Introducing the world's first accurate **mass flow meter for biogas**

- **The GP-MF mass flow meter is a Danish product, developed and patented by Geopal System A/S**
- **Accurate measurements - also allowing for variations in gas composition**
- **Makes it possible to optimise the process in anaerobic digesters**

geopal SYSTEM A/S

Mass Flow Meter

The Geopal mass flow meter, GP-MF, is the result of years of development. The groundbreaking feature of this unique and user-friendly product is that you continuously take into account the variations in the gas composition. This feature, which the patent is based on, makes it possible to determine the methane mass flow with an accuracy of less than ± 3 %.

THE METHANE MASS FLOW IS AN IMPORTANT PARAMETER IN THE OPERATION OF ANAEROBIC DIGESTERS

Anaerobic digesters produce biogas, which is a mixture of methane and carbon dioxide. The production of methane is a crucial control parameter in everyday operations. By monitoring the methane mass flow in relation to the load at the treatment plant and the amount of sludge that enters the digester you are able to ensure that the digestion process runs optimally.

Moreover, with a continuous reading of the methane mass flow you can now get a correct picture of how much energy the produced amount of biogas actually represents. This makes it possible, for instance, to continuously monitor the efficiency in gas engines and gas boilers

PRINCIPLE OF THE MEASURING METHOD

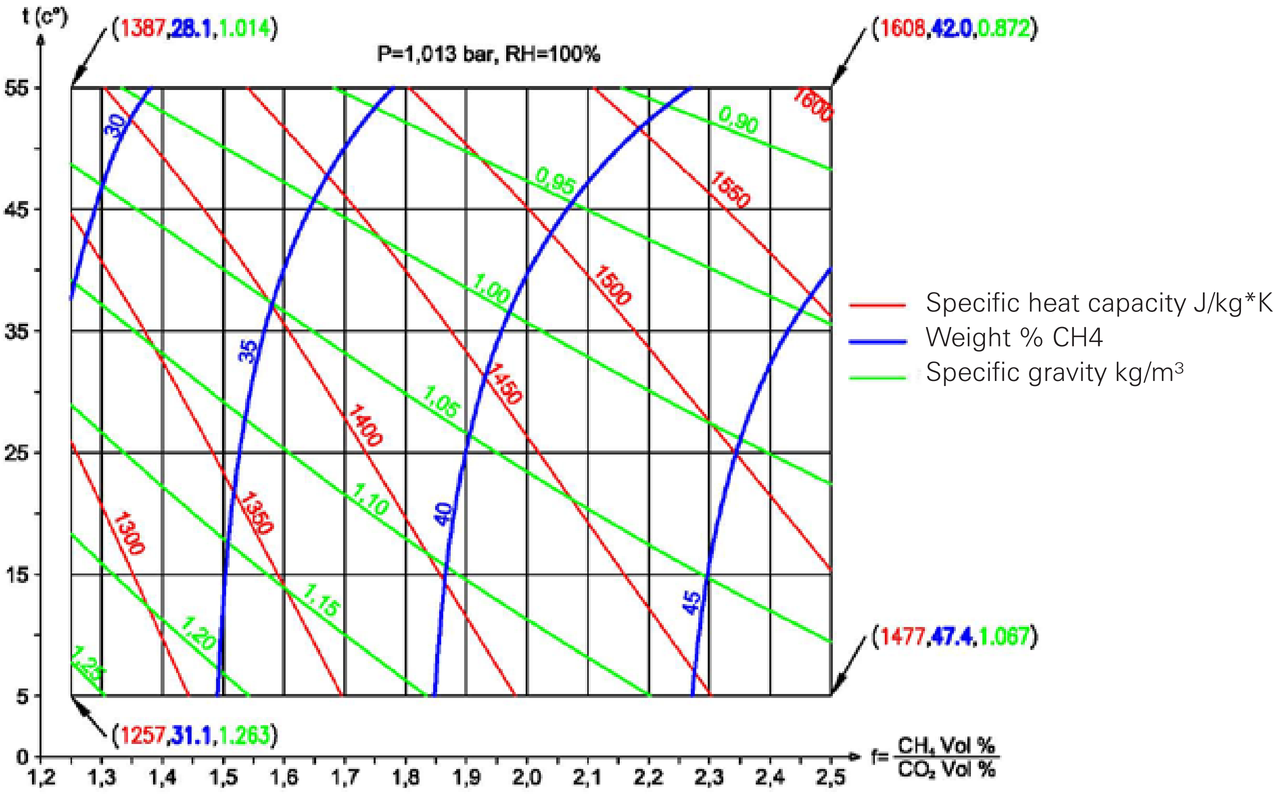
The total mass flow is determined on the basis of the principle of heat capacity, which is:

$$E = m * Cp * \Delta t \rightarrow m = \frac{E}{Cp * \Delta t}$$

Where E is the power that is added to the gas, Cp is the specific heat capacity of the gas, Δt is the increase of temperature in the gas, and m is the mass flow of biogas. With a continuous reading of the methane content in the gas you can calculate the methane mass flow as follows:

$$mCH_4 = \frac{m * \text{vægt \% } CH_4}{100}$$

The unique feature of the GP-MF mass flow meter is that it continuously takes into account the variations in the specific heat capacity and the composition of the gas. The GP-MF is particularly designed to measure a mixed composition of different gases, including saturated water vapour, such as biogas. If you do not take the natural variations in the composition of the gas into account, there will be a model inaccuracy of app. ±25%, as shown below. A model inaccuracy of this proportion is a common characteristic in other flow meters on the market.



Figur 1.

WHY IS IT DIFFICULT TO MAKE ACCURATE BIOGAS MEASURE-MENTS?

The biogas that is generated from anaerobic digestion is a mixture of methane and carbon dioxide. When the biogas leaves the digester it will also be saturated with water vapour at the local digester temperature. The ratio of methane to carbon dioxide depends on the composition of the sludge and/or other waste that is added to the digester. Methane is insoluble in water and all the methane that has been generated will consequently end up in the biogas. As for carbon dioxide, the situation is different. Depending on the particular operating conditions, part of the carbon dioxide will dissolve in the water and be discharged with the digested sludge. Given the normal variations relating to e.g. stirring, sludge composition, pH, and temperature, there will be considerable variations in the ratio of methane to carbon dioxide in the biogas.

As there is a major difference between the specific heat capacity and the specific gravity of methane and carbon dioxide, variations in the gas composition cause a significant model inaccuracy in gas measurements based on the commonly used principles, which do not take into account the composition of the gas. The problem is compounded by the fact that specific heat capacity and specific gravity are temperature-dependent.

For example:

Table 1 shows how specific heat capacity, specific gravity and methane content (weight %) vary in relation to gas composition and temperature

In order to cover the normal variation range regarding gas composition you have on the X-axis a ratio of methane to carbon dioxide at 1.25 – 2.5 in dry gas. This corresponds to a methane content in the gas of app. 56-71 %.

As for temperature, the variation range is set at 5-55°C, corresponding to the normal extremes you might encounter in measurement of biogas. Hot gas from a thermophilic digester is typically 55°C, and at wintertime, the gas from a gas holder can reach 5°C. It is generally assumed that the gas is saturated with water vapour at the given temperature, i.e. the relative humidity is 100%.

The variation of the different parameters would be within ± 12 – 26% of the mean value of the chosen range. If you fail to take these variations into account, the measurement accuracy can never be improved. Consequently, the model inaccuracy for the three most commonly applied measurement principles will be ± 23 – 28% of the mean value of the methane mass flow.

Principle of heat capacity:

$$\frac{\text{Weight \% } CH_4}{\text{Specific heat capacity}} \quad (\pm 23\%)$$

Principle of differential pressure:

$$\text{Weight \% } CH_4 \cdot \sqrt{\text{Specific gravity}} \; (\pm 27\%)$$

Vortex principle:

$$\text{Weight \% } CH_4 \cdot \text{Specific gravity} \; (\pm 28\%)$$

CONSTRUCTION OF THE GP-MF

The GP-MF mass flow meter comprises a measuring tube and a control cabinet. The measuring tube contains a heating element and a number of temperature sensors. Right after the measuring tube there is a meter that continuously monitors the methane content of the gas. Adding power/electrical energy (E) to the heating element the gas flow is heated from T1 to T2. Based on the added power, the registered temperatures, and the measured content of methane in the gas, you calculate the mass flow of methane, carbon dioxide and water vapour. The computer, installed in the control cabinet, perform these calculations continuously, providing ongoing readings of the individual mass flows on the display.

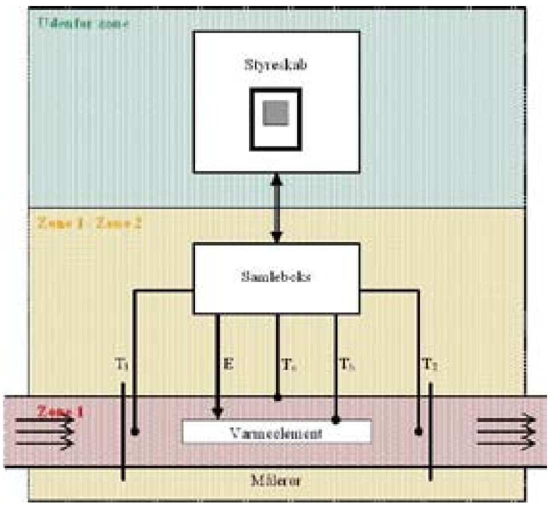


Table 2. Technical diagram of the methane mass flow meter.

VERIFICATION

In Denmark, in the summer of 2008, a Geopal GP-MF meter was installed at the Holbæk Waste Water Treatment Plant, where it was implemented in their automatic Control, Regulation and Monitoring system. The client has expressed complete satisfaction with the product, which is used actively in daily operations. The measurement accuracy for Geopal GP-MF has been verified at this treatment plant. The gas that passes through the flow meter is subsequently burned in a gas boiler. The boiler is fitted with energy meters that measure how much heat is being produced. Data on the registered mass flow of methane and produced amount of heat is collected in the Control, Regulation and Monitoring system and used in the calculation of efficiency of the boiler. For verification of the accuracy of the GP-MF a series of measurements focusing on boiler efficiency were conducted in collaboration with the boiler supplier. The calculated and the measured values were subsequently compared, and a satisfactory correspondence between these values was found.

COST BENEFIT

From a perspective of process engineering it is important to know the precise production of methane so that you are able to optimise the process in the digester.Experience shows that a continuing optimisation of these processes leads to enhanced solids conversion, with the following benefits:

- Cost reduction in connection with the disposal of sludge
- Increased methane production

In addition, the GP-MF meter contributes the following advantages:

- Possible reduction of operating hours regarding stirrers
- Minimising condensation problems in "gas trains"
- Correct measurement of methane concentration
- Reading of the methane concentration in dry gas

For example, let us assume that the application of the GP-MS makes it possible to optimise the digester operation at an 80,000 PE plant, thereby enhancing the conversion process by 10%.

Reduction in the amount of sludge

A 10% increase of the conversion will imply that the daily sludge production is reduced by app. 250 kg TS/day. This means that if the sludge is dewatered to 25% TS, the amount of dewatered sludge would be reduced by app. 360 t/year.

Increased gas production

If the methane production is increased by app. 100 kg/day, this would correspond to an annual amount of energy of app. 500,000 kWh. If the gas is used for electricity production in a modern gas engine, you would be able to produce app. 160,000 kWh /year. By comparison, the GP-MF mass flow meter uses 0.2 kW, or app. 1,800 kWh/year.

Reduced number of stirring hours

At the Holbæk Waste Treatment Plant an unexpected benefit was discovered - once they were able to determine the methane mass flow accurately. It turned out that a reduction of the operating hours for the stirrers in the digester did not have any negative effect on the methane production. As a consequence, the stirring time has now been reduced.

Minimising condensation problems in "gas trains"

It is clearly beneficial that the gas, when leaving the meter, has been heated and therefore is nowhere near the dewpoint temperature. By ensuring that the section after the meter has been properly insulated, condensation problems in, for instance, "gas trains" can be avoided.

Correct measurement of methane concentration

A correct measurement of the methane concentration in the biogas is an important parameter in the operation of anaerobic digesters. An overload or a toxic condition will very soon show up by way of a drop in the methane concentration. When you know the methane concentration all the tim the digestion tank should 'turn acidic'.

The existing methane meters on the market tend to be very sensitive to water vapour in the gas. One of the major suppliers has stated that their meter can be applied only within a range of 5 - 95 % relative humidity (RH). As the gas passes through the GP-MF mass flow meter, it is heated and the humidity is reduced to about 55% RH. This makes it possible to get an accurate measurement of the methane concentration, and that is the reason why the methane concentration meter is placed after the mass flow meter

Reading of methane volume % as dry gas

The methane concentration determined by the concentration meter is read in volume % of the actual gas composition, i.e. a composition of methane, carbon dioxide and water vapour. As the content of water vapour varies according to temperature, you need to 'adjust' for water vapour when you just want to calculate the ratio of methane to carbon dioxide.

In the GP-MF, the signal from the concentration meter is converted to volume % of dry gas so that the methane/carbon dioxide ratio can be determined right away. Furthermore, the results from the mass flow meter can be directly compared with results from laboratory analyses.

TECHNICAL DATA	
Mass flowmeter GP-MF 50	2-50 kg methane/h
Supply voltage	1x230V ± 10%
Frequency	50/60 Hz
Max output	650 Watt
Max fusing	13 A
Output signals:	
Signal for volumetric percentage	4-20mA
Indicates:	Volumetric percentage: 0-100 methane
Signal for current mass flow	4-20 mA (2 mA in case of error)
Indicates:	kg/h; 0-100 % of the measurement range 0-50 kg/h
Signal for accumulated amount	Relay contact
Indicates:	0.5kg per status change
Input signals:	
Methane volumetric % meter	4-20 mA
Indicates:	Volumetric percentage: 0-100 methane
Supply, methane meter	24 V AC/DC
Installation temperature, control cabinet:	0 °C to + 50 °C
Ambient relative humidity	max 95 %, non-condensing
IP rating (Ingress Protection)	IP 54
Flow CH_4 kg/h	2-50
Heating rod W	600
Tube DN/PN	80/10
Pressure loss above the meter at 50 kg/h	12
Respect distance at installation	0
Absolute accuracy better than	+/- 3 %
Long-term stability	+/- 3 %
Repeat accuracy	+/- 1 %
Parts in contact with biomass	AISI 316L
Connection box	Painted aluminium
External casing	Painted PE-HD
Installation temperature, measuring tube:	-25 °C to + 50 °C
Storing temperature :	-25 °C to + 50 °C
Gas temperature (intake):	5 °C til + 65 °C
IP rating (Ingress Protection):	IP 55
Shut off temp. for heating rod:	90 °C

APPROVALS EEX	
Explosive atmospheres	94/9/EC (ATEX)
Certificate no	Epsilon 07 ATEX 2397
	Ex II 2G EExd d e ia IIC T5
CE-marking	
Conforming to the provisions of	
Low Voltage Directive	2006/95/EC (LVD)
Electromagnetic Compatibility Directive	2004/108/EC (EMC)

03 ATEX Q133996 DBI reg. Nr. 233.301 A12060 ISO9001:2000

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