FLOX®-LCV Gas Utilization at Biogas Upgrading Plants

Application
At biogas upgrading plants three different gas types can be distinguished.

1. Biogas produced anaerobically from different types of biomass (~ 55 – 70 Vol.% CH₄). Biogas is frequently used as fuel in combined heat and power (CHP) facilities. Biogas may be used in a separate hot water boiler to provide peak load heat for the fermentation process.

2. Biomethane often called substitute natural gas (SNG, ~ 98 Vol.% CH₄) is upgraded biogas suitable to be injected into the gas grid.

3. Low caloric value (LCV) gas formed e.g. by CO₂ separation and methane slipping from the upgrading process (approximately > 90 Vol.% CO₂, rest CH₄). LCV gas is considered as harmful greenhouse gas and thus has to be minimized or treated.

e-flox GmbH offers various ranges of LCV gas combustors. The modular system can be scaled from 20 Nm³/h to about 1000 Nm³/h LCV gas flow. The gas may consist of 2 – 20 Vol.% CH₄ in CO₂. The whole facility is installed within a container allowing fast and easy set up on site.

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All systems can be designed to provide heat to the digester by a highly efficient waste heat recovery system. This information sheet describes a modular system for larger LCV gas flows.

**Description of the FLOX®-LCV combustor**

The LCV gas has to be fed to the combustor with a pressure of 50-80 mbar. If required e-flox supplies an LCV gas fan for this purpose. The combustor is an insulated (adiabatic) combustion chamber where LCV gas burners and air injectors are installed in the furnace roof.

Both, the LCV gas burners and the air injectors are based on recuperative burner systems (Figure 1). The recuperator is a counter flow heat exchanger made of high temperature steel. The fins on the heat exchanger improve the heat transfer. The hot flue gas coming from the combustor passes the outer surface of the recuperator, transferring heat to the inner surface where air or LCV gas flows to the burner nozzle. The temperature in the furnace is around 900°C. At least one of the burners is equipped with an additional flame burner which is required to heat up the combustor to the operation temperature of about 850°C. Natural gas, LPG or digester gas can be used as a fuel for the flame burner. Once the operation temperature is reached the system switches to FLOX®-mode where LCV gas can be burned.

The arrangement of the burners, the design of the burner nozzles and the combustion control system ensure that the combustor works in flameless oxidation (FLOX®) mode. Due to a high internal recirculation of hot combustion products the LCV gas, air and flue gas mixes almost perfectly before oxidation starts. Thus, oxidation appears not only on a flame surface, but in the entire combustor volume. This makes sure that all combustibles are completely oxidized. CO and CH₄ emissions are typically below 10 ppm. Due to the homogeneous temperature profile thermal NOx formation is suppressed almost completely. These are benefits in comparison with catalytic combustion systems where the degree of conversion of combustibles depends heavily on the available catalyst surface and the residence times of the gas. Figure 2 shows an example of such a LCV combustor system for 700 m³/h of LCV gas with down to 2% Methane.

Optionally secondary air nozzles for the injection of cold air and a hot gas bypass system to extract the hot flue gas directly and not via the recuperators can be integrated. Both measures allow to cool the furnace if the methane concentration in the LCV gas is higher than so called autothermal CH₄ concentration which is sufficient to maintain the operation without auxiliary fuel. The minimum autothermal concentration depends on the burner type and the gas composition. The following table gives an overview for the different burner types available.
Tailor made design

e-flox calculates a computer based mass- and energy balance of the combustion process. The model is based on the overall LCV gas flow and the gas composition. With this data the size and number of the recuperators and burners is determined. Furthermore secondary air nozzles and hot gas bypass systems are included if required. The simulation gives also information on the energy available as waste heat and the flue gas composition.

Optional auxiliary equipment

Heat recovery boiler: The combuster produces, depending on the heating value of the LCV gas, a flue gas with 500-800°C. If there is no direct use for the hot flue gas, e.g. in a drying process, a hot water, steam or thermal oil boiler can be attached. e-flox is able to supply complete systems where the recovery heat boiler is connected to the combustion control system. Furthermore a hot gas stack can be added to bypass the boiler if the heat is temporarily not required.

Intermediate gas storage: If the gas flow and the gas concentrations of the LCV gas fluctuate, a system to buffer and homogenize the gas flow might be necessary. e-flox provides a storage system which is integrated in a metallic silo. An ultrasonic sensor measures the filling level and uses the signal to control an LCV gas fan. This fan feeds the LCV gas to the combustor. The size of the gas storage depends on

<table>
<thead>
<tr>
<th>Burner type</th>
<th>Rekumat C</th>
<th>Rekumat M</th>
<th>Rekumat S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency of the heat exchanger</td>
<td>medium</td>
<td>high</td>
<td>very high</td>
</tr>
<tr>
<td>Autothermal CH₄ concentration in CO₂</td>
<td>6 Vol%</td>
<td>3.6 Vol%</td>
<td>2.5 Vol%</td>
</tr>
<tr>
<td>Autothermal CH₄ concentration in air</td>
<td>4.5 Vol%</td>
<td>3 Vol%</td>
<td>2 Vol%</td>
</tr>
<tr>
<td>chemical durability</td>
<td>high</td>
<td>medium</td>
<td>medium</td>
</tr>
<tr>
<td>fouling vulnerability (particulate matter, siloxane, etc.)</td>
<td>low</td>
<td>low</td>
<td>medium</td>
</tr>
<tr>
<td>Max. combustion temperature</td>
<td>1200°C</td>
<td>1000°C</td>
<td>1000°C</td>
</tr>
</tbody>
</table>

Figure 2: 3-D view of a 500 Nm³/h LCV combustor
the gas flow and its fluctuations. 

Heat storage: If hot water is produced, e.g. to heat the fermenter of a digester plant, the heat demand may change considerably due to fermenter needs. To buffer this fluctuations in heat demand or heat production a hot water heat storage of sufficient size should be included. This allows complete use of the recovered heat, minimizing the need for supplemental fuel. A special feeding and extraction system creates a thermal layering within the heat storage to improve the storage performance.

Figure 3: CAD Design of a LCV 250 combustor with heat recovery boiler and 10 m stack, integrated in a 30 ft container

Inquiry form

Customer address and contact data:
Name: __________________________________________________________________________
e-mail: __________________________________________________________________________
Tel.: ______________________________________________________________________________
Address: __________________________________________________________________________

LCV gas: Volume flow (min/max m³/h): ______________
         CH₄-content (min/max Vol.%): ______________

Optional modules:
□ bio gas compressor  □ gas analyser  □ heat recovery boiler (………..kW)
□ Intermediate gas storage  □ heat storage