Foster Wheeler Advanced Bio CFB Technology – Kaukas 125 MWe CFB Design and Operation Experience

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ABSTRACT

Circulating Fluidized Bed technology is an ideal technology to be used for large scale power generation with a broad variety of biomass fuels. The well known benefits of CFB technology, such as the superior fuel flexibility, inherently low emissions and high availability can be fully utilized for this purpose. Today the biomass fired CFB technology offers a high efficiency boiler scale-up to 300MWe and fuel flexibility from clean biomass to RDF.

One of the latest Foster Wheeler Advanced Bio CFB’s is Kaukas Kaukaan Voima Oy’s power plant located UPM-Kymmenen Oyj Paper Mill site in Lappeenranta, Finland. The Kaukas Kaukaan Voima’s boiler is designed to fire bark, branches, tops, stumps, small wood and peat producing electricity and process steam for the paper mill site and district heat for the City of Lappeenranta. The power plant is Finland’s largest user of solid biomass fuels. The nominal capacity of the CFB boiler is 125 MW_e (net), designed to produce 149 kg/s of superheated steam at 115 bar(a) pressure and 550 °C temperature. The boiler was taken successfully into commercial operation in February 2010.

This presentation describes the status of Foster Wheeler Advanced Bio CFB technology that represents the state-of-the-art for large scale Biomass Firing. Kaukas Kaukaan Voima Oy CFB boiler concept, main technical solutions and operation experience are presented.

INTRODUCTION

The European Union has set a well known objective to reduce at least 20 % of the European greenhouse gas emissions by 2020 from the 1990 level, and increase the share of renewable energy to 20 % of energy consumption, by the same year. The target is to also improve energy efficiency by 20 % from the current level by 2020. Foster Wheeler’s objectives to increase the boiler efficiency and increase the use of biomass and other renewable fuels are well in line with the objectives set by the European Union, and globally.

Foster Wheeler has extensive knowledge of utilizing a broad range of Biomasses in energy production. Today the Foster Wheeler CFB technology provides the high efficiency boiler scale-up to 400MW_e for pure biomass firing, fuel flexibility from clean biomass to RDF and the scale-up to 800MW_e with supercritical steam parameters for biomass and coal co-combustion applications.
This is a result of continuous and determined development work, based on an experience database of over 370 reference CFB boilers sold. Of these, over 50 CFB boilers are designed for biomass (or bio-mix) and nearly 50 CFB boilers for waste (or waste-mix) containing biodegradable fractions, which are considered CO₂-neutral. When including the biomass fired Bubbling Fluidized Bed boilers (BFB) into the reference base, Foster Wheeler can utilize lessons learnt from nearly 200 biomass fired fluidized bed projects.

The paper shows that Foster Wheeler Advanced Bio Circulating Fluidized Bed technology is an ideal technology to be used for large scale power generation with a broad variety of biomass fuels. The well known benefits of CFB technology, such as superior fuel flexibility, inherently low emissions and high availability can be fully utilized for this purpose. This paper underlines that the combustion properties of biomass and waste may vary considerably, sometimes demanding complex design options. An adequate knowledge of the biomass fuel characteristics, their range of variability, along with a proper understanding of how such variables influence the combustion process are paramount to design and operate a boiler in a most economical and efficient way.

One of the latest Foster Wheeler Advanced Bio CFB’s is Kaukas Kaukaan Voima Oy’s power plant located UPM-Kymmenen Oyj Paper Mill site in Lappeenranta, Finland. The Kaukas Kaukaan Voima’s boiler is designed to fire bark, branches, tops, stumps, small wood and peat producing electricity and process steam for the paper mill site and district heat for the City of Lappeenranta. The power plant is Finland’s largest user of solid biomass fuels. The nominal capacity of the CFB boiler is 125 MWₑ (net), designed to produce 149 kg/s of superheated steam at 115 bar(a) pressure and 550 °C temperature. The boiler was taken successfully into commercial operation in February 2010. Kaukas Kaukaan Voima Oy CFB boiler concept, main technical solutions and operation experience are presented.

2 BIOMASS FUELS

To reduce emissions of greenhouse gases such as carbon dioxide (CO₂), boilers for heat and power production will be operated with increasingly high shares of biomass. Earlier, the size of the biomass fired plants has been limited for the locally available biomass fuel sources. Today the biomass market has changed from Local to Global. The green tariffs provided by most countries in the EU are making it possible to procure biomass globally using large biomass resources in America and Asia. This has created an interest for the large scale biomass fired units.
To date, biomass combustion systems use mainly forest industry biomass resources such as wood and wood residues. As the demand for biomass fuels grows and the price for wood-based biomass fuels increases, there is a growing interest to utilize not only wood-based fuels but also agricultural biomass, biomass residues and biomass wastes as fuel.

The quality of biomass fuels vary considerably due to fuel supply, preparation and processing, as well as local conditions such as soil chemistry, rainfall, and farming practices. In Table 1 properties of selected biomass fuels are shown.

Table 1. Properties of selected biomasses

<table>
<thead>
<tr>
<th></th>
<th>Timber pellets</th>
<th>Timber chips</th>
<th>Saw dust</th>
<th>Bagasse briquette</th>
<th>Straw pellets</th>
<th>Peat</th>
<th>Recycled wood</th>
<th>RDF fluff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture %</td>
<td>5-10</td>
<td>20-50</td>
<td>45-60</td>
<td>8</td>
<td>12</td>
<td>50</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Lower Heating Value</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MJ/kg</td>
<td>17</td>
<td>7,5-13,9</td>
<td>6-10</td>
<td>16</td>
<td>14.7</td>
<td>9.3</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Bulk Density kg/m3</td>
<td>650</td>
<td>130-280</td>
<td>300-350</td>
<td>650</td>
<td>650</td>
<td>340</td>
<td>300-400</td>
<td>100</td>
</tr>
<tr>
<td>Energy density</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MWh/m3</td>
<td>3</td>
<td>0.55</td>
<td>0.45-0.7</td>
<td>2.9</td>
<td>2.7</td>
<td>0.9</td>
<td>1.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Ash % ds</td>
<td>0.9</td>
<td>0.4-5.3</td>
<td>0.4-0.5</td>
<td>6</td>
<td>7</td>
<td>5.1</td>
<td>5</td>
<td>10-20</td>
</tr>
<tr>
<td>S % ds</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>0.01-0.03</td>
<td>0.22</td>
<td>0.1</td>
<td>0.1-0.5</td>
</tr>
<tr>
<td>Cl % ds</td>
<td>&lt;0.03</td>
<td>&lt;0.05</td>
<td>&lt;0.03</td>
<td>&lt;0.03</td>
<td>0.1-0.8</td>
<td>0.02-0.06</td>
<td>0.1</td>
<td>0.3-1.2</td>
</tr>
<tr>
<td>Alkali % ds</td>
<td>0.1-0.3</td>
<td>0.1-0.3</td>
<td>0.1-0.3</td>
<td>0.4-0.7</td>
<td>0.3-1.7</td>
<td>0.1</td>
<td>0.1-0.5</td>
<td>0.4-1</td>
</tr>
<tr>
<td>P % ds</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.04</td>
<td>&lt;0.05</td>
<td>0.05-0.8</td>
<td>&lt;0.35</td>
<td>&lt;0.3</td>
<td>&lt;0.5</td>
</tr>
</tbody>
</table>

If biomass fuel is compared with fossil fuels, the most important differences can be found in the variability of fuel characteristics, low energy density, higher moisture contents and low nitrogen and Sulfur contents of biomass fuels. Ash content is low but ash has a low melting temperature. The main constituents of ash are alkali and earth alkali elements and additionally Phosphorous in agro biomass. The moisture content of biomass has a large influence on the combustion process and on the resulting efficiencies.

All biomass fuels have their own special characteristics that are related to the chemistry and physical properties of the fuel. For example, Chlorine (Cl) and alkali contents are key parameters affecting corrosion and fouling in the boiler. Particle size and the earlier mentioned moisture content are examples of the physical properties having an effect on the combustion characteristics of the fuel.

Agricultural and field crop residues including straw, shells and hulls are identified as the most problematic fuels having the strongest potential to create operational difficulties, such as agglomeration of fluidized bed, fouling and corrosion of the convective heat surfaces. Such high
potential is not only dependent on the ash content of fuels, since the ash in biomass fuels is frequently low. Agro biomasses contain elevated concentrations of alkali, phosphorous and chlorine compounds, which produce low melting eutectics during combustion. The concentrations of these elements tend to be at the upper range of typical fuel specifications for biomass fuels, and are higher than commonly used in wood-fired boilers. The unfavourable composition of the ash is the main reason why so far the utilization of novel biomass fuels has been limited in energy production.

The flue gases originating from the combustion of certain biomass fuels contain vaporized salts and ash particles that can condense and stick on cooler surfaces, leading to fouling of heat exchangers. Fouling during combustion of wood-based fuels is typically low and easy to clean with steam soot blowers. However, fouling during combustion of agro biomass can be very intense, resulting in the formation of thick deposits. Such deposits are difficult to clean with normal soot blowing. Fouling leads to reduced performance of the boiler and in severe cases causes shut down for manual cleaning. The most frequent corrosion problem occurring in biomass combustion is chlorine-induced high temperature corrosion, which occurs mainly in the convective heat surfaces. Such corrosion is connected to high fouling rates in the presence of elevated alkali and chlorine contents in the fuel.

Understanding of the biomass fuel characteristics is the key issue to correctly address the fuel specific requirements in the boiler design. The Foster Wheeler fuel characterization models are based on the database including nearly 10,000 fuel samples and over 1,000 tests in about 150 CFB units.

3 FOSTER WHEELER ADVANCED BIO CFB TECHNOLOGY

Today the Foster Wheeler Advanced Bio CFB technology provides the high efficiency boiler scale-up to 400MWₑ for a broad range of clean and challenging biomass fuels. This is a result of continuous and determined development work, including an experience database of over 370 reference CFB boilers sold.

In addition to the fuel properties, plant requirements and different investment factors also have an effect on boiler concept and design. Fuel characteristics are determined by measuring the physical
and chemical properties and composition of the fuel, and evaluating the agglomeration, fouling and corrosive characteristics of the fuel. Plant requirements include the type of the boiler i.e. utility or industrial boiler, capacity, operational load range, steam data, emission limits and other requirements set by legislation. Investment factors include factors like plant availability, fuel flexibility requirement, the investment cost and operation costs.

A number of designs have been developed by Foster Wheeler to address the combustion of different types of biomass fuels in efficient and economical ways. In brief, easy-to-fire biomass fuels are handled in economical boilers, and more demanding solutions are implemented as the biomass fuel quality is more challenging.

Correct boiler design is the key issue to meet the demands of the fuel, plant requirements and different investment factors. The key design features of the Foster Wheeler Advanced Bio CFB (ABC) technology for the broad range of biomass fuels are shown in Figure 1.

Figure 1. The key Design features of the Foster Wheeler Advanced Bio CFB (ABC) technology.

The basic Foster Wheeler specific design features for all kinds of biomass fuels are the fully integrated water or steam cooled solids separator design and return leg designs, INTREX™ superheater and/or reheater design and step grid design:
- Foster Wheeler’s modern circulating fluidized bed boiler design utilizes the fully integrated water or steam cooled solids separator design and return leg designs. The solids separators as well as solids return legs are fabricated using cooled, straight membrane walls. No thick, insulating refractory is required in this design, only thin refractory is used in some locations for protection against wear. This arrangement allows the separator to be positioned adjacent to the furnace without expansion joints, providing a “Compact” configuration. The main benefits of this well proven design are its compact size, with a smaller foot print, cooled structure that recovers heat and lowers the start-up times and flue gas temperature entering convection pass, and low requirements for maintenance, which allow a flexible, reliable and economical operation of the unit.

- Intrex™ is a proprietary heat exchanger located in the return legs from the separators, where circulating material is returned to the CFB furnaces. This heat exchanger is constantly immersed in the returning material, which is fluidized like the bed of a bubbling fluidized bed, but more gently. As a result, this heat exchanger benefits from a more effective heat transfer than an exchanger in the convective pass, it does not suffer erosion while remaining free from deposits, and it is not exposed to corrosive flue gases. Therefore, higher steam temperatures can be attained safely with this well proven INTREX™ design when firing corrosive fuels such as biomass and waste.

- The step grid was developed in the 1990’s to handle fuels that contain large fractions of inert material, such as stones and metallic debris. This grid features flat nozzles arranged into stepped rows, usually separated by refractory pre-casts. This design does not offer any appendages onto which fuel debris can hang, and creates an air flow that forces large inert fractions to evacuate the furnace via the wide bottom ash chutes, thus assuring the effective removal of un-fluidized material. This design is essentially standard in Foster Wheeler CFBs firing biomass and/or waste.

In case of challenging biomass fuels like agro biomass fuels, recycled woods etc more attention is needed in boiler design and process conditions to control increased agglomeration, fouling and corrosion risks:

- To maintain the adequate and stable combustion temperature profile in the furnace, special attention is needed in the design of the furnace heat transfer surfaces and the fuel feeding systems and the fuel feeder locations, air distribution and correct fluidization velocity in the furnace. Flue gas recirculation can be used both to stabilize combustion temperature profile locally by improving fuel mixing near the fuel feeding points and to control furnace
combustion temperature level by adjusting the heat balance between the furnace and convection pass.

- Heat transfer surfaces in the convection pass are designed with suitable steam parameters, tube pitches and tube materials and are located in an optimum flue gas temperature to control to be fired biomass fuel fouling and corrosion risks
- The alternative bed materials and various additives can be adopted to overcome agglomeration, fouling, and/or corrosion of challenging biomass fuels.

During the boiler operation the plant operator needs to have a proper fuel quality management system in order to understand the biomass fuel quality to be fired all the time. This allows the optimum operation of the plant. Foster Wheeler also offers the SMART BOILER™ datalog and diagnostics tool to assist the operation of the boiler in an optimized manner. Foster Wheeler Advanced Bio CFB Technology allows the boiler design and process optimization for a broad range of biomass fuels to meet large scale, effective and highly reliable boiler operation.

4 KAUkas KaukaAn VoimA oy’S CFB PrOject

One of the largest biomass fired Foster Wheeler Advanced Bio CFB’s is Kaukas Kaukaan Voima OY’s power plant located UPM-Kymmenes Paper Mill site in Lappeenranta, Finland. The Plant produces electricity and process steam for the UPM paper mill site and district heat for the City of Lappeenranta. The nominal capacity of the CFB boiler is 125 MWₑ (net), 385 MWₜₜ, designed to produce 149 kg/s of superheated steam at 115 bar(a) pressure and 550 °C temperature. The boiler contract was awarded on April 2007 and the boiler was taken into commercial operation in 22 February 2010 (Figure 2).

The owner of the Kaukas Kaukaan Voima OY’s plant is Kaukaan Voima Oy that is 46% owned by Lappeenrannan Energia Oy and 54% by Pohjolan Voima Oy. The main economical drivers of the project were more effective utilization of paper mill by-products and replacing gas with biomass fuels for Lappeenranta City’s electricity and district heat production. The Kaukas Kaukaan Voima OY’s plant is a continuation in UPM's long term strategy to utilize biomass efficiently.
The Kaukas Kaukaan Voima OY’s plant incorporates a back pressure Siemens turbine to produce steam for district heating and 27 MWₑ condensing section. Steam extractions from turbine are 15 bar and 10 bar, with a back pressure of 3.5 bar. Steam is delivered to UPM mills. Fly ash from the boiler is used as a forest fertilizer.

The Foster Wheeler’s delivery comprised boiler island including engineering and design, boiler house enclosure with steel structures, boiler pressure parts, auxiliary equipments, main steam piping, fuel silos and fuel feeding equipment, electrostatic precipitator, erection, construction, start-up, commissioning and training.

The plant meets the following emission limits corresponding to (6% O₂, dry): 150 mg/m³ n NOₓ, 200 mg/m³ n SO₂, 200 mg/m³ n CO and 20 mg/m³ n particulates with primary measures. The boiler is equipped with an electrostatic precipitator (ESP) and ammonia injection both in the furnace and the separator (SNCR). Limestone injection in the furnace is included for DeSOₓ purposes.
The Kaukas Kaukaan Voima OY’s boiler is designed to fire peat and pulp and paper mill by-products (mainly clean biomass fuels like bark, forest residue, sludge, etc.) as detailed in Table 2. The peat and biomass fuel can be fired separately or co-fired.

Table 2. Kaukas Kaukaan Voima OY’s CFB fuel specification

<table>
<thead>
<tr>
<th></th>
<th>Mixture A</th>
<th>Mixture B</th>
<th>Bio</th>
<th>Peat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>48.8</td>
<td>51.5</td>
<td>50.5</td>
<td>45.0</td>
</tr>
<tr>
<td>Ash</td>
<td>2.85</td>
<td>2.54</td>
<td>1.86</td>
<td>5.0</td>
</tr>
<tr>
<td>LHV</td>
<td>9.23</td>
<td>8.45</td>
<td>8.46</td>
<td>11.29</td>
</tr>
<tr>
<td>C</td>
<td>53.0</td>
<td>52.3</td>
<td>51.6</td>
<td>56.0</td>
</tr>
<tr>
<td>H</td>
<td>6.0</td>
<td>6.0</td>
<td>6.0</td>
<td>6.1</td>
</tr>
<tr>
<td>N</td>
<td>0.92</td>
<td>0.78</td>
<td>0.46</td>
<td>1.9</td>
</tr>
<tr>
<td>S</td>
<td>0.094</td>
<td>0.078</td>
<td>0.045</td>
<td>0.2</td>
</tr>
<tr>
<td>O</td>
<td>37.1</td>
<td>38.3</td>
<td>40.1</td>
<td>30.8</td>
</tr>
</tbody>
</table>

5 KAUKAS KAUKAAN VOIMA OY’S CFB BOILER DESIGN

The Kaukas Kaukaan Voima OY’s CFB boiler design is based on Foster Wheeler’s Advanced Bio CFB design for clean biomass fuels utilizing the fully integrated water cooled solids separator design and return leg designs, INTREX™ superheater and partial step grid design (see Figure 3).

The design of the new Kaukas Kaukaan Voima OY’s boiler has solids separators built from water cooled panels integrated with the combustion chamber. The water cooled separator design avoids heavy refractory linings in the separator and expansion joints. First superheating stage of the Kaukas Kaukaan Voima OY’s boiler, convective SH I is located in first convective pass as well as second stage of superheating (convective SH II). Third and final superheating stage comprising three tube bundles in series and an INTREX™ superheater located in a special enclosure at the bottom of the furnace adjacent to the main combustion chamber. The INTREX™ superheater is located outside the main combustion area, which enables it to be used as the last superheating stage, resulting in higher steam temperatures since it is protected from the fouling and corrosive environment of the boiler’s hot flue gas. INTREX™ superheater also provides good load-following
capabilities and turndown ratios to accommodate temporary or seasonal changes in steam or district heat needs.

Figure 3. Foster Wheeler Advanced Bio CFB design in Kaukas Kaukaan Voima Oy.

The Kaukas Kaukaan Voima OY’s boiler utilizes moderate fluidizing velocity in the furnace which is an important characteristic of Foster Wheeler Advanced Bio CFB technology. Further, the design features a partial step grid next to the fuel feeding points in order to transfer heavy unfluidized particles effectively into the bottom ash removal system.

In biomass fired boilers it is essential to feed make-up sand into the furnace to maintain proper bed inventory and quality. For decreasing make-up sand consumption Kaukas Kaukaan Voima OY’s boiler is equipped with bottom ash recycling system providing the possibility to recycle bottom ash back into the furnace.
Fuel feeding system of the Kaukas Kaukaan Voima OY’s boiler consists of two similar feeding lines, one feed line at both of the long walls of the furnace. Capacity of each line is 70 % of maximum boiler capacity. Boiler has two fuel day silos for biomass and one common peat silo for both feeding lines. Fuel is fed pneumatically into the furnace via eight feeding chutes providing good fuel mixing among whole bed area of the furnace. 75 % boiler load is designed to be reached only with biomass or peat firing as the full load can be reached with mixtures of biomass and peat.

Combustion air system of Kaukas Kaukaan Voima OY’s boiler consists of primary and secondary air systems and separate air system for fluidizing the INTREX™ heat exchangers and sealing devises. Radial fans with inlet guide vane control for primary air and speed control for secondary air are used to provide air for properly staged combustion of the biomass and peat. For Induced Draft (ID) fans two radial fans are used. A flue gas recirculation system is provided to accommodate the larger variations in the fuel quality.

For controlling the emissions, boiler utilizes well known benefits of the CFB combustion like low and uniform temperature profile in the furnace and staged combustion. In addition to these combustion process related measures, the boiler is equipped with ammonia injection (SNCR) system for controlling the nitrogen oxide emission and limestone feeding system for controlling Sulfur dioxide emission. Electro Static Precipitator (ESP) is used for controlling particulate emission. With these primary measures Kaukas Kaukaan Voima OY’s boiler can easily meet the emission limits set for it (150 mg/m3n NOx, 200 mg/m3n SO2, 200 mg/m3n CO and 20 mg/m3n particulates).

6 KAUKAS KAUKAAN VOIMA OY’S BOILER OPERATION EXPERIENCE

Erection works in the Kaukas Kaukaan Voima OY’s boiler were mostly completed on June 2009 and mechanical completion was achieved on 24th July, exactly according to project schedule.

Cold commissioning the Kaukas Kaukaan Voima OY’s boiler was started on June 2009 simultaneously with last minor erection work still ongoing. During cold commissioning all the systems and devices of the boiler plant were checked after erection works and made ready for the trouble free start of chemical cleaning and hot commissioning. First fire took place on 5th of August
2009 followed by chemical cleaning of the boiler. On 20th August blow-out of steam piping was started and finished only eight days later after eleven blow-outs performed.

![Boiler plant on July 2008 and July 2009](image)

Figure 4. Boiler plant on July 2008 and July 2009

Solid fuel firing started after the steam piping restoration at the beginning of the September and the new unit was synchronized to electrical grid first time on 9th of September. During first operation month systems were initially tuned while boiler was operating on load below the design minimum. Boiler load was increased on the middle of November and final tuning of the boiler with different fuels and fuel mixtures over whole load range could be started. Boiler tuning included optimization of the boiler economical and environmental performance in steady and transient load conditions.

After the boiler was initially tuned and the boiler met all the environmental requirements, the so called Production Commissioning period was started on 23th of December 2009 lasting for 52 days including 21 days of Continuous Operation Period. During this 52 days period, boiler performance was fine tuned while it was on normal commercial operation as a part of the Kaukas mill steam network producing process steam for Kaukas mill, electricity and district heat for the city of Lappeenranta.

During fine tuning it was mainly concentrated to optimization of the SNCR system in order to find optimal ammonia feeding concept for all the different fuel mixtures. Also economical performance of the boiler plant was optimized by minimizing the losses and auxiliary power consumption. Boiler performance was excellent after fine tuning as was later demonstrated during the Performance Test period.
Boiler emissions and load as daily averages during the Continuous Operation Period are shown in following table.

Table 3. Daily average emissions and load during Continuous Operation Period.

<table>
<thead>
<tr>
<th></th>
<th>NOx (mgNO2/m³n @6%O2, d)</th>
<th>CO (mg/m³n @6%O2, d)</th>
<th>SO2 (mg/m³n @6%O2, d)</th>
<th>Steam production (kg/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>129</td>
<td>13</td>
<td>37</td>
<td>125</td>
</tr>
<tr>
<td>Min.</td>
<td>120</td>
<td>3</td>
<td>1</td>
<td>97</td>
</tr>
<tr>
<td>Max.</td>
<td>143</td>
<td>53</td>
<td>142</td>
<td>141</td>
</tr>
</tbody>
</table>

During boiler commissioning and production operation Foster Wheeler carried out an extensive R&D testing program on the Kaukas Kaukaan Voima OY’s boiler. Performance of the boiler was tested on different load levels with different fuel mixtures in order to deepen the knowledge and understanding of the biomass firing on large CFB boiler.

Production Commissioning of the boiler plant was completed on 12th of February 2010 and the plant was taken into a commercial operation right according original project schedule on 22th of February.

Performance Test for the boiler was carried out including steady state test with biomass, peat and two different mixtures of these at the end of the March 2010. Boiler dynamic behavior as a part of the mill’s steam network was tested separately. Based on the results of these tests all the performance guarantees were clearly met.

Large variations on boiler load and fuel mixtures are typical for industrial boilers like Kaukas Kaukaan Voima OY’s boiler. This set a challenge for boiler controls to maximize economical and environmental performance in continuously transient conditions. While the fuel quality and load are changing, boiler controls still needs to keep gaseous emissions below the allowable limits without over feeding the sorbents and without risking the availability. When SNCR system is most of the time used for controlling the NOx level in Kaukas CFB, is limestone feeding for controlling SO2 used only with pure peat firing. Gaseous emissions during normal operation of the boiler are shown...
in following figure 5. Peaks in SO₂ are result of changes in peat content of the fuel mixture, but still limestone feeding is not needed as the emissions remain under the limit.

Figure 5. Gaseous emissions as measured during typical boiler operation.

Fuel flexibility, high combustion efficiency and low emissions are well known advantages of CFB boilers. Kaukas Kaukaan Voima OY’s boiler designed according to Foster Wheeler’s Advanced Bio CFB technology has fully demonstrated these advantages. During Production Commissioning period and first year of the commercial operation Kaukas Kaukaan Voima OY’s boiler has demonstrated its capacity to operate on full load range with large variety of fuels and fuel mixtures in reliable and environmentally friendly manner.

7 SUMMARY

Foster Wheeler has an extensive knowledge of biomass firing based on the knowledge of nearly 200 CFB and BFB units sold. The modern Foster Wheeler Advanced Bio CFB technology provides
state-of-the-art solutions for effective CO₂ reduction in large scale power generation with a broad range of biomass fuels.

The biggest challenges encountered in biomass firing are the tendency towards bed agglomeration and fouling of convective heat surfaces, often associated to corrosion. Such challenges are marginal with certain woody biomass, but they intensify when more challenging biomass fuels like agro biomass or waste are fired, and further grow when boilers must operate at the highest efficiency.

This paper underlines that an adequate knowledge of the fuel characteristics, their range of variability, along with a proper understanding of how such variables influence the combustion process are the key issues to design and operate a suitable boiler while avoiding unnecessary complexities and costs. The Foster Wheeler Advanced Bio CFB technology is the optimum choice to meet the market’s demand now and in the future to utilize a broad range of biomass fuels in large scale power generation.

One of the latest large scale biomass fired boiler based on Foster Wheeler Advanced Bio CFB technology was started in Lappeenranta, Finland, at the end of year 2009. Plant owned by Kaukaan Voima Oy is located in UPM-Kymmene Kaukas Paper Mill site and is producing process steam and electricity for the paper mill and district heat for the city of Lappeenranta.

Fuel used in Kaukas Kaukaan Voima OY’s boiler is mostly consisting of paper mill by-products like bark, forest residue and sludge. Other bio-fuels and peat as well natural gas as a backup fuel are part of the fuel palette of the Kaukas Kaukaan Voima OY’s boiler.

Kaukas Kaukaan Voima OY’s boiler based on Foster Wheeler Advanced Bio CFB technology has demonstrated good availability, low emissions and high combustion efficiency over full operation range during the first year of commercial operation. The Kaukas Kaukaan VOima OY’s power plant is Finland’s largest user of solid biomass fuels.