PM CEMS – technology options

Sankar Kannan
Early Air pollution control device

1556
PM CEMS - history
PM CEMS - history

RINGELMANN SCALE

Opacity (%)
PM CEMS- history

RINGELMANN SCALE
PM CEMS- history

BACHARACH SCALE – SOOT NUMBER

Reference scale

Filter paper slot

Pump

Sampling pipe
CEMS

VARIOUS TECHNOLOGIES

PM Measurement

Automated

In-situ

Optical

Transmissiometry

Scatterlight

Non-Optical

Triboelectric

Electro Dynamic

Manual

Extractive

Beta Radiation

Wet Extractive

Gravimetric Sampling (Iso-kinetic)

Manual
Colliding particles exchange their electrical charge with the measuring electrode. The electrical charge transfer depends on the respective mass, velocity and electric charge of the particles.

This effect is used by the so-called “Tribo flow effect”
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ELECTRODYNAMIC

Particles procedure a charge movement by charge induction.

(Charge on the particle transfer charge in the probe as it passes.)

\[ I_{AC} = K_I \cdot K_M \cdot m \]

\( I_{AC} \) = measured AC-current (A)

\( K_I \) = const., function of the geometry of the stack

\( K_M \) = material-dependent

\( m \) = mass-concentration of particulates (mg/s)

Source: Lecture K. Smolders and J. Baeyens, Belgium, I
Points to ponder

- Triboelectric / Triboflow / Electrodynamic is velocity dependent. So not suitable for any process where there is a variation in the velocity.
- Mostly suitable for mass flow measurement and not for instantaneous concentration measurement.
- Widely used as a switch for detection of filter bag rupture
- Internal Zero & Span check is not possible
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DIFFERENT EFFECTS OCCURRING WHEN ILLUMINATING A PARTICLE

reflection

diffraction

absorption

refraction

"Fortschritt-Berichte VDI" Reihe 8, Nr. 773, Düsseldorf: VDI Verlag 1999
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TRANSMITTANCE / OPACITY

Transmission

\[ T = \frac{I}{I_o} \]

Opacity

\[ Opac = 1 - \frac{I}{I_o} \]

Extinction

\[ E = \log \left( \frac{1}{T} \right) \]

Dust concentration is proportional to Extinction

- \( I \) = received light;
- \( I_o \) = emitted light
- \( k \) = extinction coefficient
- \( E \) = extinction
- \( c \) = dust concentration
- \( L \) = length of optical measurement path

(auto-collimating: 2 x distance)
Relationship between
- path length
- particle size
- dust concentration

To measure low concentrations → a long measuring path is required
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SCATTER LIGHT
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DIFFERENT REGIONS OF SCATTERED LIGHT

“Fortschritt-Berichte VDI” Reihe 8, Nr. 773, Düsseldorf: VDI Verlag 1999
Dust concentration in mg/m³
Calibration according to the recommendation of the Guideline VDI 2066.

Direct measured light scattered from particles
Small scattered light intensity requires high measurement accuracy and sensitivity
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Scattered light (forward) probe
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BACKWARD SCATTER LIGHT

Sender
Receiver

Measuring volume
Points to ponder

• Both these opto-electric measurement are time tested and used for a long time

• Transmissiometers are suitable for medium to high concentration of dust.

• Scatterlight instruments are used for measurement of very low to medium concentration of dust

• Various standards are available for dust monitors based on these measurement principles
Particles in the extracted partial gas flow are collected on a filter paper in defined time intervals (approx. 5 min).

Beta-radiation on the filter paper provides measured values directly proportional to the dust weight, not influenced by particle size and color.

Device provides only mean values (normally 5 to 20 min), no information about actual measured values.

Radiation source needs high safety effort.

High costs for consumables.
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WET EXTRACTIVE
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GRAVIMETRIC MEASUREMENT – REFERENCE MEASUREMENT
## PM CEMS- technologies

### SUMMARY

<table>
<thead>
<tr>
<th>Measuring principle</th>
<th>Type</th>
<th>Procedure</th>
</tr>
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<tr>
<td>Gravimetric measurement</td>
<td>extractive</td>
<td>discontinuous</td>
</tr>
<tr>
<td>Beta Ray</td>
<td>extractive</td>
<td>discontinuous</td>
</tr>
<tr>
<td>Scatter light wet gas</td>
<td>extractive</td>
<td>continuous</td>
</tr>
<tr>
<td>Scatter light dry gas</td>
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<td>Triboflow</td>
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<tr>
<td>Transmission</td>
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</tbody>
</table>
Summary

Selection of technology depends on the CEMS- and application requirements, e.g.

- Local regulation requirements
- Gas conditions (gas matrix, gas “wet” or “dry”?)
- Certification of Analyzer by a third party
- Reliability of the Analyzer according to gas conditions
- Measurement task
- Maintenance frequency and availability of support personnel

Each solution is also dependant on investment in comparison with operational costs

Local regulation and engineering and consultancy.
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MANY THANKS FOR THE ATTENTION