Emissions from wood pellet combustion

Jürgen Brandt, 10.4.2014

Northeast Biomass Heating Expo, Portland, USA
The company
Who is Windhager?

- traditional Austrian company since 1921
- main factory and headquarter located in Seekirchen, Salzburg
- one of Europe's leading producers of solid fuel boilers, especially for pellet and log-wood
- core competence: development, production and sales of central heating boilers and equipment for biomass fuels
- employer for ~ 400 employees
Which products do we offer?

Central heating boilers for Pellets, Wood & Coke, Gas and Oil as well as accessories in the output range of 2,9 - 180 kW
System solutions with function guarantee
Modern biomass boilers established during the 90’s
  • ~ 1990 log wood gasification boiler
  • ~ 1997 pellets boiler

• Big advances during the last 15 years
• Pellets boilers as real alternative to oil and gas fired boilers for fully automated operation

Customers view:
• Price of fuel
• Price of boiler
• Comfort

Sales are also influenced by a lot of external factors such as fuel prices, investment costs, funding, emission limits and availability of boilers.
Biomass Heating Co-Emissions

CO [1000 mg/Nm³]

Efficiency

year
Focus in Europe: dust emissions

- KCl, K₂SO₄, K₂CO₃ etc.
- CO₂, H₂O, CO, CₓHᵧ
- Cooling of the flue gas
- Condensation
- Gas phase reactions (KCl, K₂SO₄, ZnO etc.)
- Gas phase burn-out (CO₂, H₂O, CO, CₓHᵧ)
- K, Na, S, Cl, Zn, Pb, Cd
- CO, CₓHᵧ, H₂, etc
- Nucleation
- Release of primary particles, soot formation
- Bottom ash
Focus in Europe: dust emissions

PM1 particle emissions are subject to fuel elements

RG ... Flue gas; TS ... Dry matter
Pe ... Softwood Pellets, HG ... Different chipped wood, SH ... Log wood
Focus in Europe: dust emissions

Amounts and chemical compositions of PM₁ emissions from old and modern residential biomass combustion systems

Obernberger: Workshop “Aerosols from small-scale biomass combustion plants”, Graz, 27.01.2011
Focus in Europe: dust emissions

About 90% of PM emissions are coming from old installations.
»It will be most useful **for emission reduction** as well as **for primary energy use** for the EU to replace old type heating boilers and stoves and to replace them to state of the art equipment!

»**Best values will be achieved with Pellets!**
BioWin 2 boiler development
Boiler development

**Motivation**

Easy heating and reliability were building the success of Windhager. The new boiler shall have a low pellet consumption and the ability to perform efficiently over the whole power range.

**Targets**

Development of a Pellet boiler especially designed for single and multiple-family houses. Focus was laid on a low emission combustion together with a high efficiency in the full power range – on test stand and in field!
Boiler development: CFD-simulations

Optimization by CFD simulation: geometry of the simulation area (left) and different nozzle diameters and angles of the secondary air inlet (right)
Optimization by CFD simulation: CO concentrations [ppmv] for different nozzle diameters of the secondary air inlet
Boiler development: CFD-simulations

Optimization by CFD simulation: temperatures of combustion chamber and burner wall for different nozzle angles of the secondary air inlet; D=7,5 mm
Boiler development: CFD-simulations

Varied parameters:
- Diameter of secondary air inlet
- Angle of secondary air inlet

Target values in observation:
(a) Temperature of the combustion chamber
(b) Temperature of the temperature probe
(c) Temperature of burner wall
(d) Temperature of flue gas in the burner
(e) Oxygen concentration in the burner
Results
## Type test results BioWIN 26 kW

*(Type test performed by TÜV SÜD Industrieservice GmbH)*

<table>
<thead>
<tr>
<th></th>
<th>Nominal load</th>
<th>Partial load</th>
<th>Nominal load</th>
<th>Partial load</th>
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</thead>
<tbody>
<tr>
<td>Power</td>
<td>kW</td>
<td>26,0</td>
<td>7,6</td>
<td>~89,000</td>
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<tr>
<td>Efficiency</td>
<td>%</td>
<td>93,8</td>
<td>93,9</td>
<td>%</td>
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<tr>
<td>CO</td>
<td>mg/MJ</td>
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<td>lbs/mmBTU</td>
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<td>NOx</td>
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<td>HC</td>
<td>mg/MJ</td>
<td>1</td>
<td>1</td>
<td>lbs/mmBTU</td>
</tr>
<tr>
<td>Dust</td>
<td>mg/MJ</td>
<td>5</td>
<td>7</td>
<td>lbs/mmBTU</td>
</tr>
</tbody>
</table>
Results: type testing and field tests

Type testing results (01.07.13) compared to field (average of 11.02.13 and 18.03.13) in chimney sweep mode; emissions in mg/Nm³ at 13% O₂
Reference load cycle test runs

Test runs performed according to the reference load cycle developed by TFZ based on VDI directives and the "ISEB Leitfaden"

The heat demand cycle starts and ends at a feed water temperature of 55°C; in the minimum load phase the boiler stops when it gets overheated (82°C) and it restarts when the feed water temperature falls below 55°C but boiler operation ends latest 8h after the start of the heat demand cycle; the progress of feed and return water temperature is exemplary, the interrupted lines denote, that the trends are dependent on the boiler settings, but they have to meet at the beginning and end of the load cycle.
Test runs with BioWIN 2 boiler (nominal boiler capacity 10 kW) according to reference load cycle.
Dust reduction potential with BW2

Scenario for Europe: all boilers from 2017 on are Windhager BioWIN 2

70% reduction

Basic calculations done by Wuppertal Institute (Germany) within the project UltraLowDust. BAU: business as usual; BioWIN 2: all pellet boilers are BioWIN 2 boilers.
Further innovations

- minimal space requirements
- best results in field application
- utilization-dependent maintenance
- robust stainless steel burner
- self-cleaning
- removable XXL ash box

Windhager is very strongly committed to low emission, now and in the future!
The research leading to these results has partially received funding from the European Union Seventh Framework Program (FP7/2007-2013) under Grant Agreement n° 268217 and Grant Agreement n° 268189.
Thank you for your attention!

Northeast Biomass Heating Expo, Portland, USA