacuum distillates** (370 – 540°C)
  - LN (370 – 425°C)
  - IN (425 – 485°C)
  - HN (485 – 540°C)

- **Vacuum residue** (540°C+)
  - BS (540°C+)
## Typical Specifications of Lube Base Oils in India

<table>
<thead>
<tr>
<th>Properties</th>
<th>Light</th>
<th>Inter</th>
<th>Heavy</th>
<th>B.Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kin. Visc., cSt100 °C</td>
<td>4.5 – 7</td>
<td>10-12</td>
<td>14 – 19</td>
<td>30 – 32</td>
</tr>
<tr>
<td>Viscosity Index</td>
<td>100</td>
<td>98</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Pour Point, °C</td>
<td>-12</td>
<td>-9</td>
<td>-9</td>
<td>-6/-9</td>
</tr>
<tr>
<td>Flash Point, °C</td>
<td>200</td>
<td>240</td>
<td>260</td>
<td>290</td>
</tr>
<tr>
<td>Color, ASTM</td>
<td>1.5</td>
<td>3.0</td>
<td>3.5</td>
<td>4.5</td>
</tr>
<tr>
<td>C.C.R., % wt</td>
<td>0.05</td>
<td>0.10</td>
<td>0.10</td>
<td>0.60</td>
</tr>
</tbody>
</table>
Base oil Attributes

- Low volatility
- Proper viscosity
- High viscosity index (VI)
- High oxidation and thermal stability
- Low pour point (PPT)
- Seal compatibility
- Solubility for additives
<table>
<thead>
<tr>
<th>Families / VI</th>
<th>Typical Structure</th>
<th>Main Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Straight chain Paraffins</strong></td>
<td><img src="image1" alt="Structure" /></td>
<td><strong>Favorable</strong>&lt;br&gt;High viscosity index (175 +)&lt;br&gt;High Pour point</td>
</tr>
<tr>
<td><strong>Branched paraffins and paraffins with few rings</strong></td>
<td><img src="image2" alt="Structure" /></td>
<td><strong>Favorable</strong>&lt;br&gt;Good to high viscosity (155)&lt;br&gt;Good resistance to oxidation</td>
</tr>
<tr>
<td><strong>Naphthenics</strong></td>
<td><img src="image3" alt="Structure" /></td>
<td><strong>Favorable</strong>&lt;br&gt;Good resistance to oxidation&lt;br&gt;Low pour point&lt;br&gt;Low viscosity index (VI ~80)</td>
</tr>
<tr>
<td><strong>Aromatics</strong></td>
<td><img src="image4" alt="Structure" /></td>
<td><strong>Favorable</strong>&lt;br&gt;Generally low-pour point (50)&lt;br&gt;Low viscosity index&lt;br&gt;Very poor resistance to oxidation</td>
</tr>
</tbody>
</table>
1. Conventional Refining
   (Solvent Extraction + Solvent Dewaxing + Hydrofinishing)
   (Separation Based : Produce Group-I base oils)

2. Hybrid Type Refining
   (Solvent Extraction + Catalyst Dewaxing/Wax isomerization)

3. Advanced Refining
   (Hydrocracking + Catalyst Dewaxing/ Isodewaxing + Wax isomerization)
   (Conversion Based : Produce Group-II/III base oils)

4. More Advanced Technology/Synthetic
   (Synthetic Type : Produce Group-III base oils)
   Products – PAO, esters, silicon oils etc.
Conventional Refining

- Crude dependent
- Works on subtraction principle
- VI limitation
- By-product (aromatic extract, wax) generation
- Energy intensive
Process Concept

Lube complex consists of following units

- Solvent extraction - to remove aromatics and improve VI
- Solvent Dewaxing - to remove wax and improve pour point
- Hydrofinishing - to improve colour and stability
Lube Extraction

• **Purpose**
  - Lube extraction is carried out to remove poly aromatic hydrocarbons from the feed stocks to improve Viscosity Index, Colour, Oxidation Stability

• **Process**
  - It is a counter current solvent extraction process to remove undesirable poly aromatic hydrocarbons from the lube distillates
  - The undesirable poly aromatics are accumulated in solvent rich Extract phase due to their preferential solubility in solvent
  - The desirable paraffinic & naphthenic components are accumulated in lighter raffinate phase
Process Units

- Extractor
- Raffinate recovery
- Extract Recovery Section
Extractor

Light Phase (Raffinate)
Outlet

Interface Level

Heavy Phase (Solvent)
Inlet

Light Phase (Feed)
Inlet

Outlet

Heavy Phase (Aromatic Extract)
Process Variables

- Temperature
- Solvent Ratio
- No of Equilibrium Stages
- Dispersion
- Extract Recycle
- Anti Solvent
- Temp Gradient
Commonly Used Solvents

- Phenol
- Furfural
- NMP (N-methyl Pyrollidone)
### Characteristics of different Solvents

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>NMP</th>
<th>FURFURAL</th>
<th>PHENOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density, @ 15°C</td>
<td>1.03</td>
<td>1.16</td>
<td>1.07</td>
</tr>
<tr>
<td>Boiling Point, °C</td>
<td>204</td>
<td>162</td>
<td>182</td>
</tr>
<tr>
<td>Freezing Point, °C</td>
<td>-24</td>
<td>-39</td>
<td>+40</td>
</tr>
<tr>
<td>Relative Cost</td>
<td>1.5</td>
<td>1.0</td>
<td>0.36</td>
</tr>
<tr>
<td>S/ F Ratio</td>
<td>Very Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Solubility in Water</td>
<td>Complete</td>
<td>Partial</td>
<td>Partial</td>
</tr>
<tr>
<td>Selectivity</td>
<td>Very good</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Solvent Power</td>
<td>Excellent</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Stability</td>
<td>Excellent</td>
<td>Good</td>
<td>Very good</td>
</tr>
<tr>
<td>Extraction Temperature</td>
<td>Lowest</td>
<td>Highest</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Refined Oil Yield</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
Rotating Disc Contactor (RDC)
Furfural Based Lube Refining

- Mostly all old units are furfural based
- Highly selective solvent; Better Raffinate Yields
- High extraction temperatures can easily handle viscous and waxy stocks
- De-aeration and inert gas blanketing are required to check deterioration of furfural due to oxidation and polymerization
- Heating during solvent recovery restricted < 232°C to prevent thermal degradation of Furfural
- Azeotropic distillation is required for solvent purification
Licensor of NMP Based Lube Refining Technology

- Exxon - Mobil
- Texaco
- IIP-EI L-CPCL
NMP Based Lube Extraction Process

- Superseding phenol- fufural lube refining
- High solvent power, lower solvent-to-feed ratio required
- Low temperature & energy efficient operation.
- Use of water gives higher raffinate yields
- Quick phase separation and fast settling lead to increased throughput and smaller new units for a given size of the plant
- Lower operating cost
- High “ON STREAM” factor
## Comparison of NMP & Furfural

Benefits of NMP (Feed IN) in terms of S/F and feed rate

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Furfural</th>
<th>NMP</th>
<th>% Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvent/Feed ratio V/V</td>
<td>3.15</td>
<td>2.18</td>
<td>31</td>
</tr>
<tr>
<td>Raffinate yield Vol%</td>
<td>65</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Feed rate m³/day</td>
<td>1122</td>
<td>1622</td>
<td>44.6</td>
</tr>
</tbody>
</table>
## Comparison of NMP & Furfural

### Benefits of NMP (Feed IN) in terms of Utilities

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Furfural</th>
<th>NMP</th>
<th>% Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam, Kg</td>
<td>32.9</td>
<td>15.4</td>
<td>53.2</td>
</tr>
<tr>
<td>Fuel gas Million Kcal</td>
<td>0.24</td>
<td>0.20</td>
<td>16.7</td>
</tr>
<tr>
<td>Total Energy consumption Million Kcal</td>
<td>0.28</td>
<td>0.23</td>
<td>17.9</td>
</tr>
</tbody>
</table>
By-Product of Lube Extraction

- Aromatic Extract or Aromatic Oil
  (A mixture of aromatic hydrocarbon)

Applications

- CBFS
- Rubber Process oils
- Feed for pitches
- Feed for needle coke
- Feed for secondary conversion units
- Feed for coker
- Fuel oil component
Dewaxing

Process Concept:

Dewaxing is used to remove wax from waxy raffinate obtained after solvent extraction to get relatively wax free oil having low temperature flowability.

- **Solvent Dewaxing:**
  
  Precipitation and separation of wax crystals at low temperature in presence of solvent.

  - MEK: Toluene
  - Propane
Hydrofinishing

- **Purpose**
  - Stabilize (hydrogenation) and
  - Decolourize base oils
    (removal of O, N and S)

- **Feed**
  - Dewaxed oil and H$_2$

- **Operating conditions**
  - Catalyst : Ni/Mo or Co/Mo
  - Catalyst Support : Silica or Alumina
  - Temp : 300 – 500 °C
  - LHSV : 0.1 – 8.0
  - H$_2$ pressure : 40 – 50 Kg/Cm$^2$
  - H$_2$ Purity : 65 – 85 %

- **Hydrofinished Oil Yield**
  - 98%
Improvement in Base Oil Propose by Hydrofinishing

<table>
<thead>
<tr>
<th></th>
<th>DWO</th>
<th>HF Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pour point (°C)</strong></td>
<td>(-3) to -6</td>
<td>(-3) to -6</td>
</tr>
<tr>
<td><strong>Kin. Viscosity at 100 °C</strong></td>
<td>9-9.3</td>
<td>9-9.2</td>
</tr>
<tr>
<td><strong>VI</strong></td>
<td>95-97</td>
<td>95-97</td>
</tr>
<tr>
<td><strong>Flash Point (°C)</strong></td>
<td>230-235</td>
<td>230-240</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>6-7</td>
<td>1-1.5</td>
</tr>
</tbody>
</table>

**HN**

<table>
<thead>
<tr>
<th></th>
<th>DWO</th>
<th>HF Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pour point (°C)</strong></td>
<td>(-3) to -6</td>
<td>-3 to -6</td>
</tr>
<tr>
<td><strong>Kin. Viscosity at 100 °C</strong></td>
<td>14-17</td>
<td>14-17</td>
</tr>
<tr>
<td><strong>VI</strong></td>
<td>90-93</td>
<td>90-92</td>
</tr>
<tr>
<td><strong>Flash Point (°C)</strong></td>
<td>24.5-250</td>
<td>245-255</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>6-7</td>
<td>2-3</td>
</tr>
</tbody>
</table>

**BN**

<table>
<thead>
<tr>
<th></th>
<th>DWO</th>
<th>HF Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pour point (°C)</strong></td>
<td>-3</td>
<td>-3</td>
</tr>
<tr>
<td><strong>Kin. Viscosity at 100 °C</strong></td>
<td>33-38</td>
<td>32-36</td>
</tr>
<tr>
<td><strong>VI</strong></td>
<td>90-92</td>
<td>90-93</td>
</tr>
<tr>
<td><strong>Flash Point (°C)</strong></td>
<td>290-300</td>
<td>290-300</td>
</tr>
<tr>
<td><strong>Colour</strong></td>
<td>7-8</td>
<td>2-3</td>
</tr>
</tbody>
</table>
Typical VI of Products

- **Lube Distillates** (VI = 40-70)
- **Raffinate** (VI = 90-120)
- **HF** (VI = 85-107)
- **DWO** (VI = 85-105)
- **LOBS + Additives**
  - VI = 120-160
- **AR**
- **SDU**
- **Wax**
  - (VI = 140 - 180)
- **VDU**
- **SEU**
- **Aromatics**
  - (VI = < 30)
- **Naphthenic Oil** (VI = 40 - 65)
Hybrid Type Refining

- Combining Solvent extraction with Hydrotreating
- Low investment option for Group-I + /Group-II base oils
- Better yield and quality of raffinate
- Uses existing solvent extraction facilities
- Debottlenecks solvent extraction
- Preserve wax production
Manufacturing Sequence of Base Oil Refining

- Hybrid type Base Oil Refining (Group I\(^+\) & II base oils)
  - Hydro-treatment prior to solvent extraction
  - Hydro-treatment after solvent extraction
  - Raffinate hydroconversion
Manufacturing Sequence of Base Oil Refining

- Hybrid type Base Oil Refining
  - Hydro-treatment prior to solvent extraction
    - Higher raffinate yield (≈5-8%)
    - Less solvent treat rates (10%)
    - Higher t’put
  - Hydro-treatment after solvent extraction
    - Better quality of Raffinate
Raffinate Hydroconversion

- **Purpose**
  - To Upgrade solvent extracted raffinate (VI 95) into high VI 105-120 base oils

- **Chemistry**
  - Hydrogenate Aromatics
  - Remove Hetroatoms
  - Cracking of some hydrocarbons as light fuel components

- **Feed**
  - Raffinate from solvent extraction unit

- **Operating conditions**
  - Catalyst: Ni/Mo or Co/Mo
  - Temp: 340 – 420 °C
  - LHSV: 0.1 – 1.0
  - H₂ pressure: 800 – 1500 psig

- **Lower investment option via Integration with existing solvent lube plant**
Integration of RHC with Solvent Lube Plant

Lube Vacuum Distillation → Solvent Extraction → RHC → Solvent Dewaxing

- Light Neutral
- Inter Neutral
- Heavy Neutral
- Wax
- Aromatic Extract
- Fuels

Raffinate Hydroconversion
Hydroprocessing can be Integrated with Solvent Extraction plants to improve product Quality/Yield & flexibility to make Group II/III Oils.
To meet future finished lubricant’s requirements upgradation of current base oil quality is needed.

Future lubricants requirements focus on improved fuel economy, lower emissions, better low temp. properties and high temp performance.

To meet above requirements base oils should have lower viscosity, lower volatility, high VI, high saturates, low pour, low sulfur.

Conventional base oil can’t produce high performance Group-I/Group-II base oils.

High performance Group-I/Group-II base oils can be produced by conversion based hydroprocessing technology.
Advanced Refining include Hydrocracking+ Catalyst Dewaxing/Isodewaxing+Wax isomerization

- Reshape less desirable Hydrocarbon molecules
- Convert wax into high quality iso-paraffins
- Removes impurity
- No solvent is required
- Can make same product from different crude source
Hydroprocessing Refinery

Lube Hydrocracker → Cat Isom/Dewax → Lube Hydrofinisher → Group II Base Oils

LVGO → LN
MVGO → MN
HVGO → HN
Hydroprocessed Lubes

• **Purpose**
  - To produce high VI 105-140 base oils from Vacuum distillates

• **Chemistry**
  - Aromatics Hydrogenation
  - Aromatics dealkylation
  - Naphthenes cracking
  - Remove Hetroatoms
  - Heteroatom removal

• ** Feed**
  - Vacuum distillates

• **Operating conditions**
  - Catalyst : Ni/Mo or Co/Mo
  - Temp : 340 – 420 °C
  - LHSV : 0.5 – 1.0
  - H₂ pressure : 100 atm
Catalytic Dewaxing

- Catalytic dewaxing transforms high melting point waxy molecules into low pour products of non-waxy structure.
- Concept is to selectively crack high pour straight chain paraffins and then isomerize them into low pour iso-paraffins.
- Two licensors: Chevron, ExxonMobil
- Broad range of feed from low wax to 100% wax can be processed
- VI of the final product 95-140
Straight chain and slightly branched waxy molecules selectively cracked over Zeolite catalyst (ZSM - 5).

- Applicable to wide range of raffinates
- DWO of very low pour point can be obtained but there is associated loss of VI
- Removes more paraffins to reach same pour point. That is less yield than solvent dewaxing
- By products - LPG and Naphtha.
- Reduced capital and operating cost.
Development of more shape selective catalyst around isomerization rather than conversion

- Catalyst with strong Hydro-Isomerization activity transforms Waxy molecules into non-waxy isoparaffins plus small distillates
- Improved selectivity for wax conversion gives more yield and higher VI Lube compared to MLDW
- Highly refined base oils substantially reduced S & N from feed such as Lube Hydrocrakates, Fuel Hydrocracker Bottom or Hydro - converted raffinates
- Higher VI & Better yield of base oils than Solvent Dewaxing
Chemistry of MSDW

- Catalyst is More Selective than ZSM-5
  - Accessible to waxy n-Paraffins
  - Better at excluding non-waxy branched paraffins
- Can isomerize waxy n-Paraffins to low pour/high VI branched Paraffins
  - Higher Lube Yield and VI than MLDW

<table>
<thead>
<tr>
<th>C_{26}H_{54} Isomers</th>
<th>Pour Point</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>nC_{26}</td>
<td>56°C</td>
<td>159</td>
</tr>
<tr>
<td>C_2—C—C_{21}</td>
<td>30°C</td>
<td>158</td>
</tr>
<tr>
<td>C_2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example of how isomerization can lower pour point, yet maintain high VI
- GTL synthesis promises an abundance of high performance lubricants
- Technology is costly
- Base oils are of very high quality equivalent to Group-III Product/synthetic
Fischer Tropsh

- **Purpose**
  - To produce very high quality base oils VI >140

- **Feed**
  - Natural gas

- **Operating conditions**
  - Catalyst : Fe/Co
  - Temp : 190 - 250°C
  - Pressure : 10-40 bar
  - LHSV : 0.1 - 8.0

- **Yields**
  - 30-70%
Fisher Tropsch Synthesis as GTL the Route for Waxy Lube Feeds

- **Generation of Syn-gas (i.e. CO, H₂)**
- **Syn-gas**

**Oxygen (Air)**

**Natural Gas**

**Steam**

**Syn-gas**

**FT - Reactor**

**HC synthesis is (mixture of liquid and wax) (FT - reactor)**

**Normal solid / liquid : 50:50 (depending on catalyst)**

**Liquid to further treatment or direct use**

**Wax**

**Hydrocracking & hydroisomerization clear liquid**
Super clean Group III+ Base Oils From Fisher TROPSCH Waxes

Fisher Tropsch waxes

H₂ from syngas

Hydrogenation

Light products

H₂

Hydroisomerization isodewaxing

UHVI (XHVI) LUBE BASE OILS

VI >145, Sulfur 0 ppm, Nitrogen 0 ppm, low noack (6-7 for 150N) characteristic, Yield 70%

Shell Malaysia Plant
## Comparative Properties of Base Oils

<table>
<thead>
<tr>
<th>Index</th>
<th>Solv. Refined</th>
<th>Hydrocracked</th>
<th>GTL 36 Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kin. Visc. cSt at 40°C at 100°C</td>
<td>18.5</td>
<td>16.91</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>3.81</td>
<td>3.95</td>
<td>4.5</td>
</tr>
<tr>
<td>VI</td>
<td>92</td>
<td>130</td>
<td>144</td>
</tr>
<tr>
<td>Pour Point, °C</td>
<td>-18</td>
<td>-27</td>
<td>-21</td>
</tr>
<tr>
<td>Noack, % wt</td>
<td>32</td>
<td>15.3</td>
<td>7.8</td>
</tr>
<tr>
<td>Total N₂, ppm</td>
<td>17</td>
<td>12</td>
<td>--</td>
</tr>
<tr>
<td>Aromatics % wt</td>
<td>18.2</td>
<td>7.7</td>
<td>0</td>
</tr>
<tr>
<td>Non-aromatics, % wt</td>
<td>81.8</td>
<td>92.3</td>
<td>100% i-P</td>
</tr>
</tbody>
</table>
Summary of Base Oil Manufacturing Technologies

**Crude Source** → **V.I. Upgrading** → **Dewaxing** → **Finishing** → **Base Oil**

- **Conventional**
  - Solvent Refining

- **Modern**
  - Hydrocracking

- **Alternate**
  - Hydrocracking

- **Alternate**
  - Solvent Refining/ Hydrotreating

- **More recent**
  - Syn gas formation

- **Low pressure Hydrotreating**
  - Hydrofinishing (With Base Metal Catalyst)

- **Solvent Dewaxing**
  - Catalytic Dewaxing

- **Isodewaxing/ MSDW**

- **Hydrofinishing** (With Noble Metal Catalyst)

- **Wax isomerization**

- **Hydrofinishing** (With Noble Metal Catalyst)
Used Oil Refining Technology

• About Technology

CSI R-IIP has developed a Technology for Re-refining of Used Lube Oil using ‘Tailor made Solvent’

• Salient Features

- Separation based- Solvent extraction
- Moderate operating conditions
- No need of hydrogen
- Eco-friendly
- Low investment
- Yields of re-refined oil >95% on feed basis
Used Oil Refining Technology

**Societal Impact**

- Reduces Import of Lube Oil
- Conservation of Oil resource
- Eco-friendly disposal of Hazardous Waste
- Employment Generation
- Reduces $\Delta$ of Demand & Supply of Lube

**Product Quality of Re-refined Oil**

- The base oil produced by CSIR-IIP technology is chemically and physically indistinguishable from virgin base oils.
Processing Steps

General Approach

Innovative Approach

WCO → LBO → LBO Raffinate

WCO → MBO → MBO Raffinate

WCO → HBO → HBO Raffinate

WCO → WCO Raffinate

WCO → LBO
WCO → MBO
WCO → HBO
Fractionation of WCO Raffinates

Product Quality
Summary

• Group – I base oils produced by Conventional solvent refining still dominates in the market

• Demand of High quality Group – II and III base oils is growing

• GTL although produces very high performance base oil but production cost is very high and therefore faces tough competition with synthetic PAO base oils

• Used oil re-refining is also gaining attention of leading base oil manufactures due to environmental & base oil conservation issues and their high quality – equivalent to virgin base oils

• New Group – II and III base oils are posing challenges for additive manufactures to formulate new additive packages as group-I additives can’t be used as such for Group – II and III base oils
CSI R-IIP invites Academia for Joint Projects on

- Development of new solvents/Co-solvents for conventional lube base oil production
- Catalyst development for Group – II and Group - III base oils
- New additive development for Group – II and III base oils