The Viking Gasifier
Biomass Gasification Group

- Thermal conversion of biomass
- 15 years of experience
- 12 Employees
- Externally financed
Two-stage gasification

✗ Separated pyrolysis and gasification
✗ Partial oxidation of pyrolysis gases
→ No tar in gas nor in waste
→ High efficiency
Viking gasifier at DTU

Commissioned August 2002

Small scale (75 kW\textsubscript{fuel})

Unattended operation

Engine woodgas operation for > 1100 hours

Waste: only ash, carbon dust and water
Key data April 2003

- Thermal input: 68 kW
- Fuel: wood chips
- Moisture content: 35-45%
- Gasifier efficiency: 93%
- Engine efficiency: 32%
- Electric efficiency: 27%
- Overall electric eff.: 25%
- Tar level: <5mg/Nm$^3$
- Dust level: <5mg/Nm$^3$
Materials

- Partial oxidation zone: Brick lining
- Metal 700-1100°C: MA-253 high temp. steel
- Metal <700°C: Stainless steel
- Baghouse filter: Polyethylene
Bag house filter system

- Particle removal just above water dew point.
- Filter cleaning by N$_2$ back flush.
  - Bulk particles and condensate recovered separately.
  - Pressure drop <100 mmWG
  - Low energy consumption
Gas cleaning performance

1200 hours of reliable operation without permanent increase of the pressure drop.

- Dust after filter <5 mg/Nm³
- Residual tar condenses on particles, removed with these

→ Tar level in gas drops from 25 to "no tar" (<5 mg/Nm³)

Police filter after 1200 hours
Viking condensate quality

Amounts: 2-6 l/h
NH$_3$: 1 g/l
Naphthalene: <20 µg/l
Other PAH: <2 µg/l
Smell: NH$_3$

⇒ OK for standard biological surridge plant!
Viking dust quality from bag house filter

Amounts: 100-600 mg/Nm³
=5-30 g/h

Ash: Approx. 50%

Tar: <5% mass

→Low temperature reburning in boiler should be possible.
Ash from gasifier

• Unconverted carbon in ash from gasifier: \( \approx 30 \% \)

• Total unconverted carbon:
  0.1 wt.% of fuel
  0.3 % of energy in fuel
Intake manifold of the engine after 1100 hours on Wood Gas
Experiences

● No problems with brick lining
● Minor deposits of salts and carbonates in the hot gas system
● No corrosion of hot metal parts
● No deposits or corrosion in clean gas system and engine
● Shutdown corrosion in the system with cold uncleaned gas
Hurdles on the way

- Ash removal failed
Hurdles on the way

- Ash removal failed
  -> Totally new design
Hurdles on the way

- Ash removal failed
  - Totally new design
- Condensation in ash
  - Heat tracing
Hurdles on the way

- Ash removal failed
  -> Totally new design
- Condensation in ash
  -> Heat tracing
- Ceramics failed/smelted
  -> New reactor top using brick lining
Hurdles on the way

- Ash removal failed
  -> Totally new design
- Condensation in ash
  -> Heat tracing
- Ceramics failed/smelted
  -> New reactor using bricks

Minor hurdles
- Valves stuck during idle periods
- Fuel feed blockages
- Engine ignition system
Results during April 2003

Operation:
• Gasifier
  380 hours April
  (>1300 hours total)
• Engine
  346 hours
  (>1100 hours total)
Average dry gas composition

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume %</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
<td>30.5 %</td>
</tr>
<tr>
<td>CO</td>
<td>19.6 %</td>
</tr>
<tr>
<td>CH₄</td>
<td>1.2 %</td>
</tr>
<tr>
<td>CO₂</td>
<td>15.4 %</td>
</tr>
<tr>
<td>N₂</td>
<td>33.3 %</td>
</tr>
<tr>
<td>LHV</td>
<td>5.6 MJ/N m³</td>
</tr>
<tr>
<td>HHV</td>
<td>6.2 MJ/N m³</td>
</tr>
<tr>
<td>Gas flow</td>
<td>37.1 m³/h (dry. 0°C)</td>
</tr>
</tbody>
</table>
Gas temperatures in char bed

Time

Temperature [°C]

above char bed (T33)
Top of char bed (T36)
above grate (T54)
Heating up
Start up1
Start up2
Engine operation
Shut down
Conclusions

- Fully automatic unattended operation
- 1300 hours of operation
- 25 % efficiency from biomass to electricity to the grid.
- No tar in the gas
- Good engine performance - no deposits in engine
- Condensate not a waste problem
- Dust can be treated separately
- Absence of tars ⇒ simple, cheap gas cleaning system.
Questions?