Application of biogas technologies using railway transport

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Abstract. Currently, there is a large number of energy installations capable of producing electrical and thermal energy. One of such systems is biogas plants. Biogas is formed in the process of fermentation of organic substances and can arise everywhere, where there is no access of oxygen. In order to increase functioning efficiency of the considered biogas energy complexes, biogas is subjected to the process of enrichment to natural gas. Passing through special installations, gas is cleaned of impurities and as a result natural gas is obtained, which can be used both in industry, and everyday human activities. On transport, the use of biogas gives large opportunities and prospects. In particular, in railway transport biogas can be used as a fuel for autonomous locomotives, as source for wagons heating, as well as in stationary boilers. Mobile biogas stations installed on trains can produce heat and energy, as well as biofertilizers, when biogas process is combined with biotechnology. Biogas capacity depends on the type of raw material. Greater biogas yield is generated during processing bird droppings, clobber, algae and channels silt. Development of mobile biogas stations is a promising way for energy industry growth. The use of these stations allows providing the necessary areas with heat, energy and biofertilizers.

1. Introduction

Biogas plants are divided into installations with or without heat supply [4]. In turn, the installations without heat supply are divided into installations with or without mixing of the fermented mass. Installations with heat supply are mainly applied with stirring of the fermented mass.

Stationary biogas plants are widely used in Sweden, Germany, USA, China [2, 3, 5, 6]. Some of them produce gas in such volumes, that after using the required quantity for generation of heat and electric energy for own needs and needs of affiliated consumers, gas excess after cleaning is supplied to the central gas pipeline systems.

Disadvantages of stationary biogas plants, such as local application, lack of mobility, high capital costs, impossibility of regulated and variable gasification of remote receivers, high costs of communication networks construction, justify the creation of a mobile complex for biogas production. Moving such installation is possible with the use of transport systems, including railway transport. The installation can be used practically in any place where there are railways. The ability to move the installation will allow to apply the complex for a variety of tasks as:

- mobile waste recycling plant (for wastes suitable for biogas generation);
- mobile source of heat and electricity;
- the main or reserve source of gas supply and power supply.

2. Development of mobile biogas station structure
The complex should be the autonomous system, fully or partially. With partial autonomy, the movement of mobile biogas station (MBS) is carried out by attracting of the additional capacities in the form of locomotives, trains and other transport systems capable of acting as a driving force. In the case of autonomous system of station operation, the traction force with a thermal engine working on biogas, acts as a locomotive (figure 1).

![Figure 1. MBS structural scheme in railway transport: I – locomotive; II – mobile biogas plant.](image)

MBS includes feeder, feed system, methane-tank, gasholder, gas transportation system, gas purification system, biofertilizers drying system, biofertilizers transportation and storage system, heat and electricity generation system. Besides, it is possible to operate the complex without the biofertilizers drying process. In this case, more tanks are needed for storage of the fermented residue.

All equipment is located on railway platforms (figure 2).

![Figure 2. MBS components: 1 – locomotive; 2 – feeder; 3 - raw material input compartment; 4 - methane-tank; 5 - raw material feed device for methane-tank; 6 - gas removal device; 7 - fermented mass rejection device; 8 - biofertilizers storage; 9 - gas storage; 10 - gas supply device; 11 - generator of heat and electricity.](image)

For placement a horizontal methane-tank, tanks with gas and biofertilizers (in the absence of a drying system), railway platforms with following parameters are used: load capacity of 72 tons, internal dimensions of the board 13400x2500x0 mm. For installation of electricity generation, a platform with following characteristics is used: load capacity of 93 tons, internal dimensions of the
board 14000x2830x0 mm. To arrange the rest equipment, the platforms with following characteristics are used: load capacity of 70 tons, internal dimensions of the side 13300x2770x500 mm.

3. Results and discussion

MBS capacity depends on the type of processed raw materials. Table 1 shows the possible production of biogas as a function of raw material type [1].

| Material type         | Biogas yield per organic waste mass unit (l/kg) | Material type         | Biogas yield per organic waste mass unit (l/kg) |
|-----------------------|-----------------------------------------------|-----------------------|-----------------------------------------------|
| Pig manure            | 340-550                                       | Hemp                  | 380                                           |
| Cattle manure         | 90-310                                        | Green crop wastes     | 330-360                                       |
| Horses manure         | 200-300                                       | Salley                | 405                                           |
| Bird droppings        | 310-620                                       | Reed                  | 170                                           |
| Sheep manure          | 90-310                                        | Clover                | 430-490                                       |
| Wheat straw           | 200-300                                       | Sunflower leaves      | 300                                           |
| Rye straw             | 200-300                                       | Potato tops           | 280-490                                       |
| Barley straw          | 250-300                                       | Grass                 | 280-550                                       |
| Oat straw             | 290-310                                       | Plant seeds           | 620                                           |
| Corn straw            | 380-450                                       | Leaves                | 210-290                                       |
| Rice film             | 105                                           | Algae                 | 420-500                                       |
| Flax                  | 360                                           | Channels silt         | 310-740                                       |

Analysis of the data of Table 1 shows that the largest biogas yield is obtained by processing the bird droppings, clover, algae and channels silt. There are various technologies for increasing the waste processing efficiency, which can be used in the development of MBS. One such technology is biogasvermitechnological process [7, 8]. The authors show that a new combined method of using biogas technology and vermitechnology in order to obtain additional energy, significantly reduces the consumption of fossil fuels for electricity production and improves the efficiency. The co-product of this method of organic waste processing is biohumus - a valuable fertilizer. It is also shown in the study, that a decrease in the obtained biogas consumption can be achieved by aligning the electric load graph, which can be extended to the thermal energy too. Similar results are presented in the paper of professor Shklyarskiy Y.E. [9].

The general operating principle of MBS is similar to the operation of stationary installation. The main difference is the presence of biofertilizers drying complex. The drying system is implemented to simplify warehousing and storage of fertilizers and allows to use for storage simple wagons for transportation of bulk cargoes instead of special tanks.

The use of MBS allows the collection and utilization of wastes from any point where their regular and irregular accumulation and warehousing is formed. The main recycling condition is a close location to railway stations or places of communication ways, where stopping and parking of trains is possible.

After loading the raw materials into the methane-tank, the train can continue motion along the required route. Start of movement and train movement process is a favorable factor for the biogas production and facilitates the mixing of the fermented mass. This feature ensures the continuous movement of the train along the organic wastes collection points. An additional advantage of MBS is the ability to provide the necessary areas along the route of the train with biogas and biofertilizers.

One of the main tasks that must be solved in MBS development, is the connection and interaction of systems, providing stable and continuous operation of the whole installation. Such a problem is solved with the use of flexible couplings and connectors with flexible designs. Based on the criterion
for minimizing the number of railway platforms in MBS train, the use of locomotives with a carrying capacity of more than 380 tons is recommended.

4. Conclusion

Thereby, the following conclusions can be made:

1. Organic wastes processing - one of the most important problems of modern society.
2. The use of biogas complexes is relevant, promising and environmentally friendly method of waste disposal.
3. The positive effects of MBS: biogas, suitable for use in industry, as well as for supply, after the purification and enrichment process to natural gas, the common gas pipeline; development of high-quality biofertilizers, necessary in any branch of agriculture.
4. The installation of a methane tank on railway platforms is not accompanied by significant changes in the existing design.
5. The development of MBS in railway transport is a reasonable and promising way of the energy industry growth.

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