CFB – Multi-Fuel Design Features and Operating Experience

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CFB – Multi-Fuel Design Features and Operating Experience

Presentation outline:

• Fuel based challenges
• Solutions to selected challenges
• Fuel based CFB concepts
• Bio / Multifuel concept
  • Design features
  • Operational experience
• SRF concept
  • Design features
  • Operational experience
• Conclusions
## Fuel based challenges

<table>
<thead>
<tr>
<th>Challenge field</th>
<th>FUEL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fossil</td>
</tr>
<tr>
<td>High temp corrosion</td>
<td>0</td>
</tr>
<tr>
<td>Mid temp corrosion</td>
<td>0</td>
</tr>
<tr>
<td>Cold end corrosion</td>
<td>0</td>
</tr>
<tr>
<td>Superheater fouling</td>
<td>0...2</td>
</tr>
<tr>
<td>Cold end cleaning</td>
<td>0</td>
</tr>
<tr>
<td>Bed agglomeration</td>
<td>0...2</td>
</tr>
<tr>
<td>Loop agglomeration</td>
<td>0...2</td>
</tr>
<tr>
<td>High bottom ash/debris flow</td>
<td>0...2</td>
</tr>
<tr>
<td>High fly ash flow</td>
<td>0...2</td>
</tr>
<tr>
<td>Back pass erosion</td>
<td>1</td>
</tr>
<tr>
<td>Emissions</td>
<td>1</td>
</tr>
</tbody>
</table>
Challenge: Erosion / Emissions
Solution: Cyclone with high collection efficiency

Benefits of high collection efficiency:

• Fine particles stays in hot loop circulation:
  - Even temperature profile
  - High combustion efficiency
  - Low NOx
  - High inherent SO$_2$ capture by fuel alkalis
  - Low erosion in furnace and back pass (critical for PbCl induced corrosion/erosion)

• High bottom ash/fly ash flow ratio
  - Reduced dumping cost

• Minimized make-up sand consumption
Challenge: High temp corrosion
Solution: Fluidized bed heat exchanger

- Final superheater is located in loop seal, effective gas flow isolation from both furnace and cyclone side
- Gas atmosphere is much less corrosive compared to furnace or back pass location
- Layered tube design for SRF applications to avoid alkali chlorine condensation

Inside $T = 450..520$ °C
Outside surface $T \sim 700$ °C
Challenge: Mid temp corrosion
Solution: Easily replaceable superheaters

• To minimize the downtime of the boiler when Pb induced corrosion cannot be fully prevented
• 5 days replacing time per bundle
Challenge: High debris flow / bed agglomeration
Solution: Grid design and bed ash recirculation
Fuel based CYMIC CFB concepts

**Fossil**
- Low solids
- High solids
- 100 - 1200 MW<sub>th</sub>
- Max 565 C, 175 bar

**Bio/Multi**
- Agro
- Wood
- Portion of SRF
- 75 - 900 MW<sub>th</sub>
- Max 545...565 C, 175 bar

**Recycled Wood**
- 75 - MW<sub>th</sub>
- 520...540 C / 90 bar

**SRF**
- Multifuel
- 75 - 200 MW<sub>th</sub>
- 480 C / 70 bar...
- 520 / 90 bar
CYMIC for Bio / Multifuel
Special design features

- Extended refractory in the furnace for WID compliance on 2 s in 850°C in waste co-combustion
- Two wall fuel feeding for high reliability
- Final superheater in the loop seal bed
- Possibility for additive injection
- Appropriate arrangement and spacing of the superheater surfaces against fouling and corrosion
CYMIC for Bio / Multifuel
Case example: Porin Prosessivoima, Pori, Finland

Steam Data
• Steam Power 177.4 MW<sub>th</sub>
• Flow Rate 67.2 kg/s (72.0) (kg/s)
• Temperature 522 °C
• Pressure 84 bar(a)

Fuels
• Peat 0…100 %
• Coal 0…100 %
• Wood based biomass 0…50 %
• Recycle Fuel (REF I-II) 0…10 %

Start-up
Handover December 2008
Delivery time 25 months
Operational experience: Fuel consumption, energy basis

<table>
<thead>
<tr>
<th>Year</th>
<th>Oil</th>
<th>Coal</th>
<th>RDF</th>
<th>Wood</th>
<th>Peat</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>57.3%</td>
<td>30.5%</td>
<td>9.0%</td>
<td>3.1%</td>
<td>3.1%</td>
</tr>
<tr>
<td>2010</td>
<td>47.1%</td>
<td>41.1%</td>
<td>8.4%</td>
<td>3.0%</td>
<td>3.0%</td>
</tr>
<tr>
<td>2011</td>
<td>41.9%</td>
<td>44.8%</td>
<td>10.1%</td>
<td>3.1%</td>
<td>3.1%</td>
</tr>
</tbody>
</table>
## CYMIC for Bio/Multi: Porin Prosessivoima
### Operational experience: Availability

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant main outage</td>
<td>h</td>
<td>312</td>
<td>504</td>
</tr>
<tr>
<td>Boiler unavailability</td>
<td>h</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Other boiler off hours</td>
<td>h</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Run hours</td>
<td>h</td>
<td>8431</td>
<td>8235</td>
</tr>
<tr>
<td>Total</td>
<td>h</td>
<td>8760</td>
<td>8760</td>
</tr>
</tbody>
</table>

### Operational experience

- **Boiler availability**
  - 2009: 96.3%
  - 2010: 94.0%
  - 2011: 94.4%

### Boiler reliability

- 2009: 99.8%
- 2010: 99.8%
- 2011: 99.9%

### Notes

1) **Operating time**
   - 8760 h

2) **Operating time**
   - 8760 h – Planned outage
CYMIC for Bio/Multi: Porin Prosessivoima
Operational experiences: SH pass fouling and corrosion

- Slightly fouled, especially on hot end rather hard deposit
  - typical for bio mass boilers
- Slight local corrosion in PSH
- No erosion
CYMIC for Bio/Multi: Porin Prosessivoima
Operational experience: Tertiary superheater corrosion

- Practically no signs of corrosion detected in FBHE tubing
  - Cl in fuel mix varied 0.1 – 0.2 %
Other CYMIC CFB projects for bio / multi fuels

<table>
<thead>
<tr>
<th>Project</th>
<th>Fuel Sources</th>
<th>Start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stora Enso Poland S.A. Ostroleka, Poland</td>
<td>Biomass, paper and fiber rejects, sludge, coal</td>
<td>Start-up 2010</td>
</tr>
<tr>
<td>Kuopion Energia Oy Kuopio Finland</td>
<td>Peat, wood fuel, coal</td>
<td>Start-up 2011</td>
</tr>
<tr>
<td>We Energies Rothschild, Wisconsin USA</td>
<td>Forest residue, bark, pulp mill screenings, sludge</td>
<td>Start-up 2012</td>
</tr>
</tbody>
</table>

164 MW<sub>th</sub> 114 bar, 520 °C  
140 MW<sub>th</sub> 130 bar, 535 °C  
180 MW<sub>th</sub> 107 bar, 512 °C
CYMIC for SRF
Special design features

- Water sootblowing
- Easily replaceable superheaters
- Flue gas cooling down <620°C
- Final superheater in the loop seal bed, layered tube construction
- Refractory covered furnace
- FeedingMaster fuel feeding equipment
- Under-bed start-up burner
- Effective bottom ash removal, sieving & recycling
CYMIC for SRF
Case example: Stora Enso Langerbrugge, Belgium

Stora Enso Langerbrugge nv
Gent, Belgium

Steam
- 125 MW<sub>th</sub>
- 45 kg/s
- 60 bar
- 475 °C

Fuels
- RDF, untreated and treated wood, coal, gas

Start-up
- 2010
# CYMIC for SRF: Stora Enso Langerbrugge

## Operational experience: Fuel palette

<table>
<thead>
<tr>
<th>Fuel</th>
<th>RDF</th>
<th>Recycled wood</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design share</td>
<td>%</td>
<td>0-100</td>
<td>0-100</td>
</tr>
<tr>
<td>Design values:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHV, wet</td>
<td>MJ/kg</td>
<td>10..20</td>
<td>10..17</td>
</tr>
<tr>
<td>Moisture</td>
<td>%</td>
<td>5..35</td>
<td>10..30</td>
</tr>
<tr>
<td>Chlorine content</td>
<td>w-%, DS</td>
<td>&lt; 1,0</td>
<td>&lt; 0,5</td>
</tr>
<tr>
<td>Ash content</td>
<td>w-%, DS</td>
<td>10..30</td>
<td>3..5</td>
</tr>
<tr>
<td>Lead content</td>
<td>mg/kg, DS</td>
<td>&lt; 400</td>
<td>&lt; 400</td>
</tr>
</tbody>
</table>
CYMIC for SRF: Stora Enso Langerbrugge
Operational experience: Fuel split 2011, energy basis

- Recycled wood: 50.1%
- RDF: 42.1%
- Railway sleepers: 6.4%
- Coal: 1.3%
## CYMIC for SRF: Stora Enso Langerbrugge

### Operational experience: Some performance test data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>20/80</th>
<th>100/0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel share, energy % (RDF/recycled wood)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured boiler efficiency, %</td>
<td>90.4</td>
<td>91.2</td>
</tr>
<tr>
<td>Bottom ash / fly ash share, w-%</td>
<td>63/37</td>
<td>58/42</td>
</tr>
<tr>
<td>TOC in bottom ash, w-%</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>TOC in fly ash, w-%</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Flue gas O₂-content, % wet</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>Full superheating range, % of MCR</strong></td>
<td>60...100</td>
<td></td>
</tr>
<tr>
<td>2 s at 850C area without support fuel, % of MCR</td>
<td>60...100</td>
<td></td>
</tr>
</tbody>
</table>
CYMIC for SRF: Stora Enso Langerbrugge
Operational experience: Convective pass superheaters

- Fouling under control
- Moderate corrosion rate
CYMIC for SRF: Stora Enso Langerbrugge
Operational experience: Loopseal superheater

• Only minor corrosion detected in loopseal superheater surfaces
  - Cl- content in fuel up to 1 w-% (d.s.)
Operational experience: Challenging debris removal

- High amounts of metals entering the furnace
- High amount of bottom ash removal and recirculation needed to keep grid clean from debris
  → bottom ash heat loss recovered to combustion air, resulting in high efficiency

- No unavailability due to debris removal
### CYMIC for SRF: Stora Enso Langerbrugge

**Operational experience: Availability**

<table>
<thead>
<tr>
<th>Availability</th>
<th>2011</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant main outage</td>
<td>h</td>
<td>349</td>
</tr>
<tr>
<td>Boiler unavailability</td>
<td>h</td>
<td>88</td>
</tr>
<tr>
<td>Boiler availability 1)</td>
<td>%</td>
<td>95,0</td>
</tr>
<tr>
<td><strong>Boiler reliability 2)</strong></td>
<td>%</td>
<td>99,0</td>
</tr>
</tbody>
</table>

1) **Operating time**
   - 8760 h

2) **Operating time**
   - 8760 h – Planned outage
### Other CYMVIC projects for SRF fuels

<table>
<thead>
<tr>
<th>S.A. Industrias Celulosa Aragonesa (SAICA) El Burgo de Ebro, Spain</th>
<th>Mälarenergi AB Västerås Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>140 MW&lt;sub&gt;th&lt;/sub&gt;, 75 bar, 520 °C</td>
<td>155 MW&lt;sub&gt;th&lt;/sub&gt;, 75 bar, 470 °C</td>
</tr>
<tr>
<td>Paper processing reject, sludge</td>
<td>MSW, industrial waste, recycled wood, wood, peat</td>
</tr>
<tr>
<td>Start-up 2011</td>
<td>Start-up 2014</td>
</tr>
</tbody>
</table>

June 14th 2012 - Tero Luomaharju
Conclusions

• Fuel based CYMIC CFB concepts has been created to
  - Fossil fuels
  - Bio / Multi Fuel
  - Recycled Wood
  - SRF

• CYMIC for Bio / Multifuel in Porin Prosessivoima plant has proven it’s performance and reliability during 3,5 years now

• CYMIC for SRF is utilized in Stora Enso Langerbrugge also with excellent results

• Key design features in both concepts are:
  - High efficiency cyclone for good emissions and low erosion rate
  - Robust fuel feeding and bottom ash equipment
  - Sophisticated final superheater design