Internal Digester Heating Systems

Internal Digester Heating Systems

Overview

- Introduction of the BRUGG Organization
- Different types of digester heating systems
- Internal digester heating systems
- Considerations for the selection of internal digester heating systems
- Sizing of continuous corrugated stainless steel pipe heating systems
- Installation of continuous corrugated stainless steel pipe heating systems
- Maintenance of corrugated stainless steel pipe heating systems
The Brugg group
Headquartered in Brugg, Switzerland

Headquarter in the town of Brugg, 30 km west of Zurich.
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Digester Heating Systems

1. External Heating Systems
e.g. Heat Exchanger to pre-heat the input material to process temperature

- Genset
- Substrate
- Heat Exchanger
- Process temperature e.g. 100°F
Digester Heating Systems

1. **External Heating Systems**
   e.g. Heat Exchanger to pre-heat the input material to process temperature

2. **Internal Heating Systems**
   e.g. Heating pipes installed right at the digester wall

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**process temperature**

**e.g. 100°F**
Internal Heating Systems

Smooth bore pipe
e.g. 2" / DN50
(stainless) steel
Internal Heating Systems

Smooth bore pipe
e.g. 2" / DN50
(stainless) steel

Plastic pipe
e.g. 1" / DN25
polyethylene
Internal Heating Systems

- **Smooth bore pipe**
  - e.g. 2” / DN50
  - (stainless) steel

- **Plastic pipe**
  - e.g. 1” / DN25
  - Polyethylene

- **Corrugated pipe**
  - 2” / DN50
  - Stainless steel 316 L
Internal Heating Systems

Considerations for the selection of internal pipe heating systems

- Heat Transfer?
- Durability?
- Installation?
Heat Transfer

Carbon steel

- Carbon steel has reasonable heat transfer properties...
  - ...but wall thickness of approx. 2mm.
  - Medium heat transfer efficiency

PE-pipe

- Polyethylene has poor heat transfer properties...
  - ...and wall thickness above carbon steel.
  - low heat transfer efficiency = large amount of pipe to be installed

Corrugated stainless

- Helically corrugated stainless steel has excellent heat transfer properties...
  - ...and through corrugation has 40% more heat transfer area than smooth bore pipe.
  - Excellent heat transfer properties = minimum amount of pipe to be installed
Efficiency of Heat Transfer

Heat transfer from hot water to substrate subject to:

- heat conductivity of pipe material

- Stainless Steel = 30 W/m*K
- Carbon Steel = 80 W/m*K
- Polyethylene = 0.5 W/m*K
Efficiency of Heat Transfer

Heat transfer from hot water to substrate subject to:

- heat conductivity of pipe material
- “Internal” heat transfer rate
  - from hot water to the pipe surface
Heat Transfer in Corrugated Pipe

- Turbulent flow condition inside the pipe
- Eddy current in corrugation improves heat transfer rate
- Optimum heat transfer from heating medium through pipe wall
Efficiency of Heat Transfer

Heat transfer from hot water to substrate subject to:

• heat conductivity of pipe material

• “Internal” heat transfer
  ➢ from hot water to the pipe surface

• “external” heat transfer
  ➢ from pipe wall to substrate
Heat Transfer in Corrugated Pipe

Agitated flow outside

Corrugation increases heat transfer to the substrate

Optimum heat transfer from heating medium to substrate
Efficiency of Heat Transfer

Heat transfer from hot water to substrate subject to:

- heat conductivity of pipe material
- “Internal” heat transfer
  - from hot water to the pipe surface
- “external” heat transfer
  - from pipe wall to substrate
- Actual heat exchange surface per length of pipe
Efficiency of Heat Transfer

- **Straight pipe 2”**
- **Corrugated pipe 2”**
- More surface
- \(+40\%\)
- Less pipe

BRUGG PIPESYSTEMS Flexible solutions
Efficiency of Heat Transfer

k-value in a heating pipe dependent on the external flow velocity at a 45° angle

- corrugated pipe
- smooth bore pipe

![Graph showing k-value vs. external flow velocity for different flow velocities and pipe types.](image)

- Internal flow $v = 0.4 \text{ m/s}$
- Internal flow $v = 0.1 \text{ m/s}$

- Ca. 200% increase in efficiency
**Efficiency of Heat Transfer**

**EXAMPLE:** *Biogas plant „Schnega“ (Lower Saxony)*
Replacement of plastic pipes with corrugated stainless steel pipes

<table>
<thead>
<tr>
<th>PE – pipes</th>
<th>Corrugated ss pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td>heating circuits</td>
<td>13</td>
</tr>
<tr>
<td>loops</td>
<td>13</td>
</tr>
<tr>
<td>length [m]</td>
<td>936</td>
</tr>
<tr>
<td>Q [kW]</td>
<td>100</td>
</tr>
<tr>
<td>Ø = 23 m</td>
<td></td>
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<tr>
<td>H = 6 m</td>
<td></td>
</tr>
<tr>
<td>V = 2493 m³</td>
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</table>
Considerations for the selection of internal pipe heating systems

- Heat Transfer!
- Durability?
- Installation?
Installation

Carbon steel

- Pipe sections need to be bent prior to installation...
- ...and welded or threaded frequently creating multiple potential leak points!
- High labor costs and potential leaks over time!

PE-pipe

- Plastic pipes are “endless” and flexible...
- ...but large quantities required due to limited heat transfer.
- Easy installation, but lots of pipe and supports to be installed!

Corrugated Stainless

- Flexible stainless steel pipe...
- ...no joints inside digester and smallest quantity of pipe to be installed!
- Easy and fast installation, long life!
Installation

1. Installation of pipe supports
2. Unrolling the pipe
3. Attaching the pipe
4. Installation of end fittings
5. Completed digester pipe installation

- “endless” pipe
- quick installation
- reduction of installation time
- reduction of installation costs

→ Installation of the digester heating system in just a few hours
Considerations for the selection of internal pipe heating systems

- Heat Transfer!
- Durability?
- Installation!

Digester Heating
## Durability

### Carbon steel
- Welded or threaded joints over time can be subject to Microbiological Induced Corrosion (MIC)!
- Reduced lifetime and higher maintenance / replacement costs!

### PE-pipe
- Plastic (PEX) pipe over time is subject to diffusion and reduction of plasticizer.
- Reduced lifetime and higher maintenance / replacement costs!

### Corrugated Stainless
- Flexible stainless steel pipe...
- no joints or welds inside digester
- Long lifetime and no maintenance!
EXAMPLE: Biogas plant „Schnega“ (Lower Saxony)
Replacement of plastic pipes with corrugated stainless steel pipes

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<tr>
<td>Corrugated ss pipes</td>
<td>1</td>
<td>2</td>
<td>145</td>
<td>100</td>
</tr>
</tbody>
</table>
BIOFLEX Digester Heating System

- BIOFLEX 2" corrugated pipe
- "Endless" → no joints
- Wall thickness 0.02"
- Stainless steel 316L
The World of BIOFLEX

In Europe more than 900 Biogas plants equipped with corrugated stainless steel pipe BIOFLEX.

- Germany
  - > 7200 Biogasplants
  - > 800 equipped with BIOFLEX
- Italy
  - 500 Biogas plants in total
  - > 45 equipped with BIOFLEX
- Austria
- Spain
- France
- Hungary
- Denmark
- Finland
The World of BIOFLEX

- Germany: > 7200 Biogas plants > 800 equipped with BIOFLEX
- Italy: 500 Biogas plants in total > 45 supplied with BIOFLEX
- Poland
- Great Britain
- Netherlands
- Latvia
- Switzerland
- Austria
- Spain
- France
- Hungary
- Denmark
- Finland
In the United States 25 digesters equipped with corrugated stainless steel pipe BIOFLEX

- Oregon
  - Junction City
  - Aumsville
  - Dayton
- Pennsylvania
  - Salunga
- North Carolina
  - Magnolia 2x
- South Carolina
  - Moncks Corner
- Ohio
  - Akron
- New York
  - Lawnhurst
- Wisconsin
  - Fond du Lac
  - Alma Center
US References

**Project:**
Loch Mead Farms in Junction City, OR
Revolution Energy Solutions
- 2 Digesters, Volume xxxx ft.³, ø xx ft.
- sequentional batch
- psychrophillic (approximately 80 °F)

**Digester heating system (per digester)**
- 2 heating circuits
- 4 loops in total
- pipe run 595 ft.
US References

Project:
KB Compost Services, Akron, OH
Workman Industrial
- 2 Digesters, Volume xxxx ft.³, ø xx ft.
- mesophillic (approximately 100 °F)

digester heating system (per digester)
- 4 heating circuits
- 4 loops in total
- pipe run 860 ft.
Conclusions

• For efficient biogas production it is necessary to maintain proper process temperatures
• Different types of heat exchangers (external / internal)
• Different types of pipe for internal heat exchangers
• Best choice: Stainless steel corrugated pipe

➤ BIOFLEX by BRUGG Pipesystems LLC
Thank you for your attention
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