Online Fineness Measurement System for Controlling a Biomass Fired Unit

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Introduction
Introduction

**Air/fuel ratio and performance**

- Reduce process variability and shift operating point closer to the limits
- The particle size is an essential parameter with a very strong impact on combustion properties
- Identify and utilize the intricate interplay of combustion parameters

**Strategy**

- Continuous optimization
- Instantaneous adaptation to load changes

\[ \text{Air/fuel ratio (}\lambda\text{)} \]

- optimised combustion settings
- regular combustion settings
Introduction

Why is coal fineness so important?

- Fuel and air flow parameters determine the quality of combustion
- Area in which the overall generation process is least perfect
- Process not directly monitored and controlled
- Increasing variability of coal quality (co-firing)
- Renewable energies impose increasingly dynamic load adaptation (down-swing)
- Boiler are usually not operated at their design point
Why is coal fineness so important?

<table>
<thead>
<tr>
<th>Controllable O&amp;M variable</th>
<th>$\Delta \eta_{th}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal fineness</td>
<td>0.1 - 0.3%</td>
</tr>
<tr>
<td>Primary air-flow</td>
<td>0.1 - 0.2%</td>
</tr>
<tr>
<td>Fuel line balance</td>
<td>0.1 - 0.3%</td>
</tr>
<tr>
<td>Particulate-air ratio</td>
<td>0.1 - 0.3%</td>
</tr>
<tr>
<td>Carbon-in-ash (LoI)</td>
<td>0.1 - 0.3%</td>
</tr>
<tr>
<td>Excess oxygen</td>
<td>0.1 - 0.3%</td>
</tr>
<tr>
<td><strong>Total</strong>*</td>
<td><strong>0.6 – 1.7%</strong></td>
</tr>
</tbody>
</table>

* These benefits do not add up synergistically. Typically, an overall improvement in net efficiency will be around 0.3 – 1.0%
EUcoalsizer mobile - System details
Introduction

Features

- ´Inline´ and ´online´ laser-based analysing system for coal particles in coal pipes
- Simultaneous measurement of
  - Particle size distribution
  - Particle velocities
  - Mass flow
  - Air/Fuel Ratio
  - Flow temperature
- No mechanical interaction with the particles
- Immediate results with integrated evaluation and online reporting
- Portable system, easy to handle
- Fast and reliable results during operation
System specifications

**Hardware**

- Measuring range: 20 µm up to 4 mm
- Operating temp.: up to 200 °C (air cooled)
- Flow density: up to 1000 g/m³
- Lance length: 1.5 m
- Lance diameter: 51/60 mm

- **Option:** Continuous scanning by automatic traversing probe

**Software**

- Online determination of particle size distribution, velocities and load
- Statistic functions
- 2D distributions

**System set-up on site**
EUcoalsizer – Measurement principle

Measurement volume

Direction of particle movement

Parallel laser beam

Particle velocity:
\[ v_p = f_0 \times g \]

Particle size:
\[ x_p = t_p \times v_p \]

**Legend**

- \( f_0 \): frequency analysis of signal
- \( t_p \): time of flight
- \( g \): characteristic constant of the optical length

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Air flow measurement & air/fuel ratio

Air velocity

- Particle velocity = function (particle and gas properties: Re, cw, ...)
- Smaller particles show good entrainment
- The highest measured velocities are well correlated with the smallest particles

Air mass flow

- Measurement TF, pF -> rF
- \( m_F \sim (u_F, r_F) \)

Air / fuel ratio

\[ \text{AFR} = \frac{m_F}{m_p} \]
EUcoalsizer – System components

- Head of measuring probe with laser emitter and detector
- Specially protected probe head for hostile, abrasive environments
- Lance
- Harting connector
- Outside protective/cooled shield
- Measuring volume
- Purging air device (impulse)
- Hybrid cable

1 cm
EUcoalsizer – Portable control unit

- Connector to probe
- Air inlet
- Pressure gauge
- Flow meter
- Flash alarm
- Toughbook with EUcoalsizer Software
- Power supply

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EUcoalsizer – User interface

- **Overview data**
- **System status**
- **Measurement modus and system control**
- **Sequential measurement (time resolved mean values)**

**EUcoalsizer**

- **Particle size or particle velocity distribution**
- **Particle velocity or RRSB plot**

Graphs and charts illustrating different data representations:
- Size Distribution
- Velocity Distribution
- Selection Schedule Graph
- Size Distribution - RRSB Diagram
- Graph representation

Data fields:
- Step 4 of 4
- Mass flow coal
- Mass flow air
- Mean velocity
- Temperature
- Measurement time

System status:
- System state: Waiting
- Measuring process: Mass Cooling On
- Next purge air: 22
Application at coal pipe

- Measurements at coal-fired TPP

Set-up with probe & media supply

EUcoalsizer measuring probe

Instrumentation opening

Probe with measuring volume
Towards ‘best practices’
EUcoalsizer - Application at Power Station

Set-up at coal pipe

- Total time of measurement reduced to 20% of original time
- Monthly rather than yearly measurements in each unit
- Immediate analysis for improved performance management
- Performance engineers available for other tasks

Access ports (overpressure)
Results and customised online report

### Particle size

<table>
<thead>
<tr>
<th></th>
<th>F#1</th>
<th>F#2</th>
<th>F#3</th>
<th>F#4</th>
<th>A#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 mesh</td>
<td>99.2</td>
<td>98.3</td>
<td>98.4</td>
<td>98.8</td>
<td>97.1</td>
</tr>
<tr>
<td>100 mesh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 mesh</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Velocity

<table>
<thead>
<tr>
<th></th>
<th>F#1</th>
<th>F#2</th>
<th>F#3</th>
<th>F#4</th>
<th>A#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>m/sec (ft/sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean velocity</td>
<td>20.4</td>
<td>17.8</td>
<td>19.4</td>
<td>21.1</td>
<td>19.1</td>
</tr>
<tr>
<td>(ft/sec)</td>
<td>(66.9)</td>
<td>(58.4)</td>
<td>(63.6)</td>
<td>(69.2)</td>
<td>(62.7)</td>
</tr>
<tr>
<td>Std. deviation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Mass flow (rel.)

<table>
<thead>
<tr>
<th></th>
<th>F#2</th>
<th>F#3</th>
<th>F#4</th>
<th>A#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass flow dev.</td>
<td>6</td>
<td>-13</td>
<td>19</td>
<td>-12</td>
</tr>
</tbody>
</table>
Applications and results ...
**Coal / Biomass – Change of Mixture**

**Signal change during continuous measurement**

- **EUcoalsizer** delivers quantitative readings.

- **Signal changes:**
  - Sieve class >300µm  strong increase
  - Velocity and Mass Flow Air  minor increase
  - Mass Flow Coal  strong increase

- The signal fluctuation is increased significantly with biomass.

- The timing and a periodic pulsing of the biomass addition can be monitored.
Coal / Biomass – Change of Mixture

Test 3C50 – continuous measurements

EUcoalsizer - continuous measurement - <75 µm
Coal / Coal + Biomass

EUcoalsizer - continuous measurement - 150-300 µm
Coal / Coal + Biomass

EUcoalsizer - continuous measurement - <75-150 µm

EUcoalsizer - continuous measurement - >300 µm

EUcoalsizer - continuous measurement - Mean Diameter [µm]

EUcoalsizer - continuous measurement - Mass Flow Air [kg/h]

EUcoalsizer - continuous measurement - Mass Flow Coal [kg/h]

EUcoalsizer - continuous measurement - Mean Velocity [m/s]
Coal / Biomass – Change of Mixture

Observations

- EUcoalsizer reduces test time by more than 50%.

- EUcoalsizer delivers online results and online reports. Essential for the online mill and burner optimisation.

- Further data processing can be fully automated and requires no additional time.

- All measurements are very reproducible <2-3% and mostly independent from human influences.

- The exact timing of the biomass addition and a periodical pulsing can be monitored with the continuous measurement.
Summary ...
Benefits summarised

The coal particle size distribution strongly affects operating conditions e.g.

- Combustion process and efficiency
- Unit efficiency and LoI
- Emissions NO\textsubscript{x}, CO
- Tube erosion
- Slagging

... by manipulating

Though particle size distribution may not appear to be an obvious “manipulated variable” which is in the prime focus of the operator, it can be influenced significantly (voluntarily or involuntarily) by

- Mill condition (wear and tear)
- Mill settings
- Mill speed
- Coal type
Snapshot – Camera inside the boiler

Before …

... and after

Optimisation
- Classifier setting
- Mill speed
- Coal blending
- Online control with camera system
Thank you for your attention!

For more information, please visit us at booth 7A3