BIOGAS DESULPHURISATION METHODS

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Abstract: The article describes the issue of reducing the amount of hydrogen sulphide in the biogas. The described device utilizes chemisorption–biological principle disengagement H_2S from biogas. The aim was to verify the functionality of the device. The column is able to effectively reduce amount of hydrogen sulphide in the biogas, but with decreasing efficiency depending on the amount of processed biogas. The technology used in the experiment does not affect the concentration of other components of biogas.

Key Words: biogas, hydrogen sulphide, H_2S, cogeneration unit, column

INTRODUCTION

In the process of biomass gasification, sulfur contained in the feedstock is converted primarily to hydrogen sulphide (Cherosky, Li 2013). Hydrogen sulphide is a minor component of biogas. Its concentration varies according to the type of feedstock from 0–0.5% vol. Despite its relatively low representation in the total volume of biogas hydrogen sulphide is a significant technical challenge. Due to negative side effects on mechanical equipment, removing of hydrogen sulphide is necessary before further utilization of biogas. The majority of operators of biogas plants that use cogeneration as a utilization method meets the requirement for desulphurisation of biogas. Most manufacturers of cogeneration units specifies the maximum technical limits for hydrogen sulphide content in the biogas used in their devices (Deublein, Steinhauser 2102). This is due to the adverse effect ‘of H_2S on the economy of operation of cogeneration units namely shortening service intervals for replacement of oil charge and filters, as well as unfavorable corrosive processes on all steel components of these devices (Anerousis 1994). Combustion of the hydrogen sulphide results in the formation of sulfur deposits in the combustion and exhaust systems of cogeneration units. Also increases wear of sliding parts, reduction of oil filling alkaline reserve and damage to the catalyst.

Biogas desulphurisation is normally carried out by methods which are based on physical, chemical eventually biological principles. Widespread method based on physical processes is the hydrogen sulphide sorption on activated carbon. The disadvantage of this method is its capital and operating costs. In the case that the chemical way of desulphurisation is chosen, it is carried out by application of chemicals (mostly based on salts or hydroxides of iron) directly into the fermenter (Weixin, Bandosz 2007). Such an application can result in unfavorable influence on microbial balance in a sensitive environment of the fermenter, and changes in the fermentation residue properties. As for the biological methods of desulphurisation, then oxidizing aerobic bacteria of the genus *Acidithiobacillus thiooxidans* or *Thiobacillus ferrooxidans* are commonly used (Kuo-Ling et al. 2013). Modern methods include among others e.g. membrane separation, which is based on the different rate of passage of molecules through a thin membrane.

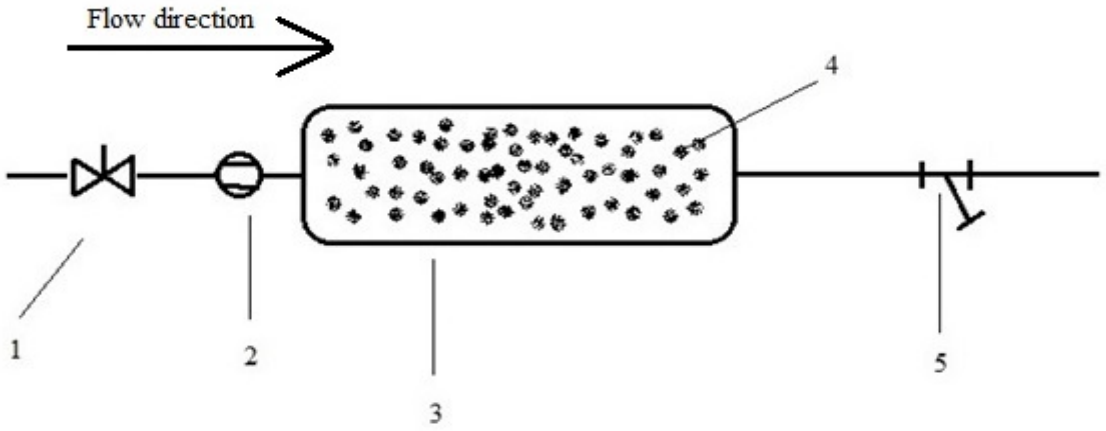
MATERIAL AND METHODS

In order to confirm the hypothesis an experimental column for biogas desulphurisation was designed and subsequently constructed. It is an externally mounted device that does not extend into biogas plant technology and is connected only to a biogas pipeline. Device, as constructed, enables testing of different types of solid desulphurisation media, both in continuous and the discontinuous testing mode.

Column description

The device's main part is detachable, hollow cylindrical body column. The column is fitted with two valves – inlet for the raw biogas supply and outlet for desulphurised biogas discharge. Inside the column, desulphurisation medium and its carrier can be found, to improve the desulphurisation effect, the desulphurisation medium can be populated by sulfur oxidizing microorganisms. The column is connected with the biogas plant pipeline by a rubber hose certified for flammable gases transport. At the inlet side, the column is equipped with a control valve and flowmeter tube for reading the biogas flow rate. The crude biogas is supplied through the inlet into the upper cover of the column, then it passes through the body of the column, coming into contact with a desulphurising medium and sulfur oxidizing microorganisms. The desulphurised biogas is discharged by outlet in the body of the column at the farthest point from the opposite point of entry. Before entering the biogas pipeline desulphurised biogas discharged from the column passes through the air filter in order to eliminate the possibility of the entry of mechanical impurities from column filling. Further, desulphurised biogas is used for its original purpose, produce electricity and heat. Just before the inlet plug, which conducts raw biogas into the column body and immediately downstream, after the discharge plug, the system is equipped with the sampling points for the biogas analysis. The device was made in two identical specimens. Scheme of the column is shown below.

Figure 1 Scheme of the column



1. Control valve; 2. Flowmeter; 3. The body of column; 4. Filling of column; 5. Air filter

Testing site

For this study, we decided to find biogas plant that use unconventional feedstock. Unconventional feedstock, which contains high amount of proteins, is associated with increased production of hydrogen sulphide. Finally the experimental biogas desulphurisation column was installed at the biogas plant Suchohrdly u Miroslavi. The biogas plant consists of two fermenters with a volume of 1500 m^3 each and integrated gas holders with a volume of 400 m^3 each. Produced biogas is utilized in four cogeneration units TEDOM Cento T170. The total electrical output of the installation is 500 kW. It is an agricultural biogas plant, where the maize silage is the main feedstock. The operator of the biogas plant uses as in additional input beet chips and pig slurry, that leads to quite high hydrogen sulphide concentration around 300–460 ppm.

Measurement methodology

Series of eight discontinuous measurements were conducted as following. A sample for analysis was collected and evaluated just before the raw biogas entered the body of the column. Second sample was collected and evaluated right at the outlet point. The hourly flow rate through the column was set at 1 $m^3 \cdot h^{-1}$. The total desulphurisation medium weight in the column was 1.17 kg. The total time of experiment was 31 hours.

For the biogas analysis gas analyzer Dräger X-am 7000 S/N: ARYJ-0090 was used.

Technical specifications, influence on the IR CO_2: ≤±0.07Vol.-%, influence on the IR Ex HC: ≤2 x zero–point repeatability, influence on all other sensors: within zero–point repeatability. The required measurement accuracy of the sensors is maintained under the influence of electromagnetic interference as set out in table 5 of EN 50270.

RESULTS FAND DISCUSSION

At a flow rate 1 $m^3 \cdot h^{-1}$ were measured concentrations of hydrogen sulphide and other gases shown in Table 1.

Table 1 Biogas components concentration

Serial number of	1	2	3	4	5	6	7	8
H_2S [ppm] inlet	292	297	344	310	376	450	436	462
H_2S [ppm] outlet	73	100	200	150	282	300	296	396
CO_2 [%] inlet	45.9	45.8	46.3	52	50	48	49	52
CO_2 [%] outlet	39.8	45.9	46.3	52	50	49	47	49
CH_4 [%] inlet	52.6	53	53.1	60	60	54	54	58
CH_4 [%] outlet	44.7	52.3	52.9	58	58	54	51	55
O_2 [%] inlet	0.4	0.5	0.3	0.5	0.2	0.9	0.6	0.3
O_2 [%] outlet	3.1	0.4	0.2	0.6	0.2	4.6	1.1	0.4

As we can see in Table 1 used technology has minimum impacts to the composition of other gases. Higher outlet values of oxygen were usually caused by the reason, that the column was opened due to some service operations, before the measuring. Therefore 100% of the gas inside the device was not replaced by biogas from fermenter. Values of methane in measurements number 1 and 7 are those which are affected by human error described above.

Figure 2 shows differences in hydrogen sulphide concentrations at the column inlet and outlet.

Figure 2 Concentration of H_2S

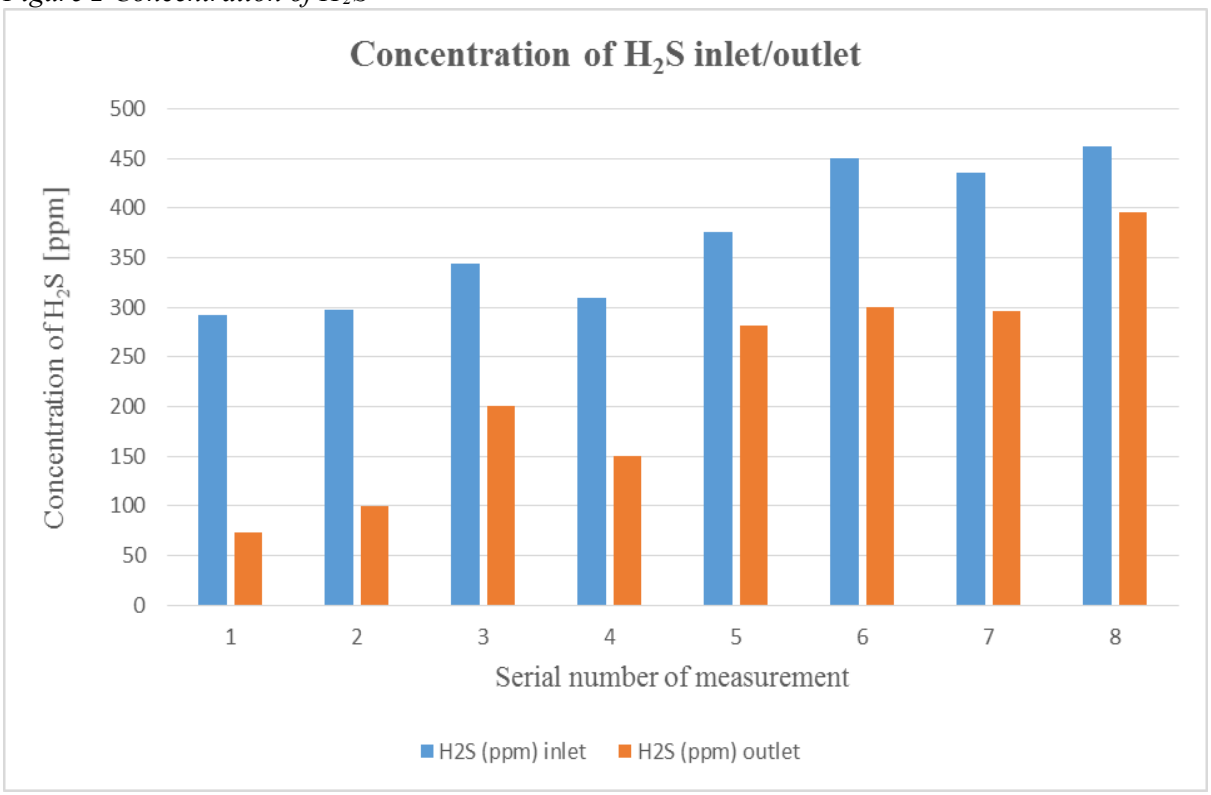
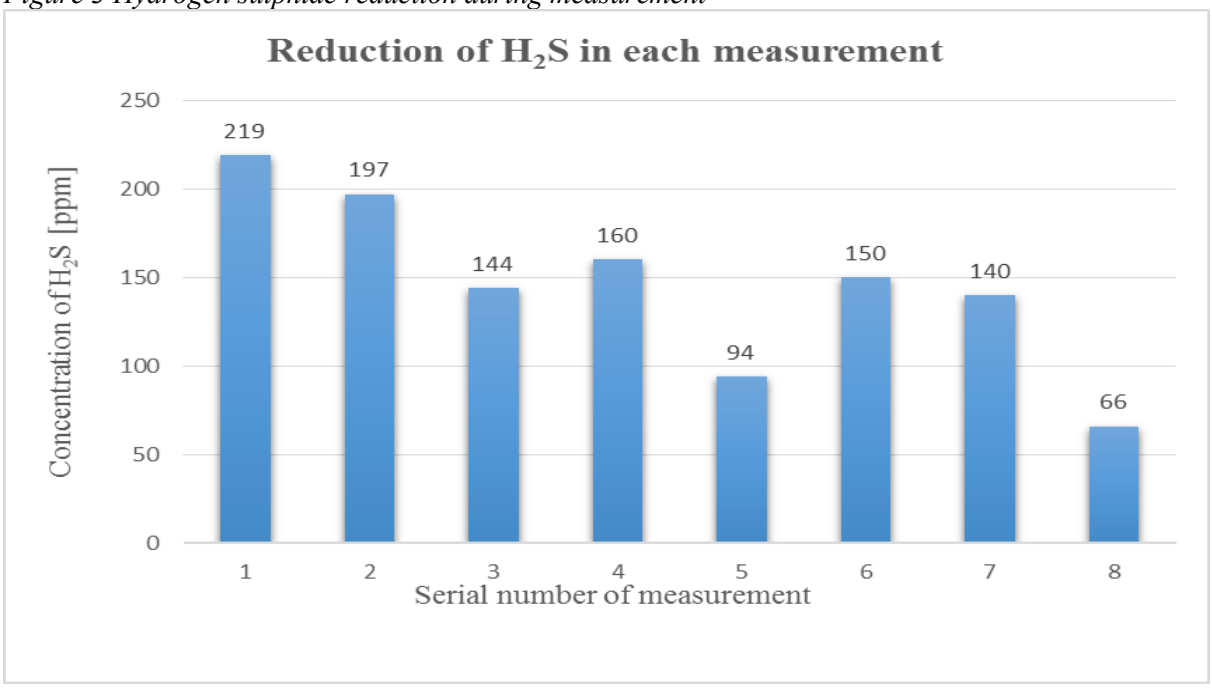


Figure 3 shows reduction in hydrogen sulphide concentration, which was captured by the desulphurisation column during each measurement.

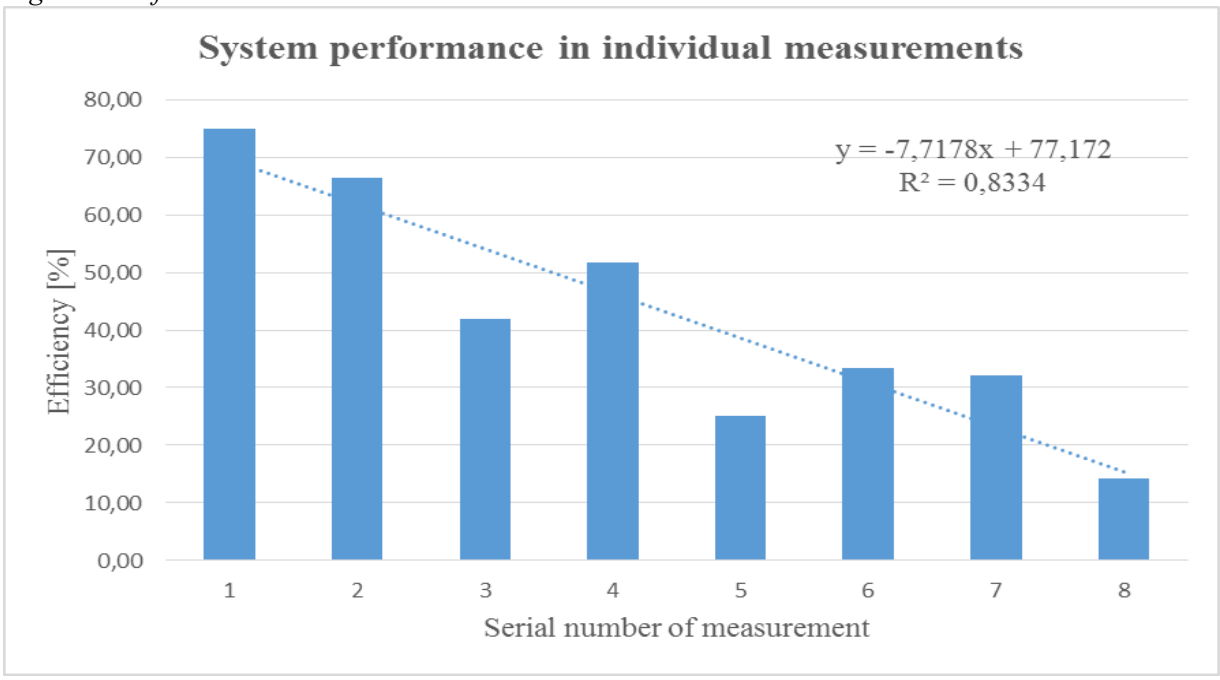
Figure 3 Hydrogen sulphide reduction during measurement



CONCLUSION

The aim of the work was to verify the functionality of the column for biogas desulphurisation. The column is able to effectively reduce amount of hydrogen sulphide in the biogas, but with decreasing efficiency, depending on the amount of processed biogas, as can be seen below in Figure 4. The total amount of biogas, which was desulphurised during all the tests was 31 m^3 and only 1.17 kg of desulphurisation media was used for the experiment. The technology used in the experiment does not critically affect the concentration of other components of biogas. We assume that column has potential for further development and research.

Figure 4 Performance in measurements



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