Biogas Monitoring – Technologies, Challenges, Solutions
Jan Talkenberger, Manager International Sales, Binder GmbH
Introduction

- Binder’s core business is Gas Flow Metering and Control.
- Aeration Control System & Digester Gas Flow Metering & Gas Analysis
Monitoring of gas quality and quantity
Challenges and technologies
Measurement of MJ
Summary
Why is it necessary to monitor Biogas Plants?
Parameters to be monitored in a biogas plant

Gas production and composition

Process parameters in the digester (pH, temperature, ..)
Equipment used for treatment and utilization of the biogas

- H$_2$S scrubber
- Blowers or compressors
- Biogas engine (CHP unit)
- Biogas upgrade technology (Membrane, …)

Typically this all are sophisticated and rather expensive devices.
How monitoring of biogas becomes essential

- Performance of H$_2$S scrubbers:
  - Control operation of H2S scrubber according to cleaning performance or oxygen values

- Control and adjustment of CHP units
  - Adjust engine parameters according to changing CH4 concentration

- Grid injection or other further use
  - Monitor gas quality (composition) and quantity
Example: Monitoring of \( \text{H}_2\text{S} \) concentration

- \( \text{H}_2\text{S} \) filter shall clean the gas to a suitable concentration for following equipment
- Performance of the \( \text{H}_2\text{S} \) filter depends on its principle and handling
- \( \text{H}_2\text{S} \) concentration at scrubber output must be monitored!
  - Scrubber performance check
  - Protect the gas-using equipment, e.g. CHP engine
## Cost - CHP engine repair vs. Gas Analyzer

<table>
<thead>
<tr>
<th>CHP breakdown</th>
<th>Gas Analyzer</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHP repair: 20.000 – 50.000 EUR</td>
<td>Purchase: 8.000 – 10.000 EUR</td>
</tr>
<tr>
<td>Loss of income: 1.000 – 10.000 EUR</td>
<td>Installation: 1.000 EUR</td>
</tr>
<tr>
<td></td>
<td>Maintenance: 1.000 EUR / year</td>
</tr>
<tr>
<td><strong>Total:</strong> 21.000 – 60.000 EUR</td>
<td><strong>Total:</strong> 10.000 – 12.000 EUR</td>
</tr>
</tbody>
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↓

Thread: bankruptcy of plant operator

Additional benefit: use measured parameter to operate the plant more efficient and economic
It is highly advisable to analyze the composition of the biogas in the raw state and before the CHP regarding \( \text{CH}_4 \), \( \text{H}_2\text{S} \) and \( \text{O}_2 \). Thus, changes in the biogas and the cleaning measures function can be monitored. The analysis must be made regularly at least daily. In case of unevenly distributed feeding and expected fluctuations in the biogas composition, the analysis frequency needs to be adapted.

It is advisable to use gas analyzer with set-limits and alarm and opportunity to integrate them into an existing plant control. Methane sensors must be pressure and temperature compensated; hydrogen sulphide sensors also need to be sufficiently resistant with peak concentrations. Regular calibration according to the manufacturer's instructions are generally to follow..."
Why is process monitoring necessary?

- **Supervision** of individual components, e.g. H$_2$S scrubber
- **Protection** of sensitive equipment, e.g. CHP-engine
- **Preventive alarm** settings to react timely on process fluctuations
- **Improve** feeding cycles and reduce raw material usage
- **Comply** to legal requirements, e.g. evidence of biogas production and gas-quality

→ *Increase of safety, efficiency and profitability*
Biogas particularities
### BIOGAS – a mixture of different gases

<table>
<thead>
<tr>
<th>Gas component</th>
<th>Description</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH4 (Methane)</td>
<td>The product which we want</td>
<td>Maximize yield</td>
</tr>
<tr>
<td>H2S (Hydrogen Sulfite)</td>
<td>The problem</td>
<td>Toxic and corrosive</td>
</tr>
<tr>
<td>O2 (Oxygen)</td>
<td>Carefully to be watched</td>
<td>Avoid explosion</td>
</tr>
<tr>
<td>CO2 (Carbon Dioxide)</td>
<td>Complementary to CH4</td>
<td></td>
</tr>
</tbody>
</table>
Typical measurement locations

(1) Substrate pre-treatment
(2) Feeding unit
(3) Hygienization
(4) Main Digester

(5) Secondary digester
(6) Fermentation residue
(7) Gas storage/H₂S scrubber
(8) Use for burners

(9) CHP-unit
(10) Satellite CHP-unit
(11) Flare
(12) Gas-upgrading
### Gas qualities on the different measuring points

<table>
<thead>
<tr>
<th>Gas Production</th>
<th>Gas User</th>
<th>Gas Upgrade</th>
</tr>
</thead>
<tbody>
<tr>
<td>dirty, wet, corrosive</td>
<td>Less dirty, partly dry, corrosive</td>
<td>Clean, dry</td>
</tr>
<tr>
<td>low pressure (-3...+3 mbar)</td>
<td>higher pressure (40...80 mbar)</td>
<td>high pressure (bar ranges)</td>
</tr>
<tr>
<td>low velocities (0,5...3m/s)</td>
<td>higher velocity (8...15 m/s)</td>
<td>high velocity</td>
</tr>
<tr>
<td>CH4 48-54 Vol.-%</td>
<td>CH4 48-54 Vol.-%</td>
<td>CH₄ 95-98 Vol.-%</td>
</tr>
<tr>
<td>H₂S up to 10000 ppm</td>
<td>H₂S &lt; 100 ppm</td>
<td>H₂S &lt; 2 ppm</td>
</tr>
<tr>
<td>O₂ 0-1 Vol.-%</td>
<td>O₂ 0-1 Vol.-%</td>
<td>O₂ 0-1 Vol.-%</td>
</tr>
<tr>
<td>CO₂ 38-42 Vol.-%</td>
<td>CO₂ 38-42 Vol.-%</td>
<td>CO₂ 2-5 Vol.-%</td>
</tr>
</tbody>
</table>
Definition Standard-Cubic-Meter

Measuring volumetric flow

compensation

Standard Volume $V_0$

Gas Mass $m$

$p$ & $T$ compensation necessary for:

- Orifice plates DP
- Vortex flow meter
- Turbine meters/ mechanical counters
- Ultrasonic flow meter
- Pitot tubes
- ...
Technologies for Flow & Analyze of Biogas
BINDERMIR® - thermal gas flow measurement
Temperature:
Sensors measure resistance (by use of Pt100 sensors) – second sensor provides as reference

Principle:
Dispersed heat provides as reference for the amount of gas-molecules passing by → direct mass-flow measurement

Advantages:
Unaffected by pressure and temperature changes, very low pressure drop, precise even at low flow rates, reference sensor can be used to provide the gas temperature.

Challenge:
A CH₄-molecule disperse a different amount of heat than a CO₂-molecule etc. Also water damp molecules disperse heat.
BINDER Gas analysis
BINDER

Analyzer station **COMBIMASS® GA-s Hybrid**

The New flexible modular analyzer system:

- flexibility in cabinet sizes & material
- flexibility in size of graphic display
- flexibility in gas cells
- flexible for indoors/outdoors
- flexible in sampling frequency and sequence (continuously/ frequently)
- **Easy assembly and maintenance**

Modular System for specific customer’s requirement
Energy Measurement
Tax options for biogas plants

- Based on energy measurement
- Based on max. possible output

→ Energy measurement is clearly in favor

But: whole measurement must be better than 3% accurate
GA-s hybrid for energy measurement

- One single sampling point in combination with one CH4 gas module
- Implementation of thermal dispersion gas flow meter (with integrated humidity correction for the measurement of dry biogas flow), Automatic correction for actual gas composition
- Automatic correction of gas composition based on ambient atmospheric pressure and gas temperature
- **Calculation of energy contents** in the gas based on gas flow and gas composition with an overall **accuracy of better than 3%**
- Various alarm settings and transfer to the PLC possible, direct wiring via Ethernet, external access as well as data transmission/”life-bit” function via GSM/GPRS
- Auto-calibration function
- Gas feed-back from analyzer into the gas pipe possible
GA-s hybrid for energy measurement

...see the real product on the exhibition table
Conclusions
Conclusion

- Importance of Plant Monitoring
- Suitable solution for particular requirements
- Maintenance made easy

→ stable, safe and profitable operations
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Visit the booth outside in the hall