Anaerobic conversion of biomass upon disintegration in ultrasonic fields of low intensity

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Abstract

Disintegration is the destruction of the cell structure to release all its contents. This process facilitates bacteria access to nutrients and it results in a substrate decomposition rate increase. We can use thermal (the brief heating below one hundred degrees temperature at normal pressure or higher one hundred degrees temperature at enhanceable pressure) and chemical (enzymes and catalysts addition, which can positively influence the process speed), biochemical and physical-mechanical methods (the sonication).
Keywords: biogas, biomass, sonication.

1 Introduction

The purpose of all influencing the substrate processes is the gas yield increase and the fermentation period reduce. In accordance with the AG ZORG data and some other investigators the gas yield after the ultrasonic disintegration increases by 45 percent. But too powerful sonication leads to the bacteria destruction therefore currently used ultrasound low power. Another previous experience is the biomass preliminary sonication Ufa State Oil Technical University was patented (RF patent number 2458868). And also method for preparing to use of liquid manure was patented by Voronezh State Agricultural University (RF patent number 2039028). But above sonication system creators didn't consider the sonication optimum power finding problem. The purpose of our work is the biomass where the humidity is 92 percent sonication optimum determination.

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2 Experimental investigation

Experiments were carried out on the "Sapphire" plant that contains transmitters produced by APC International Ltd (USA). The transmitters' power varies from 10 to 150 kW at a frequency of 44 kHz.

2.1 Experimental stand and sonication regimes

Figure 1 shows the experimental stand scheme.

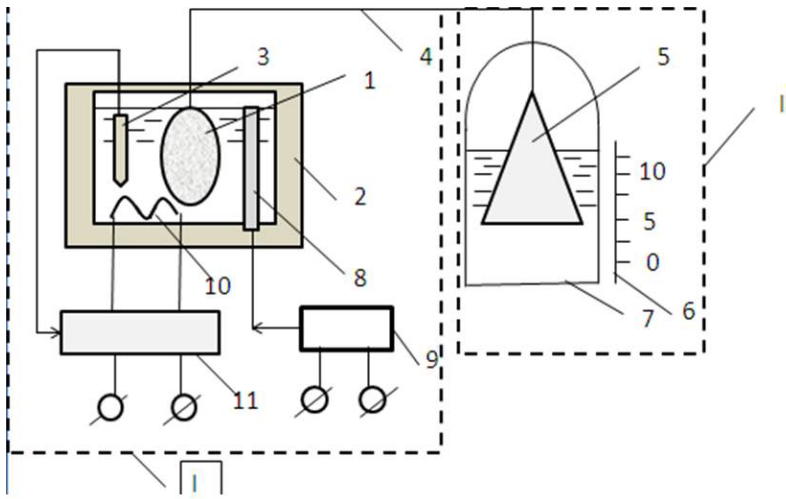

Figure 1: Experimental plant based on the ultrasound chamber "Sapphire". I – ultrasonic camera "Sapphire", II – gasholder, 1 – bioreactor, 2 –thermostat, 3 – temperature sensor, 4 – gas yield, 5 – pop thing, 6 – scale, 7 – water, 8 –ultrasonic transmitter, 9 – ultrasonic generator, 10 – thermostat, 11 – temperature control unit.

Sonication regimes are shown in Table 1.

2.1 Methodology to evaluate the ultrasound impact

Sonication dose was calculated as follows:

$$D = N \cdot t, \tag{1}$$

N – sonication power, W;
t – sonication time, an hour proportion.

Table 1: Sonication regimes.

Investigated regimes	Sonication time (min)	Sonication power (W)	Sonication dose (Wh)	Sonication power density (W/cm^3)	Sonication energy density (Wh/cm^3)
1	2	37.5	1.25	0.15	0.005
2	15	37.5	9.375	0.15	0.0375
3	20	37.5	12.5	0.15	0.05
4	30	37.5	18.75	0.15	0.075
5	2	75	2.5	0.3	0.01
6	5	75	6.25	0.3	0.025
7	10	75	12.5	0.3	0.05
8	20	75	25	0.3	0.1
9	30	75	37.5	0.3	0.15
10	2	150	5	0.6	0.02
11	5	150	12.5	0.6	0.05
12	10	150	25	0.6	0.1
13	15	150	37.5	0.6	0.15
14	30	150	50	0.6	0.2

Sonication power density was calculated as:

$$Y' = \frac{N}{V_{\text{субст}}}, \tag{2}$$

$V_{\text{субст}}$ – the substrate being processed volume in the sample.

Sonication energy density was calculated as:

$$Y'' = \frac{D}{V_{\text{субст}}}, \tag{3}$$

D – sonication dose.

2.2 Sonication dose influence

Figures 2 and 3 show biogas nonflammable components formation dynamic nature in the initial fermentation stage (CO_2, O_2) and biogas flammable components (CH_4, H_2) formation data at the methanogenesis stage. The data analysis shows that the biogas flammable components maximum increase is 34–43% at the 5–10 Wh sonication dose.

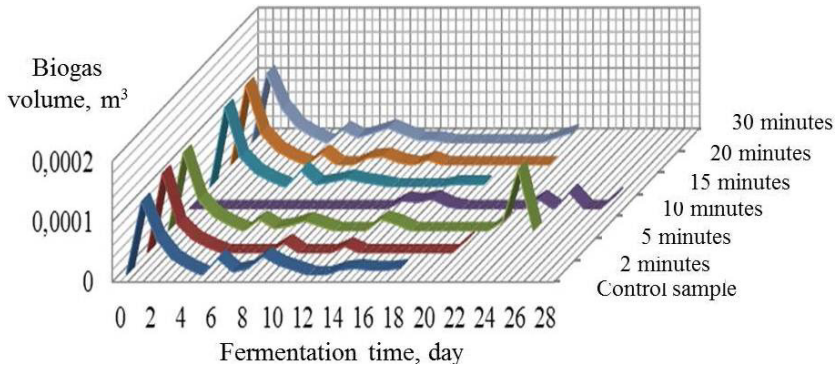

Figure 2: The gas yield in the initial fermentation stage.

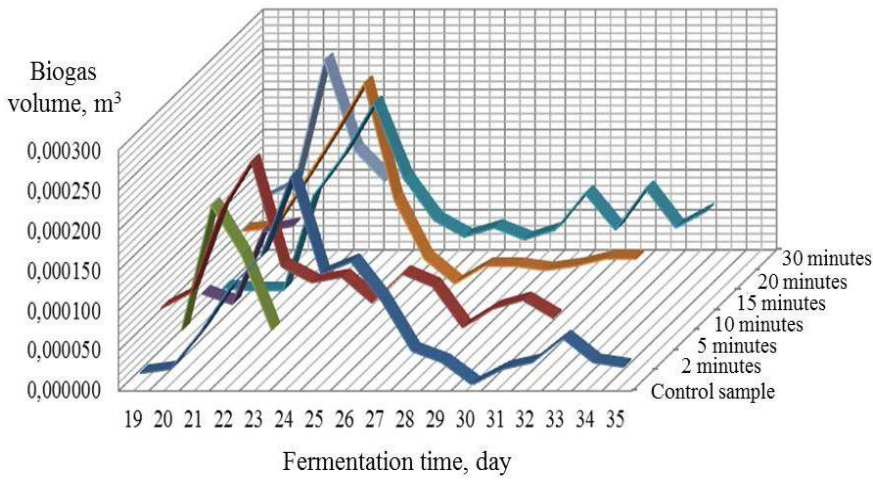

Figure 3: Biogas flammable components yield at the methanogenesis stage.

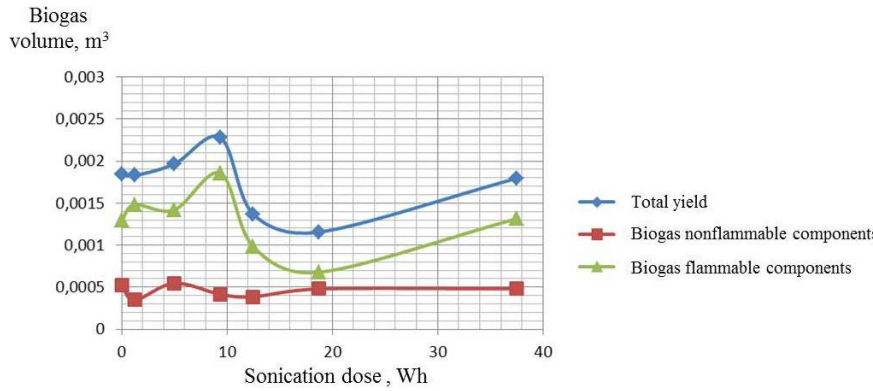

Figure 4: The biogas yield depending on the integral sonication dose.

3 Conclusion

Our investigations show that the sonication result in the biogas flammable components increase of 34–43%. Sonication maximum efficiency is achieved at a moderate sonication dose. Additional energy costs for an ultrasound field with a maximum exposure time (half an hour) for the process total duration more than 20 days is less than 1%.

References

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