Process Monitoring of Suspended Solids with Optical Sensors

OWEA 2016 BIOSOLIDS WORKSHOP

December 1, 2016
Today’s Topics

Process Monitoring

• Sensor Design
• Measurement principles
• Sensor Operation
• Applications

Absorbance & Reflectance Technology
Sensor Design
## Solids Sensor Design

<table>
<thead>
<tr>
<th>Specification</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle</td>
<td>Absorbance or Reflectance (Optical)</td>
</tr>
<tr>
<td>Light Source</td>
<td>Red or NIR</td>
</tr>
<tr>
<td>Materials - probe</td>
<td>Polyurethane or SS</td>
</tr>
<tr>
<td>Materials - window</td>
<td>Quartz or Sapphire</td>
</tr>
<tr>
<td>Measuring Range</td>
<td>Application dependent</td>
</tr>
</tbody>
</table>
Sensor Optics

- Detector
- Backscatter
- Light
- Absorbance
- Nephelometry

< 90°
Measuring Range and Detector Angle

- **90° (DIN, ISO, US EPA)**: 4000 NTU, 2-5 g/l
- **60°**: 5-10 g/l
- **180°**: >10 g/l

Intensity

Turbidity
VisoTurb® 700 IQ

Suspended Solids
ViSolid® 700 IQ
Reflectance-Based Solids Detection

Scattered light depends on:
• Type of particle (absorbance)
• Concentration (number of particles)
• Size of particles
• Shape of particles (absorbance – reflection)
• Wavelength of the light

→ Measuring result is influenced by many effects
→ No measurement of number/concentration of particles
→ Oil and gas bubbles interfere with the measurement
Let Me Show ‘Ya Somethin’
Sensor Operation
Measuring Modes – Type/Units

Turbidity
  FNU (ISO 7027)

Solids
  g/L   TSS
  mg/L  TSS
  ppm  TSS
  %    TSS
  mg/L SiO$_2$
Measuring Modes - Application

MLSS
RAS
Primary / thickened sludge
Digested Sludge
Verification/Calibration Reference
SM 2540 for Solids

2540 G %

TS = total solids
TSS = total suspended solids
TDS = total dissolved solids
VSS = volatile suspended solids
FSS = fixed suspended solids
VDS = volatile dissolved solids
FDS = fixed dissolved solids

2540 F mL/L

2540 D mg/L

2540 E mg/L

TVS
TFS
TS

VSS
FSS
VDS
FDS

Muffle oven

Evaporation of filter

Evaporation of filtrate

Filter (glass fiber)

Imhoff cone

Sample

Settleeble solids

Evaporation

Muffle oven
User Calibration – Correction Factor
### Difficult comparison of instruments of different manufacturers

<table>
<thead>
<tr>
<th>Possible when using:</th>
<th>Not possible when using:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Identical stray angle</td>
<td>• Different stray angle</td>
</tr>
<tr>
<td>• Identical light source</td>
<td>• Different light source</td>
</tr>
<tr>
<td>• Identical sample</td>
<td>• Different calibration standards</td>
</tr>
<tr>
<td>...</td>
<td>• Different compensating methods</td>
</tr>
</tbody>
</table>
Interferences - Environment

Air bubbles – accuracy / precision
• Change Sensor angle
• Increase Signal Averaging

Interferences by reflections – accuracy / precision
• Especially insertion mounts
• Change sensor angle
• User Calibration
Interferences - Fouling

- Biomass
- Grease
- Scale, Iron

Cleaning options:
- Mechanical wiper
- Air or water
- Ultrasonic
- Combination
- Manual
Applications

Upset detection

Polymer dosing

Sludge Wasting
### Sludge Wasting Control

<table>
<thead>
<tr>
<th>SRT</th>
<th>COD removal</th>
<th>COD removal + nitrification</th>
<th>COD removal + nitrification + denitrification</th>
<th>COD removal + nitrification + P removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>function</td>
<td></td>
<td></td>
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</tbody>
</table>

The graph illustrates the effect of different operational strategies on sludge wasting control, showing an increase in SRT as the complexity of the treatment processes increases.
The Concept of Solids Retention Time

- Every organism has a regeneration time
- For organism to proliferate $SRT > \text{Regen Time}$
- Washout is when $SRT < \text{Regen Time}$
Sludge Wasting

\[ SRT = \frac{\text{Inventory}}{\text{Wastage}} = \frac{(V) \times (MLSS)}{(Q_w \times X_r) + (Q_e \times X_e)} \]
Sludge Wasting

\[ SRT = \frac{\text{Inventory}}{\text{Wastage}} = \frac{(V) \times (MLSS)}{(Q_w) \times X_r} \]
Sludge Wasting Control Example
Questions?