Multi-chamber Biogas Reactor

Innovative Reactor Design «Meets all Expectations»

PFI Biotechnology has been operating its own highly innovative biogas plant to produce green electricity since the start of 2014. PFI staff member Dr. Michael Müller will describe the design of the plant and the operating experience gained so far at the international « Progress in Biogas III » conference to be held in Stuttgart on 10 September.

Traditional biogas plants have a somewhat unenviable reputation of causing nuisance noise and odour emissions, of requiring labour-intensive feeding and an external heat supply for fermenter heating, and of suffering from loss of substrate carbon due to hydrolysis reactions during substrate storage.

Thanks to the innovative Multi-Chamber Biogas Reactor (MCBR, see Fig. 1) developed by PFI Biotechnology, however, biogas plants may well soon shed their negative image: New features include not only the chamber system but also intelligent heat management for the fermenter system which supplies biogas to a combined heat and power generation plant (CHP) having an electrical output of 550 kW. Pumpable and poorly degradable biomasses such as sugar beet pulp or grass silage serve as feedstock for the MCBR. The circular reactor is made up of 12 chambers, five of which are reserved for the hydrolysis step. The others are used as fermenter and as substrate and digestate storage chambers. Most notably, this 12-chamber design means that all components of the biogas plant are located in a single container. This new type of reactor therefore has a 40 % smaller land footprint than traditional plants providing the same output. Moreover, the entire carbon of the substrate is contained, thus eliminating odour emission.

The novel reactor functions in the following way: The system pumps substrate from the storage chamber into the hydrolysis unit. Solid substrate can also be added via a solids feeder. Pre-acidification at various thermophilic temperature levels is performed in the hydrolysis section before the material is pumped on to the fermenter. The advantage of pre-acidification lies in the reduced residence time of about 20 days. The digestate is then pumped to another empty chamber.

The external walls and floors as well as the intermediate ceiling below the gas storage are insulated. The system was designed to cut heat losses to the environment to just one fifth of the level known for traditional plants. For this reason excess heat generated by metabolic activity tends to accumulate in the reactor. A heat pump positioned at the centre of the system is able to cool the chambers via a pipe system in the floors and walls and at the same time deliver the heat absorbed for thermally demanding tasks such as sanitation of the digestate.

The goal of this reactor design is to attain thermally self-sufficient operation with a reduced retention time for maximum biogas yield from poorly degradable substrates such as straw. Moreover, the design permits expansion to a biorefinery. The plant was successfully commissioned in January 2014. The organic dry matter content (ODM) of the reactor is 4.27 %. When fed with 50 t of sugar beet pulp per day the volumetric load is currently 4.3 kg ODM/(m^3 × d), corresponding to a residence time of 24 days.

The concentrations of all relevant organic acids, such as acetic acid, propionic acid, butyric acid, and valeric acid were found to lie below 100 mg/kg. The pH is stable at 7.77. The temperature of the methane reactor is constant at 48 °C. At present, no heating is necessary to maintain a constant temperature. In operation the system has an average electrical output of 550 kW, based on an average gas consumption of 302 m^3/h with a methane content of 55 %. The reactor meets all expectations. Additional results will soon be available.

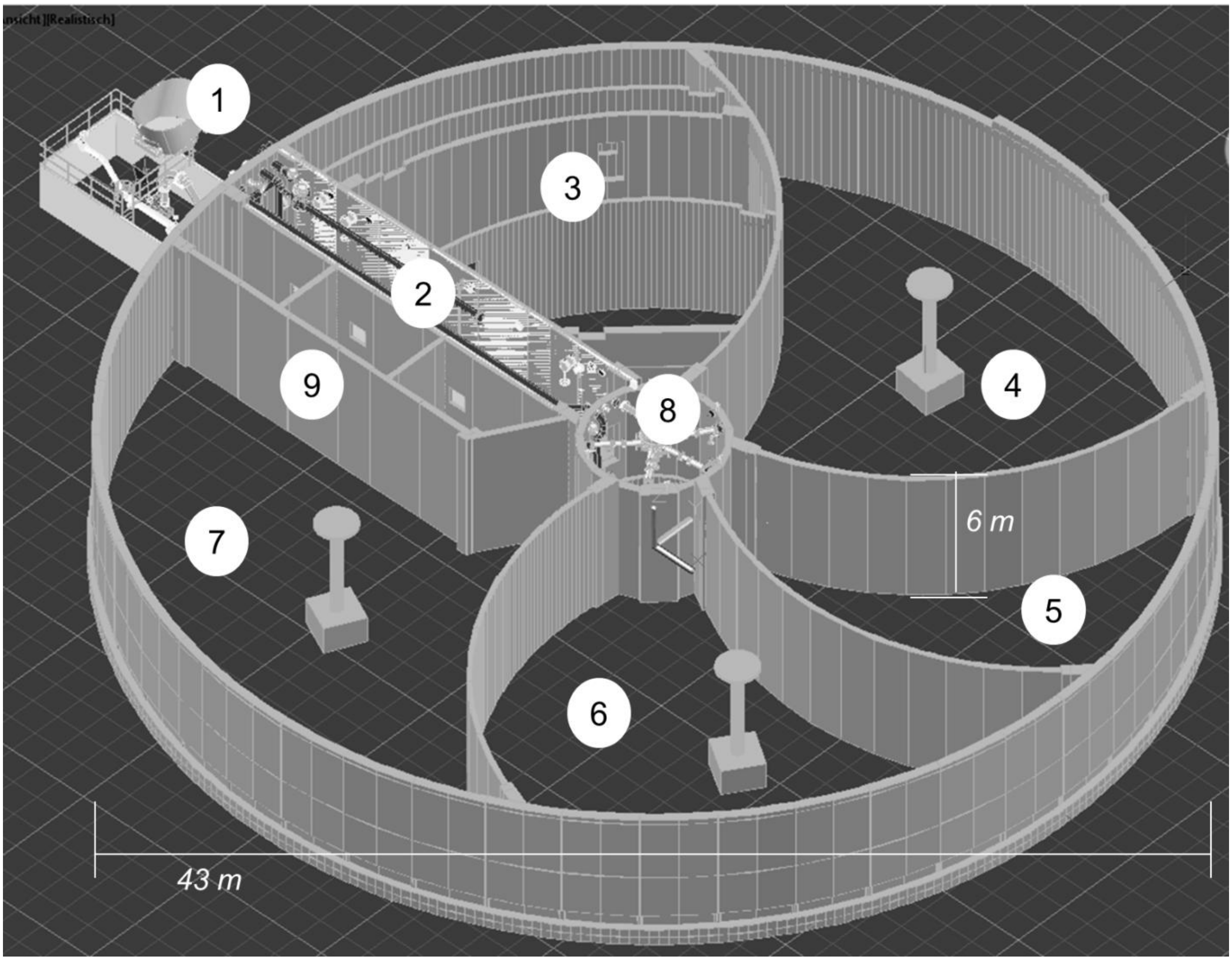

Fig. 1: Plant design schematic

Key: 1 – Solids dispenser; 2 – control engineering; 3 – hydrolysis unit (with five subchambers); 4 – methane fermenter (V = 1,574 m^3) ; 5, 6, and 7 – substrate and digestate storage 1 to 3 (V_1 = 942 m^3, V_2 = 1,548 m^3, V_3 = 1,890 m^3); 8 – high temperature heat pump and central heating system; 9 – water containers

Fig. 2: Plant (container)

Fig. 3: Plant (container) and CHP

Further information:

Dr. Michael Müller
EU Project Manager Biotechnology
Phone: +49 6331 2490 850, E-Mail: michael.mueller@pfi-biotechnology.de