Increase of steam data with challenging fuels

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Metso EET
Energy and Environmental Technology

<table>
<thead>
<tr>
<th>Business line</th>
<th>Main products</th>
<th>Main trade names</th>
<th>Customers</th>
</tr>
</thead>
</table>
| Power        | • Power generation solutions
              • Combined heat and power solutions
              • Chemical recovery systems
              • Environmental protection systems
              • Services                                         | • HYBEX
                                                  • CYMIC
                                                  • RECOX
                                                  • EVAPS                               | • Power generation
                                                  • Process industry
                                                  • Pulp and paper                       |
| Automation   | • Process automation solutions
              • Specialty analyzers
              • Life cycle services
              • Automated, control, ESD and manual valves
              • Intelligent condition monitoring         | • metsoDNA
                                                  • Kajaani
                                                  • Neles
                                                  • Jamesbury
                                                  • Sensodec
                                                  • PaperIQ
                                                  • MAPAG                                 | • Oil and gas
                                                  • Pulp and paper
                                                  • Power generation
                                                  • Industrial gas
                                                  • Alternative fuels
                                                  • Chemical industry                    |
| Recycling    | • Shredders, scrap shears, balers
              • Complete systems and service solutions                  | • Lindemann
                                                  • Texas Shredder                         | • Metal scrap recycling
                                                  • Automotive industry
                                                  • Foundries                            |
Power business line
Main boiler types

• HYBEX
  - Bubbling Fluidized Bed (BFB) boiler
  - Capacities 10-300 MWth
  - 170 deliveries worldwide

• CYMIC
  - Circulating Fluidized Bed (CFB) boiler
  - Capacities 50-600 MWth
  - 70 deliveries worldwide

• RECOX
  - Recovery boilers
    up to 7000 tons ds/day
  - 300 deliveries worldwide

Increase of steam data with challenging fuels
Outline

• Metso FtS solution

• CFB knowledge process
  - Design optimization

• Case final superheating
  - Examples of different solutions
Metso Fuel to Stack (FtS) solution

Fuel processing → Conversion process → Gas cleaning

Advanced process automation

Combustion
Gasification
Pyrolysis

Knowledge process

Regulation and legislation

CFB knowledge process

Combustibility
- Fuel
- Testing
  - Bench scale
  - Pilot scale
  - Full scale

Characterization
- Ultimate & Proximate
- Ash composition
- Communion
- Fuel, ash and additives
- PSDs
- Reactivity

Boiler designer
- Balance calculation
- Water circulation calculation

CFB modeling
- 1,5D CFB process model
- 3D CFB process model
- Emission model
- Dynamic CFB model

Steamax
- Corrosion calculation
- Fouling calculation

Design rules
- Standards
- Characteristic values

Boiler designer
- Balance calculation
- Basic dimensioning
- Water circulation calculation

Engineering
- Strength calculation
- 3D CAD

Result
- Optimized design
- Documentation

Database

Boiler inspections
Commissioning

Publications
CFB knowledge process
Combustibility

• Feedstock characterization
  - Ash attrition

Combustibility
Fuel
Characterization
Ultimate & Proximate
Ash composition
Major and minor
Combustion
Fuel, ash and additives
PSDs
Reactivity
Fuel and additives

Testing
Bench scale
Tube reactors
Pilot scale
R&D center 4 MW
Full scale
Field tests

Boiler inspections
Commissioning
Publications

Database
CFB knowledge process
Combustibility

- Full scale field tests
  - Vertical pressure profile
  - Solids density

CFB knowledge process
Combustibility

- Full scale field tests
  - Horizontal temperature profile
CFB knowledge process

Design

- Design rules
  - Standards
  - Characteristic values

- Boiler designer
  - Balance calculation
  - Basic dimensioning
  - Water circulation calculation

- Steamax
  - Corrosion calculation
  - Fouling calculation

- CFB modeling
  - 1.5D CFB process model
  - 3D CFB process model
  - Emission model
  - MVA
  - Dynamic CFB model
  - CFD

- Engineering
  - Strength calculation
  - 3D CAD

Result; Case final superheating

- Indonesia Cymic
  - Indonesia

- Porin Prosessivoima
  - Pori, Finland

- Stora Enso Langerbrugge nv
  - Gent, Belgium
Indonesia CYMIC CFB boiler

Design fuels

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Bark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture wt-%</td>
<td>13,2</td>
<td>50</td>
</tr>
<tr>
<td>LHV, wet MJ/kg</td>
<td>23,5</td>
<td>6,8</td>
</tr>
<tr>
<td>C wt-% d.s.</td>
<td>66,7</td>
<td>45,6</td>
</tr>
<tr>
<td>H wt-% d.s.</td>
<td>5,3</td>
<td>4,2</td>
</tr>
<tr>
<td>O wt-% d.s.</td>
<td>12,92</td>
<td>41,27</td>
</tr>
<tr>
<td>N wt-% d.s.</td>
<td>0,58</td>
<td>0,50</td>
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<tr>
<td>S wt-% d.s.</td>
<td>1,7</td>
<td>0,07</td>
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<tr>
<td>Cl wt-% d.s.</td>
<td>-</td>
<td>0,055</td>
</tr>
<tr>
<td>Ash wt-% d.s.</td>
<td>12,8</td>
<td>8,3</td>
</tr>
</tbody>
</table>

CYMIC boiler

Circulating Fluidized Bed (CFB) technology

Indonesia Cymic

Indonesia

Steam 520 MW,
181 kg/s
141 bar
540 °C

Fuels
Coal 0 – 100%
Bark 0 – 100%

Start-up 2006
Pori CYMIC CFB boiler
Design fuels

<table>
<thead>
<tr>
<th></th>
<th>Peat</th>
<th>Coal</th>
<th>Woody</th>
<th>REF I-II</th>
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</thead>
<tbody>
<tr>
<td>Moisture wt-%</td>
<td>50,0</td>
<td>11,0</td>
<td>56,0</td>
<td>30,0</td>
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<tr>
<td>LHV, wet MJ/kg</td>
<td>9.16</td>
<td>24.8</td>
<td>7.0</td>
<td>15.0</td>
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<tr>
<td>C wt-% d.s.</td>
<td>54,0</td>
<td>68,5</td>
<td>50,4</td>
<td>51,7</td>
</tr>
<tr>
<td>H wt-% d.s.</td>
<td>5.6</td>
<td>5.2</td>
<td>6.2</td>
<td>6.8</td>
</tr>
<tr>
<td>O wt-% d.s.</td>
<td>29,0</td>
<td>8.0</td>
<td>40.35</td>
<td>24.4</td>
</tr>
<tr>
<td>N wt-% d.s.</td>
<td>2.2</td>
<td>2.5</td>
<td>0.5</td>
<td>1.4</td>
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<tr>
<td>S wt-% d.s.</td>
<td>0.2</td>
<td>0.7</td>
<td>-</td>
<td>0.2</td>
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<tr>
<td>Cl wt-% d.s.</td>
<td>0.05</td>
<td>0.1</td>
<td>0.05</td>
<td>0.5</td>
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<tr>
<td>Ash wt-% d.s.</td>
<td>8.95</td>
<td>15.0</td>
<td>2.5</td>
<td>15.0</td>
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</table>

CYMIC boiler
Circulating Fluidized Bed (CFB) technology

Porin prosessivoima
Pori, Finland

Steam
- 177 MW<sub>e</sub>
- 67 kg/s
- 84 bar
- 522 °C

Fuels
- Peat 0 – 100%
- Coal 0 – 100%
- Woody 0 – 50%
- REF I-II 0 – 10%

Start-up 2008
Pori CYMIC CFB boiler
Fluid Control Superheater

- Final superheater located in the loop seal
- Less corrosive environment compared to back pass location
- Heat duty can be controlled by fluidization (turn down ratio 20...100%)

Langerbrugge CYMIC CFB boiler
Design fuels

<table>
<thead>
<tr>
<th></th>
<th>RDF / PDF</th>
<th>Woody treated</th>
<th>Woody untreated</th>
<th>Coal</th>
<th>Sludge</th>
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</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>wt-%</td>
<td>15,0</td>
<td>17,0</td>
<td>40</td>
<td>8,0</td>
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<tr>
<td>LHV, wet</td>
<td>MJ/kg</td>
<td>15,0</td>
<td>14,4</td>
<td>9,0</td>
<td>26,1</td>
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<tr>
<td>C</td>
<td>wt-% d.s.</td>
<td>45,0</td>
<td>49,0</td>
<td>50,0</td>
<td>70,0</td>
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<tr>
<td>H</td>
<td>wt-% d.s.</td>
<td>8,0</td>
<td>6,0</td>
<td>6,6</td>
<td>4,0</td>
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<tr>
<td>O</td>
<td>wt-% d.s.</td>
<td>25,7</td>
<td>40,9</td>
<td>41,0</td>
<td>9,0</td>
</tr>
<tr>
<td>N</td>
<td>wt-% d.s.</td>
<td>1,0</td>
<td>1,0</td>
<td>0,3</td>
<td>1,5</td>
</tr>
<tr>
<td>S</td>
<td>wt-% d.s.</td>
<td>0,25</td>
<td>0,1</td>
<td>0,1</td>
<td>1,5</td>
</tr>
<tr>
<td>Cl</td>
<td>wt-% d.s.</td>
<td>0,8</td>
<td>0,1</td>
<td>0,05</td>
<td>0,05</td>
</tr>
<tr>
<td>Ash</td>
<td>wt-% d.s.</td>
<td>20,0</td>
<td>3,0</td>
<td>2,0</td>
<td>14,0</td>
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</table>
CYMIC boiler
Circulating Fluidized Bed (CFB) technology

Stora Enso Langerbrugge nv
Gent, Belgium

Steam: 125 MWth, 45 kg/s, 60 bar, 475 °C

Fuels: RDF / PDF 0 – 100%
Woody 0 – 100%
Coal 0 – 100%
Sludge 0 – 20%

Start-up: 2010

Langerbrugge CYMIC CFB boiler
Fluid Control Superheater

- Final superheater located in the loop seal
- Advanced tube protection
  - Optimized thermal conductivity
Langerbrugge CYMIC CFB boiler
FBHE tube design

Target surface temperature is determined by corrosion and fouling calculation.

Surface temperature is achieved by controlling the tube conductivity with additional layers.

Increase of steam data with challenging fuels
Conclusions

Combustibility
- Fuel
- Testing: Bench scale, Pilot scale, Full scale
  - Reactivity
  - Comminution
  - Ash composition
- Characterization: Ultimate & Pressure, Combustion, Fuel, ash and additives

Design
- Design rules: Standards, Characteristic values
- Boiler designer: Balance calculation
- CFB modeling: 1.5D CFB process model, 3D CFB process model
- Steamax: Water circulation calculation
- Engineering: Strength calculation
- Documentation: Steamax, Corrosion calculation

Result
- Optimized design: 3D CAD
Thank You

Dziękuję