Implementation of biogas plants at food industry enterprises

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Abstract – According to the Energy Strategy of Ukraine for the period up to 2035, the priority direction of domestic energy development is renewable energy sources. Biogas is one of the most promising renewable energy sources, whose potential in Ukraine is significant. The distribution of biogas plants will also contribute to the improvement of the ecological situation in the country. The implementation of a biogas plant at the yeast production enterprise is shown in the work. The biogas plant is based on an anaerobic digestion process. The payback period of the biogas plant is less than three years.

Keywords – renewable energy sources, biogas plants, anaerobic digestion.

I. Introduction

The new Energy Strategy of Ukraine «Safety, energy efficiency, competitiveness» for the period up to 2035 was approved by the Government on August 18, 2017. According to [1], bioenergy is capable of developing at the fastest pace. Biomass is expected to provide an annual replacement of 9.2 million tons of fossil fuels. These trends are also consistent with world experience [2].

The distribution of biogas plants will also help to improve the environmental situation. Because, the organic waste from the food industry, agriculture, woodworking is one of the most dangerous for the environment.

In particular, such problems are faced by yeast companies, one of which is located in L'viv. This company not only controls most of the Ukrainian yeast market, but also delivers this product to Europe.

In the process of yeast baking production, the enterprise produces waste products that reach 2200 m^3/day. They accumulate in specially designated places. They are partially shipped to specialized enterprises for utilization or processing.

Wastewater of surface runoff is discharged into local sewage treatment plants. This is a big problem for both the company and urban wastewater treatment plants. Therefore, it is promising to install a biogas plant, which will clear the production runoff.

Since the installation will produce biogas, it can replace the natural gas that is used in the technological process of the enterprise.

Thus, the using of one biogas plant can solve two issues at once:

• reducing the burden on urban wastewater treatment facilities;

• replacement of expensive imported gas.

II. Biological processes of fermentation

The basis of the biogas installation is the biological processes of fermentation and decomposition of organic substances under the influence of methane-forming bacteria in anaerobic conditions [3]. The anaerobic digestion process includes the following stages:

hydrolysis – eco-enzymes transform complex molecules into simpler, which are better absorbed by bacteria;

acidification (acidogenesis) – acidogenic bacteria convert less formulated molecules into acetic, propane, butyric and other acids;

acetylation (acetogenesis) – a process in which bacteria convert propionic and butyric acid into octoic acid (CH_3COOH), carbon dioxide (CO_2) and hydrogen (H_2);

methane production (methanogenesis) – a process in which methanogenic bacteria in the course of their metabolism convert acetic acid, carbon dioxide (CO_2) and hydrogen (H_2) into biogas (CH_4) and a small amount of biomass.

The alternation of these processes is schematically depicted in Fig. 1.

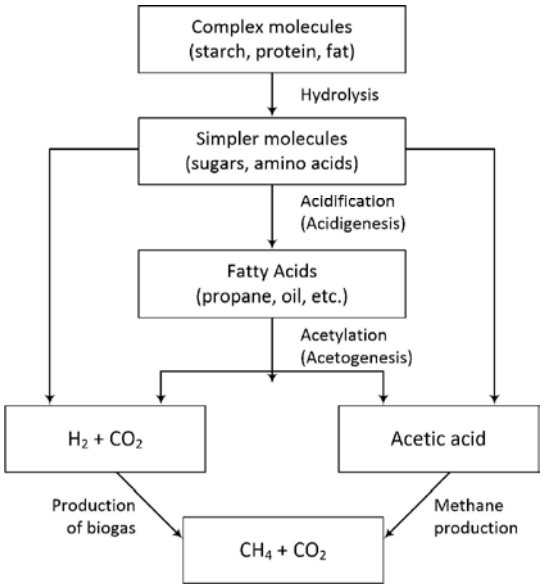

Fig. 1. Alternate processes of anaerobic digestion.

In the process of fermentation, there is a biogas release containing 40-70% methane, 30-60% carbon dioxide, about 1% hydrogen sulfide and a small amount of nitrogen and hydrogen.

The amount of biogas generated at a temperature of 35-37° and the average time of retention of raw material in the reactor for 10 days, is within 30-70 m^3 of biogas per ton of raw materials per day.

III. Scheme of biogas installation

Anaerobic fermentation is carried out in a sealed container (a reactor), usually cylindrical in the form of a horizontal or vertical arrangement.

The raw materials for bioreactors are wastewater. The company had previously installed a reactor for 800 m^3 of wastewater per day. It is necessary to install additional

reactors by 1400 m^3/day of drainage. Since the wastewater requires dilution, we choose two vertical type reactors Biobed EGSB1000 with a working volume is 1000 m^3. The expansion scheme of the biogas plant of the company is shown in Fig. 2.

Fig. 2. Expansion scheme of the biogas plant of the company.

According to the fermentation mode (mesophilic or thermophilic) it is necessary constant temperature for providing efficient fermentation in the reactor. Also it is necessary to mix the digestible raw materials regularly.

Typically, heat exchangers are used for heating, where hot water with temperature 60°C is the heat carrier. Higher temperature increases a risk of sticking the suspended particles to the surface of the heat exchanger.

The mixing can mainly be mechanical stirrers, biogas (for this biogas is passed through the thickness of raw materials) or pumping raw materials from the upper zone to the bottom.

The scheme of biogas plant operation is shown in Fig. 3.

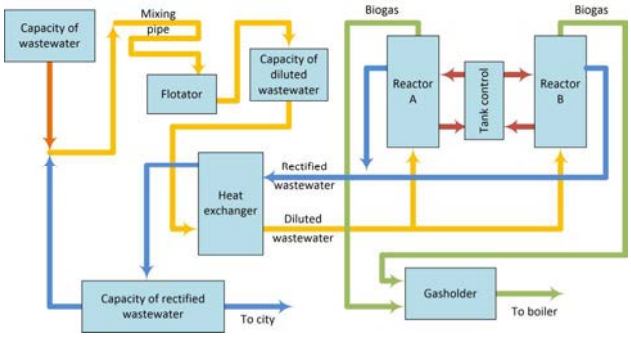

Fig. 3. Scheme of biogas plant operation.

Wastewater is formed as a result of the production of yeast so has a large amount of substances. The main characteristics of wastewater are concentration of calcium, nitrates, nitrites, ammonium nitrogen and pH level (see Table. 1).

TABLE 1

MAIN COMPOSITION OF MANUFACTURING STOCKS

Composition	Amount	Dimension
Calcium	760	mg/l
Suspended matter	370	mg/l
Nitrates	11	mg/l
Nitrite	1.5	mg/l
Ammonium nitrogen	145	mg/l
pH level	5–4.2	

These characteristics are the main, since the preparation of the wastewater to the bioreactor is tuned relative to their quantity.

Estimated volumes of biogas in the reactor depend on the volume of wastewater supplied to the treatment facilities from the enterprise, and its chemical oxygen consumption (*COC*)

$$COC = V_{runoff} COC_{spec} \quad (1)$$

where COC_{spec}=11.8 кг/m^3 – specific chemical consumption of oxygen.

Expected volume of biogas

$$V_{biogas} = COC \cdot k \quad (2)$$

where k – biomass expansion factor.

According to calculations from 2200 m^3 of wastewater production, 11925 m^3/day of biogas can be obtained.

IV. Economic benefits

Annual biogas production is 11925 m^3/day, but the calorific value of biogas is 30% less than that of natural gas. Hence the equivalent amount of biogas per day is equal

$$V_{ekv.biogas} = 0.7 V_{biogas} \quad (3)$$

So it is 8347 m^3/day.

The current price for natural gas is 6.9579 UAH/m^3. However, biogas in its properties is worse than natural gas. It has a small amount of harmful impurities, so its price will be lower than natural gas by 20%

$$C_{ekv.biogas} = 0.8 C_{gas} \quad (4)$$

that is 5.5663 UAH/m^3.

Expected annual savings will be 16.96 million UAH.

A simple payback period for biogas installation is less than three years.

Conclusion

The biogas plants are a promising direction for the development of renewable energy in Ukraine.

At the yeast enterprise are offered biogas plant which is based on an anaerobic process of fermentation and includes the four stages.

The simple payback period for the implementation of a biogas plant does not exceed three years.

References

[1] Energy Strategy of Ukraine «Safety, energy efficiency, competitiveness» for the period up to 2035 // approved by the Government on August 18, 2017.

[2] Muzychak A., Vlasenko M. Prospects for Biogas – Leaders' Experience Helps Ukraine // Litteris et Artibus: Proceedings VI-th international youth science forum (Electronic edition on CD Rom). – 2016. – P.178-179.

[3] Mes T., Stams A., Zeeman G. (2003): Chapter 4. Methane production by anaerobic digestion of wastewater and solid wastes. In: Reith J., Wijffels R., Barten H. (2003): Biomethane and Biohydrogen. Status and perspectives of biological methane and hydrogen production, 58-94.