Flue Gas Particle Characterization at Different Parts of the Power Plant

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Introduction

- Power plants and coal combustion are major sources for fine particles

- This work focuses on particle measurements at power plant

- Particle characterization at plant allows
  - Understanding particle formation and transformation
  - Optimization of combustion process
  - Optimization and control of cleaning systems
In this work we present:

• **Sampling system for power plant flue gas PM measurements**
  - Sample dilution in different locations of the plant
  - Controlled sample cooling and VOC control

• **Measurement system for power plant PM measurements**
  - Particle concentration and size measurement at power plant environment

• **Results for**
  - Particle concentration and size distribution in the flame, after heat exchangers and after baghouse filter
    - Size distribution change
    - Effect of baghouse filter cleaning system

• **Discussion**
  About PM transformation
Method 1: Sampling

- Temperature controlled probe
  - Heated and cooled with pressurised air, 200°C
  - Austenitic stainless steel for high temp measurement
- P and T measurement after probe
- Heated sampling line, 200°C
- DEED
  - Two-stage dilution system
  - Control / removal of VOC and water
Method 2: Dilution with DEED

- Three-stage dilution:
  - Heated dilution stage 1:10 reduces gaseous VOC concentration without condensation
  - Evaporation tube at 350°C evaporates already condensed VOCs
  - Cold dilution stage 1:10 cools down the sample without condensation
  - (Extra 1:10 dilution stage on/off)
DEED Offers

- Two or three dilution stages plus evaporation tube
- High dilution ratios: 1:100 and 1:1000
- Controlled sample cooling with low losses
- Heated 1st stage and evaporation tube prevent VOC and other volatile material condensation
Method 3: PM characterization with ELPI

Corona charger

Impactor with insulators and contact needles

Vacuum pump

Computer and control electronics

Electrometers

RS-232 serial

ASCII datafile

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ELPI offers

• Real-time particle size distribution 0.007/0.030 – 10 µm
• Real-time number concentration, estimation for mass
• Wide dynamic range - from ambient concentrations up to power plant levels
• Particles are collected - option for size-selected chemical /physical analysis
• Option for particle charge level measurements (ESP studies)
Measurements:

- 4 MW pilot power plant in Finland
- Circulating Fluidised Bed combustion
- Wood pellets
- Baghouse filter
- Measurement locations:
  - Right after the flame, T=800 °C
  - After heat exchangers, T=200 °C
  - After baghouse filter
Measurements
Results 1: PM concentration

- Flame (hot location) has lower number concentration
- Mass concentration is the same
- Effect of soot blowing – decrease number, increase in mass (fine particle washout)
Results 2: PM size distribution

- Increase in number-based size (and concentration) when T decreases – dominated by small particles
- Mass distribution (coarse particles) remains the same except during soot blowing
- Bi-modal distribution (seen in surface area)
Results 3: Baghouse filter

- Efficiency 90% for number, 92% for mass
- Drop in efficiency at about 100 nm
- Concentration after the filter 10.8 mg/m$^3$
Discussion

• Reason for small particle size change
  – Condensation? Agglomeration?
  – Further chemical and SEM / TEM analysis possible
Conclusions

• A system capable of measuring PM size distribution and concentration in real time at different parts of the power plant – anywhere from the flame to the flue gas exit

• Measurement shows clear change in particle size distribution when flue gas temperature decreases

• Size-resolved filtration efficiency for flue gas cleaning system
Thank you for your attention!