Fluidised Bed Combustion research in VTT aims at promoting technological development of heating- and power plants in order to secure high level of plant availability and reliability. In multifuel applications our research activities focus on solving problems related to ash behaviour such as fouling of heat transfer surfaces and hot corrosion. As the legislation on emission levels of heating and power plants is continuously tightening, we can offer our clients expertise on emission control- and reduction techniques. In process development area we promote the development of high efficiency CFB processes. Our aim is to develop process measurement- and modelling methods in order to deepen knowledge on CFB process in all its complexity. Majority of the activities is experimental research work, which takes advantage of our unique test facilities, strong experience and contacts covering the whole research community of Europe.

TEST FACILITIES

VTT have a pilot CFB reactor, a pilot BFB reactor, a bench scale BFB reactor and a fluidized bed erosion tester. Depending on the objectives and requirements these devices can be applied for the combustion and material testing.

FB REACTORS

CFB and BFB reactors are equipped with several separately controlled electrically heated and water/air-cooled zones in order to control the process conditions (for example oxygen level, temperature and load) almost independently. There are several ports in the freeboard area for gas and solid material sampling. Typically the aim is to carry out a pilot size test burn to characterize the fuel in terms of the combustion properties for a CFB or a BFB power plant. Combustion conditions can be adjusted to correspond with those prevailing in full-scale boilers. The test rigs are applied in research work relating to the formation of pollutants, ash property characterisation and combustion behaviour characterisations of problematic fuels. Deposit formation can be studied by inserting air-cooled probes into the reactors' furnace and flue gas paths. It is also excellent environment for characterising fine fly ash emissions in multifuel and waste combustion. Development of combustion process includes analysis of experimental results applying steady state and dynamic process models and also testing of advanced process control methods can be carried out.

Typical issues studied with pilot CFB and BFB reactors:
- combustion profiles (gas, solid material, temperature, heat transfer)
- emissions
- limestone dosage
- deposit formation
- bed agglomeration
- fuel and limestone reactivity
- ash properties, ash split (bottom ash vs. fly ash)
- advanced combustion control
Co-combustion of biomass and REF: distribution of chlorine between HCl and particulate matter (alkali chlorides) in 870°C BFB furnace.

Typical operational parameters for CFB and BFB pilots

<table>
<thead>
<tr>
<th>Dimensions of furnace:</th>
<th>CFB</th>
<th>BFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (m)</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Diameter (m)</td>
<td>0.17</td>
<td>0.23</td>
</tr>
</tbody>
</table>

**Feeds:**

- Fuel (g/s) 1.5-4.0 0.9-1.3
- Fuel power (kW) 25-50 12-16
- Fluidization velocity (m/s) 0.5-1 0.1-0.5
- Limestone particle size (mm) 0.5-0.05 0.2-0.01
- Total combustion air (Nm³/min) 685-1100 278
- Secondary air (Nm³/min) 0.25 0.1
- Total gas velocity (m/s) 0.5-5 0.6
- Gas reidence time (s) 2-12 8
- Fuel (g/s) 1.5-6.0 0.9-1.3
- Limestone (g/s) 0-1.5 0-1.0
- Tertiary air (Nm³/min) 0-200 56
- Secondary air (Nm³/min) 0-500 83
- Additional gases N₂, CO₂, H₂O can be mixed with combustion air

Additive feeders:
- Liquid spraying system with gas atomising, solid powder additive feeder

**Options for oxyfuel combustion in CFB fuel power up to 100 kW, additional bed heat exchanger**

**Conditions:**

- Temperature (°C) CFB 700-900 BFB 870-1100
- Bed pressure (Pa) 2000-3500
- Fluidization velocity (m/s) 1-2.5 0.5
- Total gas velocity (m/s) 2.5-4 0.6
- Gas reidence time (s) 2-4 8
- Fuel power (kW) 25-50 12-16
- Limestone particle size (mm) 0-5 1
- Diameter (m) 0.17 0.23
- Heat transfer probes (number) 3
- Additional gases N₂, CO₂, H₂O can be mixed with combustion air

**Measurements for CFB and BFB:**

- Gas composition O₂ (0-100%), CO₂ (0-100%), CO (0-5000ppm), NO (0-1000ppm), SO₂ (0-5000ppm)
- FTIR spectrometer H₂O, CO₂, CO, NO, NO₂, NH₃, SO₃, HCl, CH₄, C₂H₆, C₂H₄, C₂H₂, C₄H₁₀
- Additional gases fine particles (DLPI, ELPI), heavy metals

**Typical issues studied with bench scale reactor:**

- Characterization of fuels and sorbents
- Comminution
- Agglomerati on of bed material
- Sub-process for emission formation
- Reactivity

BENCH SCALE CFB/BFB REACTOR

Pre-heated primary air is fed to the furnace through the grid. Oxygen concentration in the furnace is set to desired level with nitrogen. Also different kind of gas mixtures can be used e.g. O₂, CO₂, SO₂, CO, NO in addition to air and nitrogen. Temperature and pressure profiles along the riser are measured. Temperature is controlled inside the reactor tube with surrounding electric heaters.
FLUIDISED BED EROSION TESTER

The fluidised bed erosion tester has been build from a commercial electrically heated fluidised bed having a total height of 950 mm and inner diameter of about 400 mm. The actual test rig consists of two horizontal arms rotated by two concentric vertical axe counter-wise within the fluidised bed.

Typical operational parameters for FB Erosion Tester

Dimensions of furnace:

- Hight (mm): 950
- Diameter (mm): 400
- Sample material: tubular rings (L = 15 mm, D_in = 15 mm, D_out = 25 mm), max number 16

Conditions:

- Bed temperature (°C): 400-500
- Bed material: aluminium oxide, mean grain size 0.22 mm
- Fixed bed height (mm): 660
- Fluidized bed height (mm): 40
- Rotation speed (1/min): 270
- Relative velocity of sand particles (m/s): 1.2-3.5
- Typical test run time (h): 100

Analyses:

- Mass loss curves
- SEM/EDS
- Atomic force microscopy

Additional information

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