AN OVERVIEW OF CHEMREC® PROCESS CONCEPTS

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AN OVERVIEW OF CHEMREC® PROCESS CONCEPTS

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2. Development Milestones of CHEMREC
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5. The Chemrec Booster in New Bern
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1. CHEMREC® - MAJOR APPLICATIONS

Ready for commercialisation:
- Booster (atmospheric air blown gasification)
  - Relieve overloaded recovery boilers
  - Capacity expansion projects

Continued development:
- BLGCC - Black Liquor Gasification Combined Cycle (pressurised oxygen-blown gasification)
  - Replacing recovery boiler
  - Increasing green power production
  - Improved pulp cooking liquors

- BLGAMF - Black Liquor Gasification with Methanol/DME Production as Motor Fuels for Automotive Uses
  - Replacing recovery boiler
  - Introducing new profitable green product line
  - Improved pulp cooking liquors
2. CHEMREC® DEVELOPMENT MILESTONES

• Atmospheric pilot plant, 3 tDS/24 h, SKF, Hofors, 1987
• Booster demonstration plant, 75 tDS/24 h, AssiDomän, Frövi, 1991
• Pressurized air-blown pilot plant, 6 tDS/24 h, Stora Enso, Skoghall, 1994
• Commercial Booster plant, 300 tDS/24 h, Weyerhaeuser, New Bern, 1996
• Pressurized oxygen-blown rebuilt pilot, 10 tDS/24 h, Stora Enso, Skoghall, 1997
• Piteå Development Plant 1 engineering starts 2001
• Start-up of the rebuilt, second generation Booster plant, Weyerhaeuser, New Bern, June 2003.
3. GASIFICATION TECHNOLOGY PRINCIPLES
4. ATMOSPHERIC, AIR-BLOWN BLACK LIQUOR GASIFICATION SYSTEM

- Gasification
- Particulate removal / Gas cooling
- Venturi scrubber
- Weak wash
- Gas cooling and dissolving of chemicals
- Reactor
- Steam
- Air
- Oxidized white liquor
- Sulphur removal
- Stack
- Green liquor
- Liquor recycle
5. THE CHEMREC BOOSTER IN NEW BERN
6. PERFORMANCE - CHEMREC BOOSTER

Black Liquor throughput: 200 - 400 tDS/d
Operating temperature: 950 °C
Pressure: 0.7 bar(g)
Carbon conversion: >99 %
Thermal efficiency: 45 %
Syngas LHV: 2.5 -3.5 MJ/ Nm³

-”- Composition: 
  H₂ 10-15 %vol
  CO 8-12 -”-
  CH₄ 0.2-1 -”-
  CO₂ 15-17 -”-
  N₂ 55-65 -”-

Na & Sulphur Separation 15% of incoming S found in syngas.
7. THE PRESSURISED BLG SYSTEM
8. THE BLG PROCESS - MILL INTEGRATION FLOW SCHEME

Pressurized BLG Process

Black Liquor

Gasifier/Quench

Gas Cleanup Plant

Electric Power or Synfuel Plant

El. Power or Methanol/DME

Oxygen

Low Sulfdity Green Liquor

Air

Oxygen Plant

Cooking Liquor Preparation

Polysulfide Liquor

High Sulfdity Green Liquor

Green/White Liquor

Sulfur Conversion

SO₂

H₂SO₄

Oxygen
9. CHEMREC BLGCC PROCESS

Air separation

Gasification

Gasifier

Quench

Gas cooling

Counter Current Condenser

Pulverization

Oxygen

MP/HP Steam

Steam water

Gas

Gas Turbine

Air

BFW

Flue gas

HRSG

HP Steam

LP Steam

BFW

Flue gas

Power and Steam in a Combined Cycle

Condensate

Fuel Gas

Weak wash

Black liquor

Green liquor

Absorber

Stripper

Sulphur handling

Sulphur generation

Polysulfid-generation

Gas

Polysulfide

White Liquor

Power
10. PERFORMANCE - CHEMREC BLGCC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Liquor throughput:</td>
<td>&gt;1000 tDS/d</td>
</tr>
<tr>
<td>Operating temperature:</td>
<td>950 °C</td>
</tr>
<tr>
<td>Pressure:</td>
<td>30 bar(g)</td>
</tr>
<tr>
<td>Carbon conversion:</td>
<td>&gt;99 %</td>
</tr>
<tr>
<td>Total thermal efficiency:</td>
<td>80 %</td>
</tr>
<tr>
<td>Syngas LHV:</td>
<td>7 - 9.5 MJ/ Nm³</td>
</tr>
<tr>
<td>Composition:</td>
<td></td>
</tr>
<tr>
<td>H₂</td>
<td>30-35 %vol</td>
</tr>
<tr>
<td>CO</td>
<td>28-32 %</td>
</tr>
<tr>
<td>CH₄</td>
<td>0.5-2 %</td>
</tr>
<tr>
<td>CO₂</td>
<td>30-35 %</td>
</tr>
<tr>
<td>N₂</td>
<td>1-4 %</td>
</tr>
</tbody>
</table>

Na & Sulphur Separation: 55% of incoming S found in gas.
11. CHEMREC BLGMF CONCEPT (EXCL. BIOMASS BOILER)
12. PERFORMANCE - CHEMREC BLGMF

Black Liquor throughput: [As for BLGCC]
Operating temperature: [As for BLGCC]
Pressure: [As for BLGCC]
Carbon conversion: [As for BLGCC]
Total thermal efficiency: 80 - 90 %*)

*) depending on product purity and type.

Syngas LHV: [As for BLGCC]
  ""- Composition: [As for BLGCC]

Na & Sulphur Separation: [As for BLGCC]

Major Thermal Losses in BLGMF:
  - Cooling Water needs: Syngas cooler, Rectisol Unit
  - Steam consumption: MeOH Distillation, Rectisol-stripper, CO-shift
  - Electric Power: ASU-, SG- and MeOH loop compressors

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13. BLGMF PROCESS BIOMASS TO FUEL EFFICIENCY

Production Efficiency = \frac{\text{Methanol/ DME}}{\text{Additional Renewable Energy}} = 65-75 \%
14. CHEMREC DEVELOPMENT PLANTS DP-1 AND DP-2

<table>
<thead>
<tr>
<th>Plant</th>
<th>Location</th>
<th>Process Units</th>
<th>Capacity tDS per d/ MW_t</th>
<th>Pressure (bar)</th>
<th>Purpose</th>
</tr>
</thead>
</table>
| DP1*)| Piteå, North Sweden | - Gasification  
- Gas Cooling  
- Gas Cleaning | 20 / 3                    | 32                         | - Verify Plant technical features.  
- Secure performance for DP-2                                                               |
| DP2*)| Kappa Kraftliner Piteå | - Full BLGCC concept | ~300 / 45                | 32                         | - Fully develop the BLGCC concept.  
- Net product approx .10 MW_e and 35 t/h of steam.                                          |

*) Plant Investments Supported by a Grant from the Swedish Government of 238 MSEK, approx 25 Mill €