Online Fineness Measurement System for Controlling a Biomass Fired Unit

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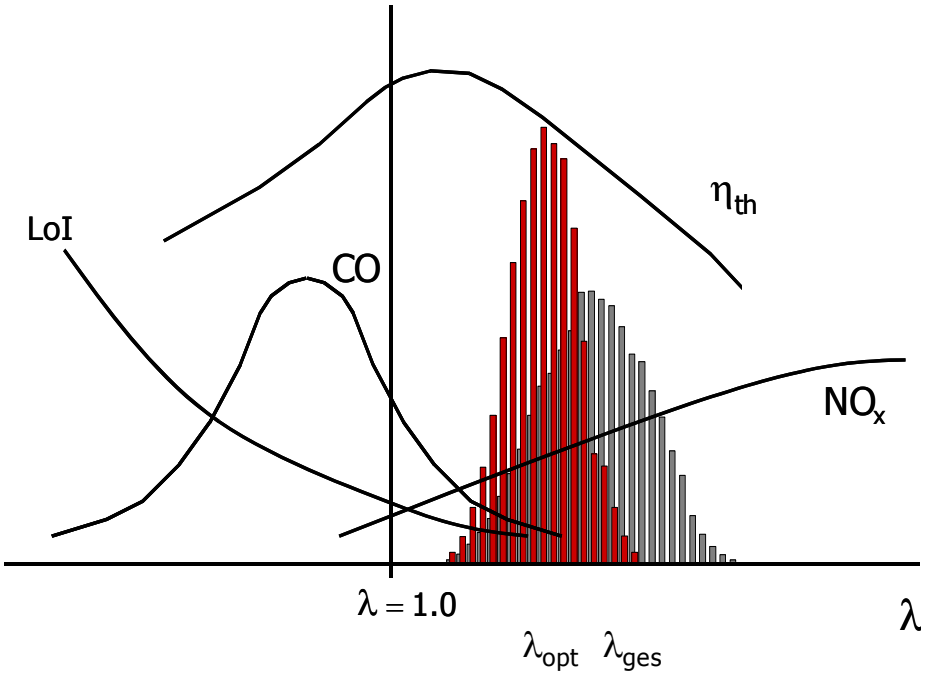
Introduction

Introduction

Air/fuel ratio and performance



Air/fuel ratio (λ) - optimised combustion settings

Air/fuel ratio (λ) - regular combustion settings

Strategy

- 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

- Continuous optimization
- Instantaneous adaptation to load changes

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?

Controllable O&M variable	$\Delta\eta_{th}$
Coal fineness	0.1 - 0.3%
Primary air-flow	0.1 - 0.2%
Fuel line balance	0.1 - 0.3%
Particulate-air ratio	0.1 - 0.3%
Carbon-in-ash (LoI)	0.1 - 0.3%
Excess oxygen	0.1 - 0.3%
Total*	**0.6 – 1.7%**

*** 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

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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

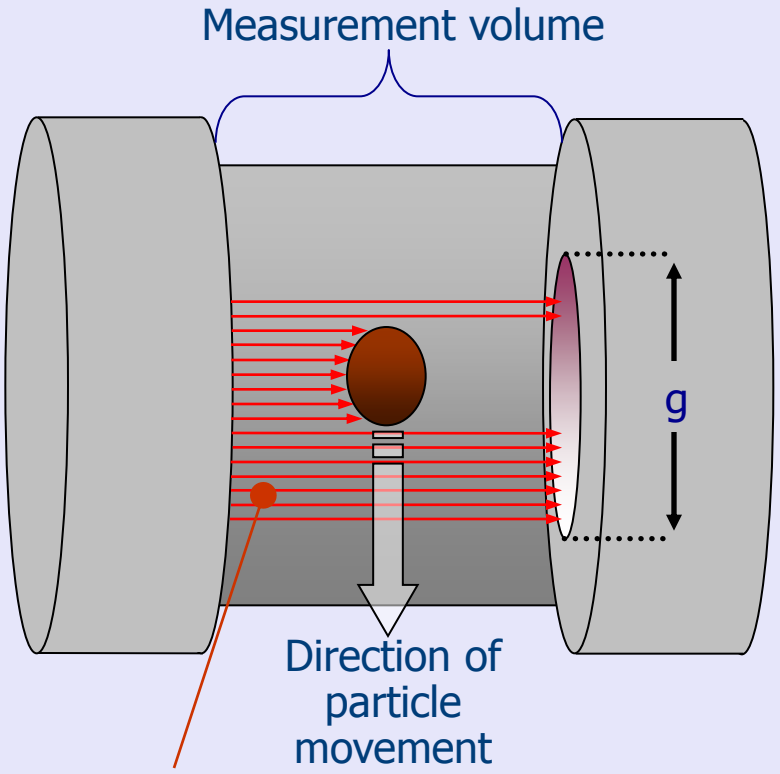
- **Option**: Continuous scanning by automatic traversing probe

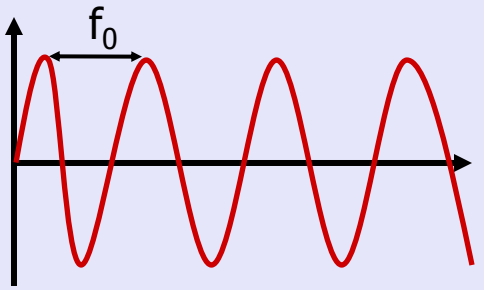
Software

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

System set-up on site

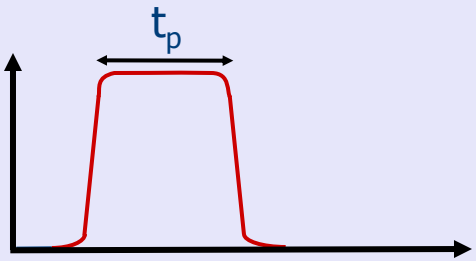
EUcoalsizer – Measurement principle





Particle velocity :

$v_p = f_0 * g$



Particle size:

$x_p = t_p * v_p$

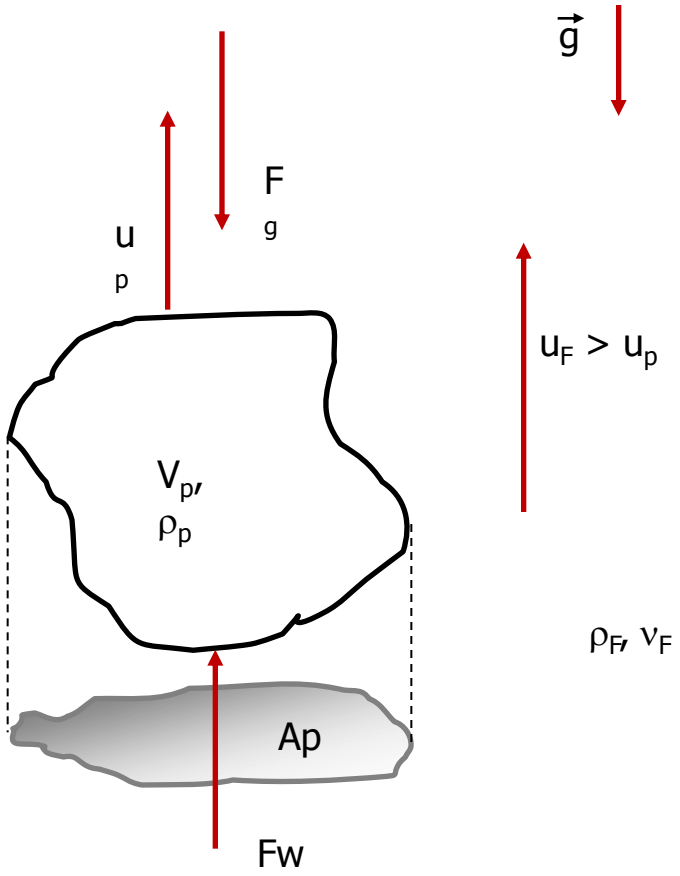
Legend

f_o = frequency analysis of signal t_p = time of flight g = characteristic constant of the optical length

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
- mF ~ (uF , rF)

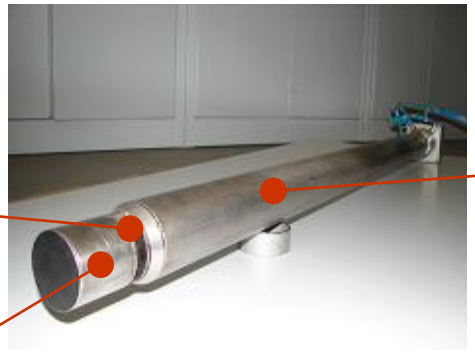
Air / fuel ratio

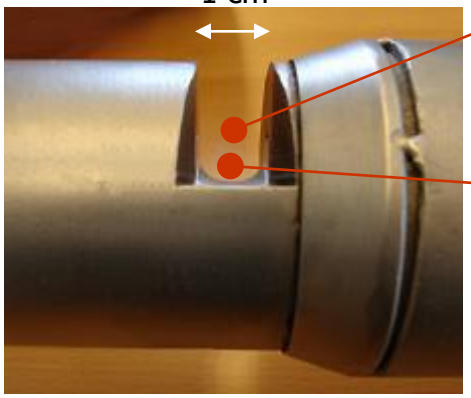
AFR = m_F / m_p

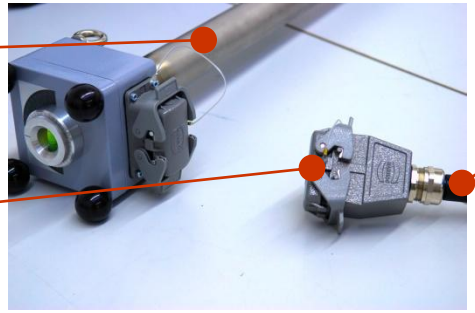
EUcoalsizer – System components

Head of measuring probe with laser emitter and detector

Specially protected probe head for hostile, abrasive environments







Outside protective/cooled shield

Measuring volume

Purging air device (impulse)

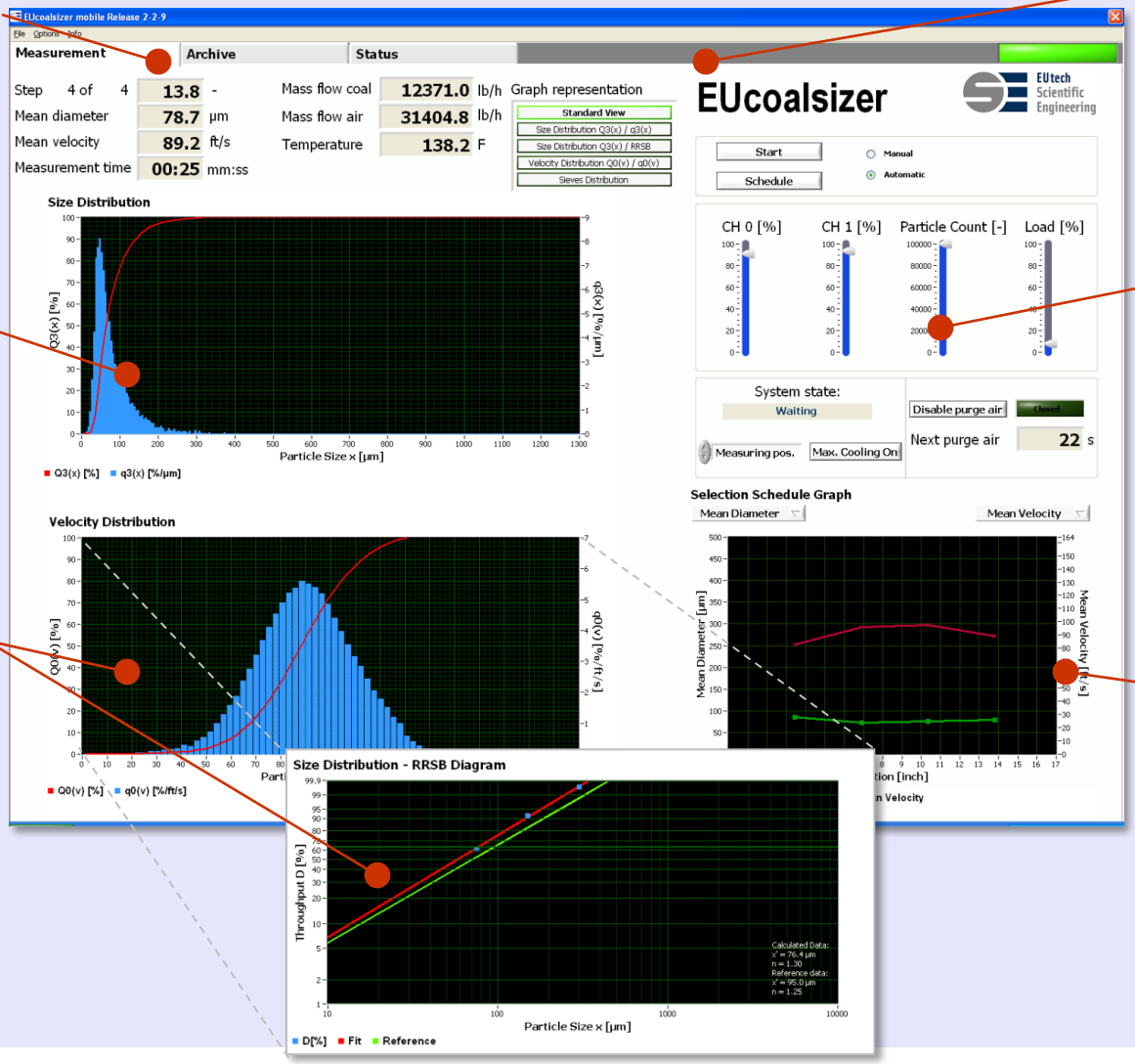
Lance

Harting connector

Hybrid cable

EUcoalsizer – Portable control unit

EUcoalsizer – User interface



Application at coal pipe

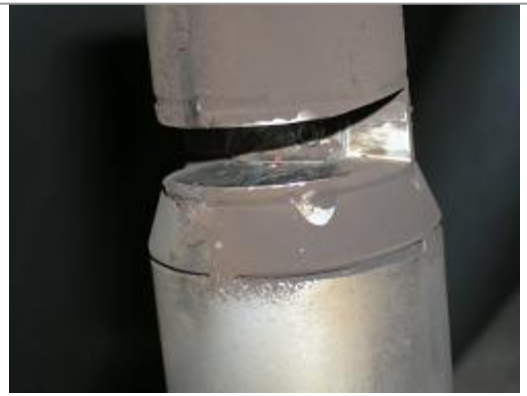
- Measurements at coal-fired TPP

Set-up with probe & media supply

EUcoalsizer measuring probe

Instrumentation opening

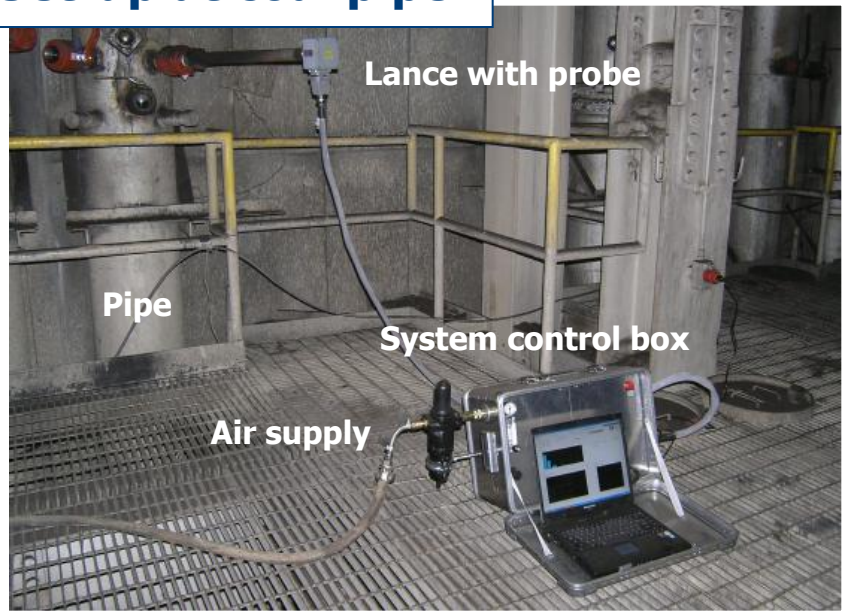
Probe with measuring volume

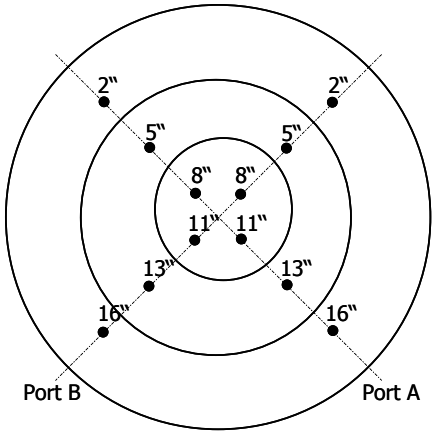


Towards ‘best practices’

EUcoalsizer - Application at Power Station

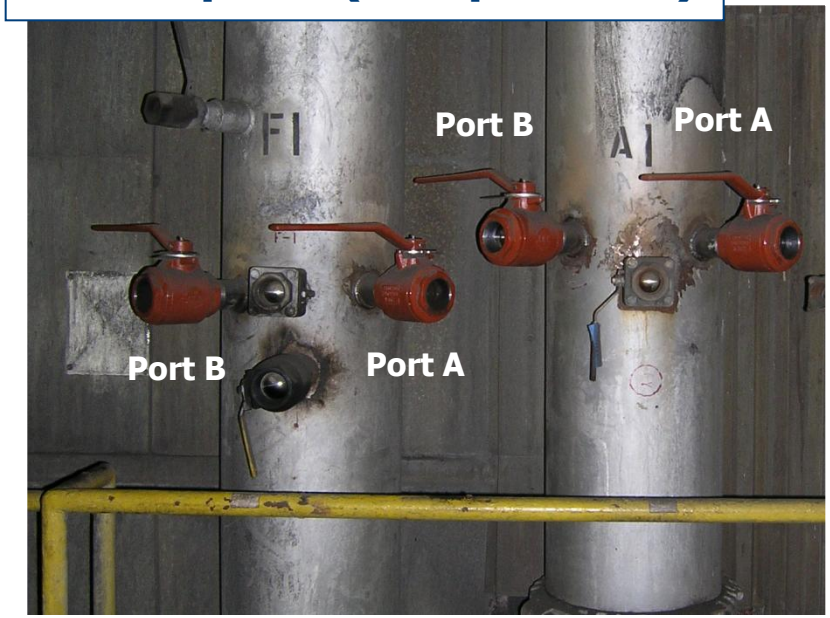
Set-up at coal pipe





- 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

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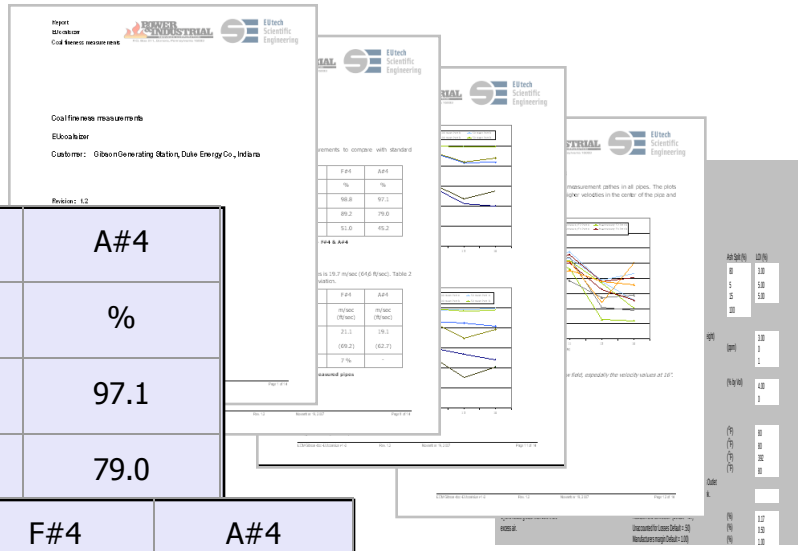


Particle size

	F#1	F#2	F#3	F#4	A#4
	%	%	%	%	%
50 mesh	99.2	98.3	98.4	98.8	97.1
100			81.2	89.2	79.0
200 mesh					

Velocity

	F#1	F#2	F#3	F#4	A#4
	m/sec (ft/sec)	m/sec (ft/sec)	m/sec (ft/sec)	m/sec (ft/sec)	m/sec (ft/sec)
Mean velocity	20.4	17.8	19.4	21.1	19.1
			(63.6)	(69.2)	(62.7)
Std. devi					

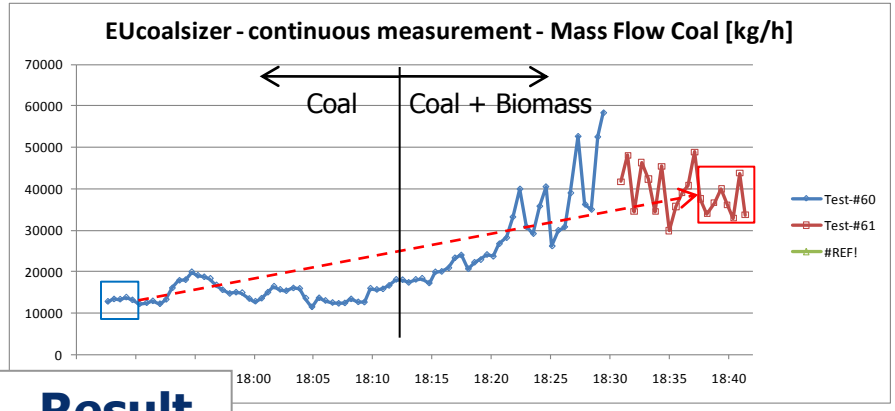
Mass flow (rel.)

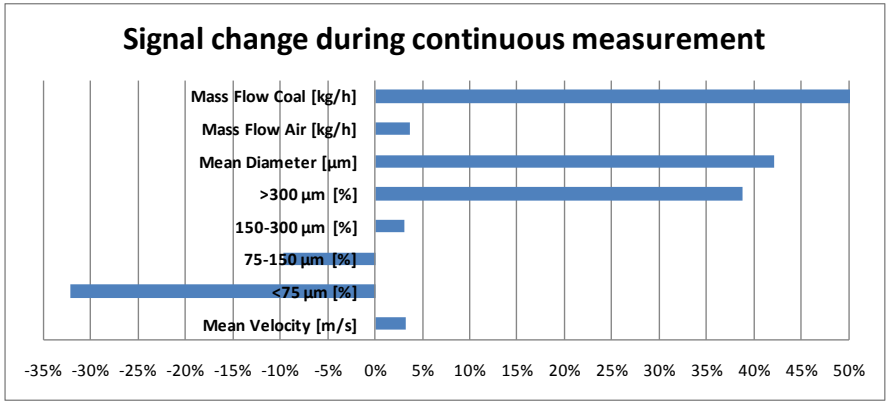
	F#2	F#3	F#4
	%	%	%
Mass flow dev.	6	- 13	19	- 12

Applications and results ...

Coal / Biomass – Change of Mixture

Signal change during continuous measurement



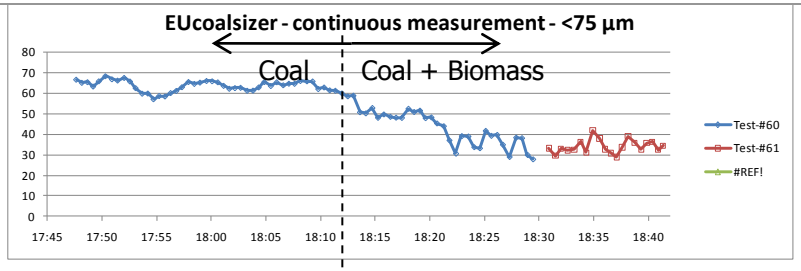


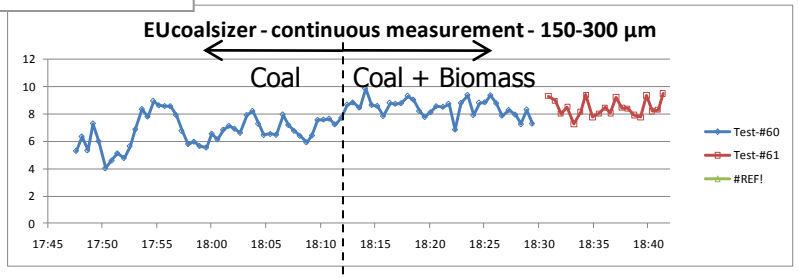
Result

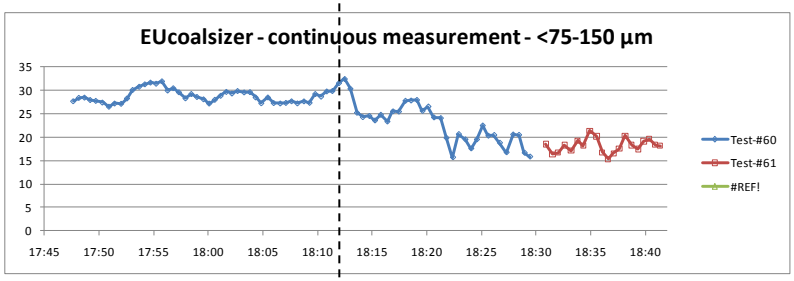
- EUcoalsizer delivers quantitative readings.
- Signal changes:
  - Sieve class >300µm — strong increase
  - Velocity and Mass Flow Air — minor increase
  - Mass Flow Coal — strong increase
- The signal fluctuation is increased significantly with biomass.
- The timing and a periodic pulsing of the biomass addition can be monitored.

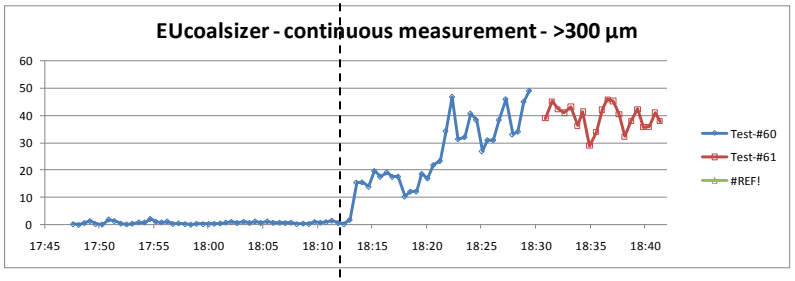
Coal / Biomass – Change of Mixture

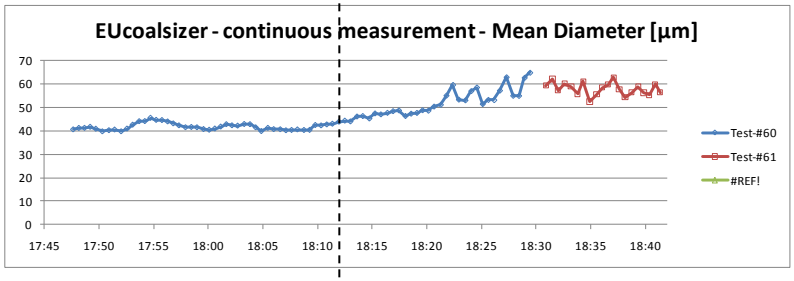
Test 3C50 – continuous measurements

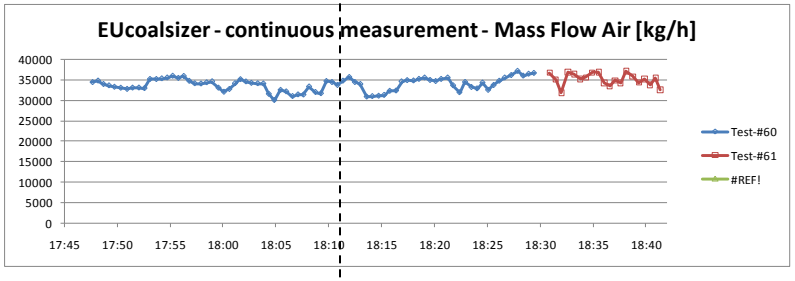


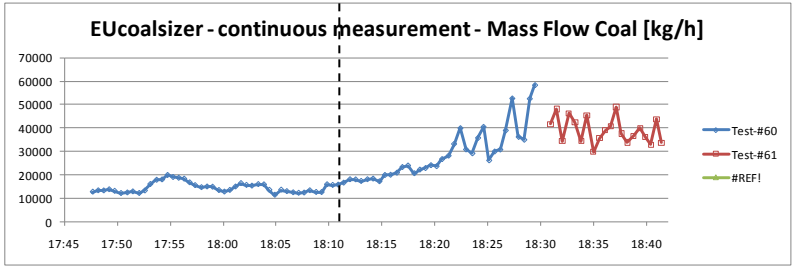


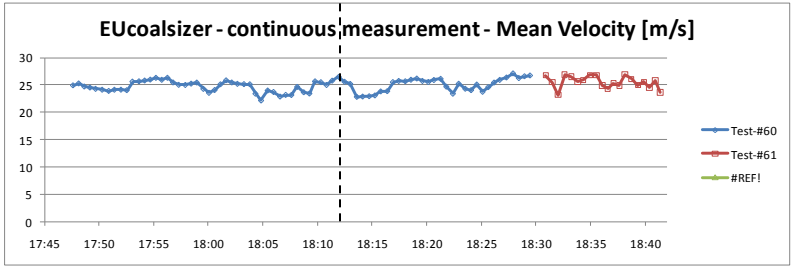












Coal / Biomass – Change of Mixture

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

Benefits ....

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

- Combustion process and efficiency
- Unit efficiency and LoI
- Emissions NO_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

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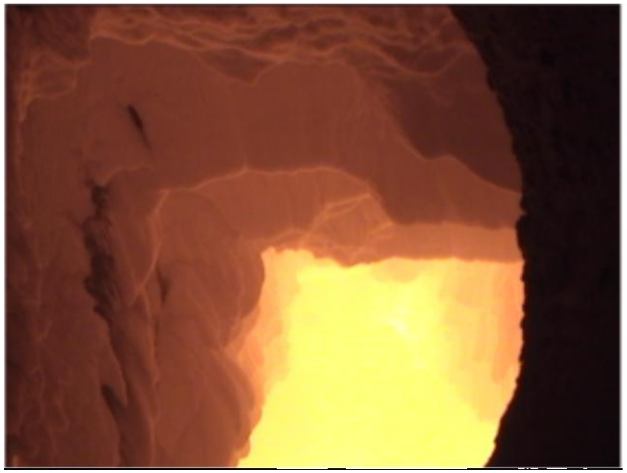
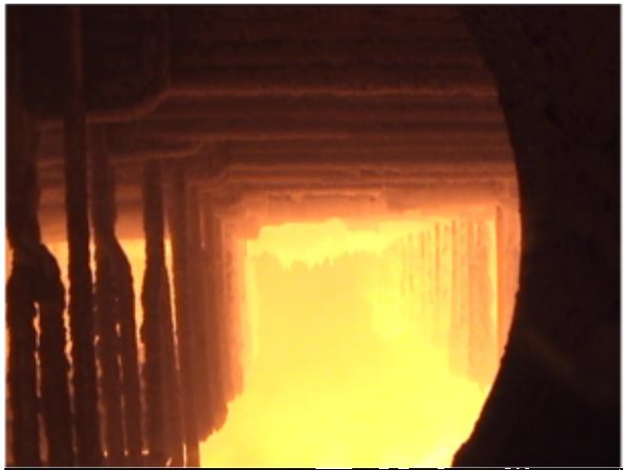
Before …



… and after



Optimisation

- Classifier setting
- Mill speed
- Coal blending
- Online control with camera system

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Thank you for your attention!

For more information, please visit us at booth **7A3**

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