Shenhua Direct Coal Liquefaction

Process and Project

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China Shenhua Coal Liquefaction Corp. Ltd.
Outline

1 Necessity to Develop Coal-to-Oil Technology

2 Development History of China Shenhua Coal Liquefaction Process

3 Shenhua Direct Coal Liquefaction Process and Characteristics

4 Shenhua Direct Coal Liquefaction Project
Energy is essential production factor and material base to human society.
Necessity to Develop Coal-to-Oil Technology

Energy is a bottleneck and standing difficult problem in the process of China’s development.
Necessity to Develop Coal-to-Oil Technology

Petroleum has become a key factor that impacts on China’s energy security and national economic development.

- China’s oil security is not so optimistic
  - Relying more and more on international imports, China’s oil supply security is full of un-stability.
  - Oil supply shortage worldwide, and rise in price.
  - Oil & gas exploitation is going to be more and more difficult. Oil & gas supply in China is of uncertainty.
1. Necessity to Develop Coal-to-Oil Technology

- Coal resources is the strategic footstone of China's economic development and energy security.

**Total proven reserves exploitable technically:** 823.1 billion Mtc.

- Coal: 87.4%
- Petroleum: 2.8%
- Natural Gas: 0.3%
- Water Power: 9.5%

**Remaining economic exploitable reserves:**
- Coal: 58.8%
- Petroleum: 3.4%
- Natural Gas: 3.4%
- Water Power: 36.9%

Coal is dominating over China's total remaining exploitable energy reserves. Relatively rich in coal, Resources is the strategic footstone of China's economic development and energy.
煤炭
Coal

催化剝
Catalyst

液化装置
Liquefaction

热
Heat

壓力
Pressure

氢气
Hydrogen gas

溶剝
Recycle solvent

轻质油
Light oil

重质油
Heavy oil

中质油
Middle oil

汽油
Gasoline

柴油
Diesel

精制
Purification
2. History of Development on China Shenhua Coal Liquefaction Process


Shenhua Direct Coal Liquefaction Technology

Use international PP experience

Developments of domestic research institute

Japanese NEDOL Technology (nature)

German lGCR Technology (nature)

American HTI Technology (nature)
<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PDU</strong></td>
<td>Shenhua and Enterprise</td>
</tr>
<tr>
<td><strong>863 Catalyst</strong></td>
<td>Shenhua and Research institute</td>
</tr>
<tr>
<td><strong>Development Test</strong></td>
<td>Shenhua and University</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td>Shenhua and research institute</td>
</tr>
<tr>
<td><strong>BSU</strong></td>
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</table>
Shenhua Direct Coal Liquefaction Process and Characteristics

Development process of “863” synthetic high-activity catalyst
The new “863” catalyst is of the following characteristics:

- Low cost
- Easy preparation and good repetition
- High activity
### Shenhua Direct Coal Liquefaction Process Flow Diagram

- **Catalyst**: Fe-S
- **Coal**: $<0.15\text{mm}$
- **Air**: $O_2$
- **N_2**
- **Donor solvent**
- **Gasification**
- **Liquefaction**
- **Separation**
- **Upgrading**
- **Fractionation**

- **Coal Preparation**
- **Slurry Preparation**

- **LPG**
- **Naphtha**
- **Aviation kerosene**
- **Diesel oil**
- **Residue**

- **ASU**

- **Temperatures**:
  - Coal: 450-470 °C
  - Liquefaction: 380-390 °C

- **Pressures**:
  - Coal Preparation: 17-30 MPa
  - Liquefaction: 15-18 MPa
Shenhua Direct Coal Liquefaction
Process and Characteristics

Pictures of Shenhua PDU and its products
Shenhua Direct Coal Liquefaction Process and Characteristics

Shenhua coal liquefaction process has the following main characteristics:

• Adopt cycle donor solvent in coal slurry preparation
• Use two forced-circulating suspension bed reactors
• Apply vacuum distillation to remove asphalt and solids
• Use forced-circulating suspension bed reactors for hydrogenation of cycle solvent and product
Liquefaction results of Shenhua direct coal liquefaction process

<table>
<thead>
<tr>
<th></th>
<th>Adopt “863” Catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion rate, % naf</td>
<td>91.22%</td>
</tr>
<tr>
<td>Oil yield, % naf</td>
<td>57.17%</td>
</tr>
<tr>
<td>Gas yield, % naf</td>
<td>13.11%</td>
</tr>
<tr>
<td>Water yield, % naf</td>
<td>12.51%</td>
</tr>
<tr>
<td>Organic residue, % naf</td>
<td>23.99%</td>
</tr>
<tr>
<td>Total, % naf</td>
<td>106.78%</td>
</tr>
<tr>
<td>H₂ consumption, % naf</td>
<td>5.65%</td>
</tr>
</tbody>
</table>
Shenhua Direct Coal Liquefaction Process and Characteristics

Shenhua PDU is operated continuously for 412 hours (nearly 18 days)
4. Shenhua Direct Coal Liquefaction Project

- **Construction Location**: Shangwan, Erdos, Inner Mongolia
- **Plant Scale**: 5Mt/a - a first-of-a-kind direct coal liquefaction commercialized demonstration plant in the world
- **Construction Period**: By phases
  - **Phase-I, 3Mt/a**
  - Design capacity of the first train (early-stage engineering): 1Mt/a, construction was commenced in August, 2004, it is planned to put into operation in 2007.
4. Shenhua Direct Coal Liquefaction Project

Main Production Units

- Catalyst Preparation
- Liquefaction Unit
- Solvent Hydrogenation
- Hydro-upgrading
- Light Ends Recovery & Desulphurization

- Coal Preparation
- Hydrogen Manufacturing
- Air Separation Unit
- Sulfur Recovery
- Waste Water Treatment
Shenhua Direct Coal Liquefaction Project

Panorama of Project Site
Shenhua Direct Coal Liquefaction Project

Reactor Framework Installation
Shenhua Direct Coal Liquefaction Project

This is the first and heaviest (2250t/set) coal liquefaction reactor in the world, the hydraulic test of which has been finished.
Shenhua Direct Coal Liquefaction Project

Site Reactor Assembly
Shenhua Direct Coal Liquefaction Project

Heavy-Duty Equipment Assembly & Welding Workshop
Coal-to-Hydrogen Unit, the weight of single gasifier is 1600t.
Shenhua Direct Coal Liquefaction Project

Equipment Installation, ASU
Shenhua Direct Coal Liquefaction Project
## Product Scheme

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity (t/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>7.00</td>
</tr>
<tr>
<td>Naphtha</td>
<td>32.09</td>
</tr>
<tr>
<td>Diesel Oil</td>
<td>62.08</td>
</tr>
<tr>
<td>Liquid Ammonia</td>
<td>1.15</td>
</tr>
<tr>
<td>Sulphur</td>
<td>4.06</td>
</tr>
<tr>
<td>Phenol</td>
<td>0.35</td>
</tr>
<tr>
<td>Total</td>
<td>106.73</td>
</tr>
</tbody>
</table>
### Estimated Economic Benefits of Early-stage Engineering

<table>
<thead>
<tr>
<th>Oil price (international market)</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>US dollar/barrel</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>IRR Before tax whole investment</th>
<th>10.70%</th>
<th>16.73%</th>
<th>21.79%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>IRR After tax whole investment</th>
<th>6.96%</th>
<th>11.67%</th>
<th>15.66%</th>
</tr>
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Shenhua Direct Coal Liquefaction Project

Up to May 31, 2006

◆ Project overall schedule: complete 44.9%

◆ Design schedule: complete 86.3%

◆ Procurement schedule: (including long-lead equipment) complete 42.73%

◆ Construction schedule: complete 29.18%
Thank You!