RAFAKO’s proecological investments – boilers and biomass installations

Presented:
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22 – 23 March 2017 r.
Content:
1. Introduction.
2. Biomass boilers.
3. Modernization of PC boiler at Stalowa Wola Power Plant.
4. CFB boilers for biomass.
RAFAKO S.A. offers, design works, manufacturing and delivery of boilers for combustion of wood and agricultural biomass.

- Conditions for the new plant arise from the type of biomass and its physico-chemical properties.
- A number of completed objects is in operation and meets the design parameters.
- In the designing and execution of biomass fired boilers and biomass handling installations RAFAKO S.A. cooperates with external companies.
Biomass boilers parameters

Thermal capacity:
- from 20 (15) MW
- up to 170 (*) MW

(*) – depending on the grate capability and steam parameters

Steam capacity:
- from 20 (15) t/h
- up to 100 (*1) 230 (*2) t/h

(*1) – reciprocating grate capability
(*2) – vibrating grate capability

Grate type biomass boilers

Steam pressure:
- from 20 (bar(g)
- up to 100 (120) bar(g)

Steam temperature:
- from saturation temp.
- up to 500 (520) °C
Biomass boilers – grate types

Kablitz air cooled reciprocating grate
DCS travelling grate
DSC water cooled vibrating grate
PETRO ETT AB combustion furnace
DSC air cooled vibrating grate
Biomass grate boilers – reference list

Operator: BHKW Saalfelden, Austria
Client: Richard Kablitz & Mitthof Gmbh, Germany
Boiler parameters: 26.5 t/h; 6.6 MPa; 485°C – in operation from 2006

Operator: Erda, Belgium
Client: Vyncke N.V., Belgium
Boiler parameters: 40 t/h; 6.6 MPa; 455°C – in operation from 2006

Operator: Stadtwerke Düsseldorf, Germany
Client: Richard Kablitz & Mitthof Gmbh, Germany
Boiler parameters: 21 t/h; 6.5 MPa; 430°C – in operation from 2006

Operator: HKW Unterbernbach, Heggenstaller Germany
Client: Richard Kablitz & Mitthof Gmbh, Germany
Boiler parameters: 55 t/h; 6.7 MPa; 485°C – in operation from 2007/2008
Biomass grate boilers – reference list

Operator: CHP Kielce, Poland
RAFAKO S.A. was the EPC contractor
Boiler parameters: 20 t/h; 5.6 MPa; 485°C – in operation from 2008

Operator: BHKW Goch, Germany
Client: Richard Kablitz & Mitthof Gmbh, Germany
Boiler parameters: 30 t/h; 6.5 MPa; 485°C – in operation from 2011

ESWE Bioenergie, Wiesbaden, Germany
Client: Richard Kablitz & Mitthof Gmbh, Germany
Boiler parameters: 49 t/h; 4.2 MPa; 425°C – in operation from 2015

Operator: Orafti, Chile
Client: Richard Kablitz & Mitthof Gmbh, Germany
Boiler parameters: 60 t/h; 7.5 MPa; 485°C – in operation from 2015
Main boiler parameters:
- Steam capacity: 26.5 t/h
- Steam temperature: 485 °C
- Steam pressure: 65 bar(g)
- Fuel: raw wood; LHV 5-10.8 MJ/kg
- Furnace: KABLITZ Turbo-System
- Primary air heated up to 250 °C

Main dates:
- Contract signing 04 2005
- Start activities on site 10 2005
- Drum lifting 11 2005
- Test run 05 2006
- Take over into operation 10 2006
Biomass grate boilers – OSr-26.5
Biomass grate boilers – OSr-40

Main dates:
- Contract signing: 09 2005
- Drum lifting: 04 2006
- Test run: 12 2006
- Take over into operation: 07 2007

Main boiler parameters:
- Steam capacity: 37 (40) t/h
- Steam temperature: 455 °C
- Steam pressure: 65 bar(g)
- Fuel: raw wood; LHV 8-13.1 MJ/kg
- Furnace: VYNCKE reciprocating grate
Main dates:
- Contract signing 08 2006
- Pressure test 08 2007
- Take over into operation 11 2007

Main boiler parameters:
- Steam capacity: 21 (22) t/h
- Steam temperature: 430 °C
- Steam pressure: 65 bar(g)
- Fuel: raw wood; LHV 10,8 -15,1 MJ/kg
- Furnace: KABLITZ Reciprocating grate
Biomass grate boilers – OSr-55

Main boiler parameters:
• Steam capacity: 55 (70) t/h
• Steam temperature: 485 °C
• Steam pressure: 66 bar(g)
• Fuel: raw wood; LHV 5-14.4 MJ/kg
• Furnace: KABLITZ Turbo-System
• Primary air heated up to 250 °C
Main dates:

- Contract signing: 04 2006
- Start activities on site: 10 2006
- Drum lifting: 11 2006
- Test run: 06 2007
- Take over into operation: 09 2007
Biomass grate boilers – OSr-55
Main boiler parameters:

- Steam capacity: 20 (25) t/h
- Steam temperature: 485 °C
- Steam pressure: 56 bar(g)
- Fuel: raw wood chips and willow; LHV 7-12 MJ/kg
- Furnace: PETRO ETT
Biomass grate boilers – OSr-20

Main dates:
- Contract signing 06 2007
- Drum lifting 07 2008
- Test run 01 2009
- Take over into operation 02 2009
Biomass grate boilers – OSr-20
Biomass grate boilers – OSr-32

Main boiler parameters:
• Steam capacity: 30.6 (32) t/h
• Steam temperature: 485 °C
• Steam pressure: 65 bar(g)
• Fuel: raw wood; LHV 6.5-11.5 MJ/kg
• Furnace: KABLITZ Reciprocating Grate
Main dates:

- Contract signing 01 2011
- Drum lifting 10 2011
- Test run 08 2012
- Take over into operation 09 2012
Biomass grate boilers – OSr-32
Main boiler parameters:
- Steam capacity: 49 (52) t/h
- Steam temperature: 425 °C
- Steam pressure: 42 bar(g)
- Fuel: Altholz AI-AIV; LHV 10-18 MJ/kg
- Furnace: KABLITZ Reciprocating Grate
Biomass grate boilers – OSr-49

Main dates:
- Contract signing 09 2011
- Start activities on site 10 2012
- Drum lifting 12 2012
- Test run 12 2014
- Take over into operation 06 2015
Biomass grate boilers – OSr-49
Main boiler parameters:
• Steam capacity: 60 (70) t/h
• Steam temperature: 485 (505) °C
• Steam pressure: 75 bar(g)
• Fuel: wood chips, eukaliptus, pine, poplar, biogas, coal (up to 20%)
Biomass grate boilers – OSr-60

Main dates:
- Contract signing 02 2013
- Drum lifting 05 2014
- Test run 07 2015
- Take over into operation 08 2015
Modernization of coal fired PC boiler OP-150 for burning of biomass fuel in Stalowa Wola Power Plant
Scope of modernization works on PC boiler
- Installation of preparation, storage and transport of the biomass
- Installation of biomass drying
- Installation of biomass dust preparation – milling plant
- Biomass fired installation
- Modernization of pressure parts of the boiler
- Installing dosing of additives
- Flue gas recirculation installation
Modernization of water steam cycle and furnace
## Stalowa Wola Power Plant modernization

<table>
<thead>
<tr>
<th>Lp</th>
<th>PARAMETR</th>
<th>„before modernization”</th>
<th>„after modernization”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TYPE OF FUEL</td>
<td>HARD COAL</td>
<td>BIOMASS</td>
</tr>
<tr>
<td>2</td>
<td>TYP OF BURNERS</td>
<td>JET BURNER</td>
<td>VORTEX BURNER</td>
</tr>
<tr>
<td>3</td>
<td>NUMBER OF BURNES</td>
<td>12</td>
<td>8x16.5MWth</td>
</tr>
<tr>
<td>4</td>
<td>BOILER CAPACITY</td>
<td>150 t/h</td>
<td>120 t/h</td>
</tr>
<tr>
<td>5</td>
<td>BOILER EFFICIENCY</td>
<td>ca. 89.0%</td>
<td>&gt;90%</td>
</tr>
<tr>
<td>6</td>
<td>FUEL CONSUMPTION</td>
<td>ca. 21.1 t/h</td>
<td>ca. 20.8 t/h</td>
</tr>
<tr>
<td>7</td>
<td>MOC CIEPLNA</td>
<td>ca. 123 MWth</td>
<td>ca. 98 MWth</td>
</tr>
<tr>
<td>8</td>
<td>LIVE STEAM PRESSURE</td>
<td>7.6 MPa</td>
<td>7.6 MPa</td>
</tr>
<tr>
<td>9</td>
<td>LIVE STEAM TEMPERATURE</td>
<td>500°C</td>
<td>500°C</td>
</tr>
<tr>
<td>10</td>
<td>FLUE GAS TEMPERATURE</td>
<td>190°C</td>
<td>150 ÷ 170°C</td>
</tr>
<tr>
<td>11</td>
<td>EMMISION OF SO₂</td>
<td>&gt;&gt; 400 mg/Nm³</td>
<td>&lt; 400 mg/Nm³</td>
</tr>
<tr>
<td>12</td>
<td>EMMISION OF NOₓ</td>
<td>&gt;&gt; 400 mg/Nm³</td>
<td>&lt; 400 mg/Nm³</td>
</tr>
</tbody>
</table>
CFB boilers for biomass
CFB OFz-201 Jaworzno
# CFB OFz-201 Jaworzno

## Boiler design data:
- **Thermal load**: 139.7 MW<sub>th</sub>
- **Electrical power**: 50 MW<sub>e</sub>
- **Live steam flow**: 201 t/h
- **Live steam temperature**: 510 °C
- **Live steam pressure**: 9.7 MPa
- **Feed water temperature**: 210 °C
- **Boiler efficiency**: >=91.5 %
- **Fuel consumption**: 14 kg/s
- **NO<sub>x</sub>, SO<sub>2</sub> emission**: <=200 mg/Nm<sup>3</sup>
- **Dust emission**: <=20 mg/Nm<sup>3</sup>

## Fuel data:
- **Guarantee**
  - Low heating value: 10800 kJ/kg
  - Ash content: 5.5 %
  - Moisture: 37 %
  - Sulphur content: 0.12 %
  - Alkali content: 0.3 %
  - Chlorine content: 0.1 %

- **Mixture 80% + 20%**
  - Low heating value: range 7500 – 17700 kJ/kg
  - Ash content: range 1.1 – 6 %
  - Moisture: range 5.5 – 50 %
  - Sulphur content: range 0.02 – 0.15 %
  - Alkali content: max. 0.303 %
  - Chlorine content: max. 0.166 %
## CFB OFz-201 Jaworzno – fuel characteristic

<table>
<thead>
<tr>
<th></th>
<th>Wood pellets</th>
<th>Wood chips</th>
<th>Rape straw pellets</th>
<th>Corn and bran pellets</th>
<th>Rape mill cake pellets</th>
<th>Sunflower hull pellets</th>
<th>Bran corns</th>
<th>Ground grain</th>
<th>Rape grain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LHV kJ/kg</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ash %</strong></td>
<td>1 – 2</td>
<td>0.7 – 4.6</td>
<td>6.4 – 7.6</td>
<td>3,3 – 6</td>
<td>4.6 – 39.8</td>
<td>3</td>
<td>4.8</td>
<td>4.8</td>
<td>2.2 – 9.3</td>
</tr>
<tr>
<td><strong>Moisture %</strong></td>
<td>6.3 – 8.3</td>
<td>17 – 51.3</td>
<td>8.3 – 11.1</td>
<td>13</td>
<td>2.9 – 6.7</td>
<td>9.4</td>
<td>13.7</td>
<td>10.6</td>
<td>6.6 – 8.6</td>
</tr>
<tr>
<td><strong>Sulphur %</strong></td>
<td>0 – 0.03</td>
<td>0.01</td>
<td>0.26 – 0.29</td>
<td>0.1 – 0.19</td>
<td>0.2 – 1.31</td>
<td>0.1</td>
<td>0.18</td>
<td>0.18</td>
<td>0.01 – 0.42</td>
</tr>
<tr>
<td><strong>Chlorine %</strong></td>
<td>0.02 – 0.112</td>
<td>0.011</td>
<td>0.047 – 0.138</td>
<td>0.074 – 0.087</td>
<td>0.067 – 0.085</td>
<td>0.085</td>
<td>0.083</td>
<td>0.11</td>
<td>0.009 – 0.081</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Olives waste</th>
<th>Black-current waste</th>
<th>Strawberry waste</th>
<th>Cotton stones</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LHV kJ/kg</strong></td>
<td>17389</td>
<td>18819</td>
<td>18569</td>
<td>19872</td>
</tr>
<tr>
<td><strong>Ash %</strong></td>
<td>7.7</td>
<td>3.6</td>
<td>5.5</td>
<td>3.7</td>
</tr>
<tr>
<td><strong>Moisture %</strong></td>
<td>6.3</td>
<td>11.6</td>
<td>7</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>Sulphur %</strong></td>
<td>0.1</td>
<td>0.14</td>
<td>0.16</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Chlorine %</strong></td>
<td>0.22</td>
<td>0.02</td>
<td>0.013</td>
<td>0.037</td>
</tr>
</tbody>
</table>
Main dates:
Contract signature - 10.05.2010
Site hand over - 01.09.2010
Drum lifting - 25.05.2011
Hydrostatic pressure test - 05.12.2011
Finish of boiler assembly - 30.09.2012
Start of trial run - 08.11.2012
CFB OFz-201 Jaworzno
Fuel preparation and delivery to the boiler

- Belt conveyor
- Scraper feeder
- Main collecting biomass feeder
- Skew scraper feeders
- Weigher
- Closed tubular feeder
- Collecting biomass feeder
- Skew scraper feeders
- Agrobiomass storage silos
- Collecting agrobiomass feeder
- Belt conveyor
- Skew scraper feeders
CFB OFz-201 Jaworzno

Erection of the agrobiomass silos
CFB OFz-201 Jaworzno

Agromass storage silos – 4x1000 m³.
Wood chips storage silos – 3x3000 m³.
Wood chips storage area – 3900 m².
CFB OFz-201 Jaworzno – operation experience

Ratio Agrobiomass/Woodchips biomass

Emission SO2 in December 2013

Emission NOx in December 2013

Dust emission in December 2013
CFB OFz-135 Vilnius

- Contract duration 28 months after Notice to Proceed.
CFB OFz-135 Vilnius
CFB OFz-135 Vilnius

**Boiler design data:**

- Thermal load: \(95.3 \text{ MW}_{th}\)
- Live steam flow: 135 t/h
- Live steam temperature: 540 °C
- Live steam pressure: 13 MPa
- Feed water temperature: 210 °C
- Boiler efficiency: \(\geq 91\%\)
- Fuel consumption: 58.5 t/h
- \(\text{NO}_x\) emission: \(\leq 140 \text{ mg/Nm}^3\)
- \(\text{SO}_2\) emission: \(\leq 50 \text{ mg/Nm}^3\)
- Dust emission: \(\leq 5 \text{ mg/Nm}^3\)
Fuel intended for use:
- Biomass – wood chips \(40 \div 100\%\)
- Willow and other energy crops, forestry residues, bark \(30 \div 60\%\)
- Straw \(0 \div 10\%\)
- Lignin \(0 \div 10\%\)

Fuel data:
- **guarantee mixture**
  - 70% + 30%

- **range**
  - Low heating value \(9000 \text{ kJ/kg}\)
  - Ash content \(1.3 \%\)
  - Humidity \(40\% \div 50\%\)
  - Sulphur content \(0.02 \%\)
  - Alkali content \(0.2 \%\)
  - Chlorine content \(0.02 \%\)

- **range**
  - Low heating value \(6600 – 12300 \text{ kJ/kg}\)
  - Ash content \(0.1 – 4.8 \%\)
  - Humidity \(28 – 60 \%\)
  - Sulphur content \(0.08 \%\)
  - Alkali content \(0.1 – 0.6 \%\)
  - Chlorine content \(0.11 \%\)
## CFB OFz-135 Vilnius

<table>
<thead>
<tr>
<th></th>
<th>Wood chips</th>
<th>Wood waste</th>
<th>Straw</th>
<th>Willow</th>
<th>Lignin</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHV</td>
<td>kJ/kg</td>
<td>9.25 - 11.3</td>
<td>6.2 - 11.6</td>
<td>11.6 - 15.6</td>
<td>10.26 - 16.4</td>
</tr>
<tr>
<td>Ash</td>
<td>%</td>
<td>0.1 - 1</td>
<td>1 - 10</td>
<td>2 - 10</td>
<td>11 - 23</td>
</tr>
<tr>
<td>Humidity</td>
<td>%</td>
<td>30 - 55</td>
<td>35 - 60</td>
<td>10 - 30</td>
<td>25 - 55</td>
</tr>
<tr>
<td>Sulphur</td>
<td>%</td>
<td>0.01 - 0.05</td>
<td>0.02 - 0.08</td>
<td>0.05 - 0.2</td>
<td>0.03 - 0.06</td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/kg</td>
<td>10 - 200</td>
<td>20 - 300</td>
<td>100 - 3000</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>mg/kg</td>
<td>200 - 1500</td>
<td>1000 - 4000</td>
<td>2000 - 25000</td>
<td>180 - 272</td>
</tr>
<tr>
<td>Chlorine</td>
<td>%</td>
<td>0.01 - 0.03</td>
<td>0.01 - 0.04</td>
<td>0.1 - 2.4</td>
<td>0.02 - 0.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.017 - 0.058</td>
</tr>
</tbody>
</table>
CFB OFz-135 Vilnius – plant location
CFB OFz-135 Vilnius – plant location
CFB OFz-135 Vilnius
Fuel preparation and delivery to the boiler
Thank You very much for Your attention