HISTORY – THERE IS NOTHING NEW

GASIFIERS FOR LIME KILNS:
• In Sweden during World War II (fixed bed gasifier)
• In South Africa => (coal gasification)
• Several cases in Europe 1980´s ("Oil chock")
• At least 2 of them still in operation
• Lurgi, Ahlström and Götawerken (now Kvaerner)

DRYERS:
• Technical need for dry fuel => Dryers developed
• Energy from flue gas or from product gas
• Fluid bed or drum type dryers
HISTORY - Existing and operating reference in Värö

SYSTEM DATA
- Gasifier output 35 MW
  - To dryer 10 MW
  - To Lime kiln 25 MW
- Fuel: Bark + saw dust
- Atmospheric CFBG
- Drum type dryer
- Start Up 1987
- 19 years of operation
HISTORY - Existing and operating reference in Värö

- Drum type dryer
- Gasifier
- Burner in Lime kiln
- Gas transport

Solid fuel
Product gas
TECHNOLOGY IN 80’s

Gasification
• CFB gasifier (mostly)
• 80’s CFB know how /design
  ⇒ Cyclone design
  ⇒ Material handling
  ⇒ Refractory solutions
• Very good basic process

Dryers
• Use of primary energy
• Flue gas based dryers
  ⇒ Corrosion
  ⇒ Fire risk
• Drum, fluid bed or flash type dryers
• High electricity and heat consumption
• VOC emissions (high temperatures)
  ⇒ Additional gas cleaning
TECHNOLOGY TODAY

Gasification

• CFB gasifier
• Today’s CFB know how/design based on CFB boiler development
• Improved mechanical solutions
• Still very good basic process

Dryers

• Maximize waste heat energy usage
• Low temperature dryers
  => No VOC emissions
• Dying Systems - dimensioned for the mill heat capacity.
• Combinations of direct and indirect dryers
• Moderate electricity consumption
TECHNOLOGY TODAY

■ More closed cycles in mills
  => Inert elements will easily accumulate in the cycle

■ Some dust will end into lime
  ⇒ Critical elements must be analyzed
    • Si, Al, Fe, Mg, K and P
    • In Värö P is critical => lime bleed is operated based on P
    • Cost of small increase in bleed is minor
MOTIVATION TODAY

HIGH OIL/GAS PRICES

- Higher than ever since second oil crisis
- Trend still going up
- In 1980’s many gasifiers were built to replace oil
- Highest value for biomass is to use it to replace oil

USD / barrel

Price
as 2004 money

31.7.2006

U. S. First Purchaser's Crude Oil Price
MOTIVATION TODAY - Value of bark

- Waste heat from mill
- Electricity

- Limestone
- Cooling water
- Electricity

WET BARK

Steam generation
BFB combustion

DRYER

Increased heating value, reduced weight
Steam generation

GASIFIER

Oil replacement in lime kiln

Oil in Finland: 25-35 €/MWh
( High S heavy oil )

Bark in Finland: 6-8 €/MWh
ECONOMICAL PROSPECTS

Estimated case:

- Location: Scandinavia Pulp Mill
- Bark cost: 7 € / MWh (2.5 $ /MMBtu)
- Oil cost: 30 € / MWh (10.6 $/MMBtu)
- Electricity cost: 50 € / MWh
- Lime kiln burner capacity: 30 MW
- Operational hours: 8 000 h/a
ECONOMICAL PROSPECTS

Estimated annual cost/savings

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original oil cost</td>
<td>6,64 M€</td>
</tr>
<tr>
<td>CO2 credits</td>
<td>1,15 M€</td>
</tr>
<tr>
<td>Consumables (electricity etc)</td>
<td>0,48 M€</td>
</tr>
<tr>
<td>Maintenance</td>
<td>0,26 M€</td>
</tr>
<tr>
<td>Manpower</td>
<td>0,37 M€</td>
</tr>
<tr>
<td>Support oil</td>
<td>0,14 M€</td>
</tr>
<tr>
<td>Bark cost</td>
<td>1,63 M€</td>
</tr>
</tbody>
</table>

Net savings: 3,7 M€
STEPS IN NEXT FUTURE

OIL REPLACEMENTS BY BIOMASS IN ANY USE:

1) Lime kiln
   ■ Technology available today
   ■ High economical potential

2) Trimming fuel for RB superheat
   ■ Increase RB electricity production
   ■ Requires gas cleaning, which is still under development
   ■ No references yet, works on paper

3) Replacement fuel for existing oil/gas boilers
   ■ Eliminate oil/gas at pulp mills
   ■ Reduced investment cost compared to new boilers
   ■ Requires gas cleaning, which is still under development
LONG TERM PROSPECTS

ATMOSPHERIC BIOMASS GASIFICATION IS REALITY

PRESSURIZED BIOMASS GASIFICATION IS A DREAM

BLACK LIQUOR GASIFICATION IS ???
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