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STUDY ON THE FEEDING SYSTEM OF A BIOGAS PLANT

Mariana DUMITRU

Lucian Blaga University of Sibiu, 10 Victoriei Boulevard, 550024, Sibiu, Romania, Phone/Fax: +40-(269) 21.60.62, E-mail: mariana_dumitru2001@yahoo.com

Corresponding author: mariana_dumitru2001@yahoo.com

Abstract

This paper wants to analise a part of a biogas plant, the feeding system. As it is known, a biogas plant is a complex installation, consisting of many components. The layout of a biogas plant depends very much on the types and amounts of feedstock supplied. As there are many different feedstock types suitable for digestion in biogas plants, there are, correspondingly, various techniques for treating these feedstock types and also different digester constructions and systems of operation. That is why, depending on the type, size and operational conditions of each biogas plant, there are various technologies for conditioning, storage and utilisation of biogas. Generally, agricultural biogas plants operate with four different process stages: transport, delivery, storage and pre-treatment of feedstock, biogas production and storage of digestate. This paper studies the feeding system of such a plant and the main pumps used in the process of transport of feedstock, such as: centrifugal pumps, pressure displacement pumps with their characteristics and components, considering that these pumps are an important part from the feeding system of the biogas plant.

Key words*: feeding system, pumps, transport system*

INTRODUCTION

A biogas plant is a solution for renewable source of energy, which can be used both in urban and rural communities. It a complex installation, consisting of a variety of elements, which can be different from plant to plant. But the layout of such a plant depends to a large extent on the types and amounts of feedstock supplied. Because there are many different feedstock types suitable for digestion in biogas plants, there are, correspondingly, various techniques for treating these feedstock types and different digester constructions and systems of operation. Thus, depending on the type, size and operational conditions of each biogas plant, different technologies for conditioning, storage and utilisation of biogas are possible to implement. As for storage and utilisation of digestate, this is mainly oriented towards its utilisation as fertiliser and the necessary environmental protection measures related to it [4].

Agricultural biogas plants operate with four different process stages:

-Transport, delivery, storage and pre-treatment of feedstock

-Biogas production

-Storage of digestate, eventual conditioning and utilisation

-Storage of biogas, conditioning and utilisation [1].

After storage and pre-treatment, the feedstock is fed into the digester. The feeding technique depends on the feedstock type and its pumpability. Pumpable feedstock is transferred from storage tanks to the digester by pumps. The pumpable feedstock category includes animal slurries and many liquid organic wastes such as: flotation sludge, dairy wastes, fish oil, etc. [3]. Feedstock types which are non-pumpable (fibrous materials, grass, maize silage, manure with high straw content) can be poured by a loader into the feeding system and then fed into the digester. Both feedstock types can be simultaneously fed into the digester. In this case, it is preferable to feed the pumpable feedstock through by-passes. From a microbiological point of view, the ideal situation for a stable anaerobe digestion process is a continuous flow of feedstock through the digester. In practice, the feedstock is added quasi-continuously to the digester, in several batches during the day. This saves energy as feeding aggregates are not in continuous

operation. There are various feeding systems and their selection depends again on feedstock quality, herewith their pumpability and on feeding intervals. [2]

The key areas that determine the food and nutrition security are: availability, access, consumption and biological utilization. For this reason it is necessary to promote the health of vulnerable groups, in this case, indigenous communities, protecting and establishing conditions to ensure the human right to food. In many rural communities, the main objective of raising animals at the site is the production of animal waste, in order to implement digesters for the production of biogas, as an alternative energy source, the production of meat stays in the background, thinking only about the community consumption and helping to ensure their food source, from this perspective, the technologies applied to rural and indigenous progress are environmentally friendly, socially just, economically viable and culturally acceptable. The theme of rural and indigenous development is focused on their food security and the use of alternative energies, considering that energy is a key element in achieving sustainable development in all sectors, therefore sought from a broad perspective solidarity and actively promote greater and more rational use of energy and the environment in remote communities, through diversification of supply sources and efficient use, thereby contributing to environmental conservation and reduction of health problems through the use of appropriate technologies.[7]

The agricultural waste management is needed to maintain soil fertility through the application of methods for recovery of the resulted biomass - namely through methods such as composting and methanisation, which will have an impact on human health and on environment protection . Soil pollution leads to affect its fertility, disturbing all its physicochemical, biological and biochemical functions. The concept of sustainable development involves the application of bio-waste recycling methods to replace conventional farming. Soil conservation in its lively form is the only guarantee of the future of every nation and of the planet as a whole [6].

In a biogas plant, a special attention must be paid to the temperature of the feedstock which is fed into the digester. Large differences between the temperature of the new feedstock and the operation temperature of the digester can occur if the feedstock has been sanitised (up to 130°C) or during winter season (below 0°C). Temperature differences disturb the process microbiology, causing losses of gas yield and must therefore be avoided. There are several technical solutions to this problem, such as using heat pumps or heat exchangers to pre-heat the feedstock before insertion in the digester.

MATERIALS AND METHODS

The purpose of this paper is to identify the main stages in the developing of a biogas plant, and especially the components of the feeding system, such as: centrifugal pumps, pressure displacement pumps.

Among the most important methods used in this purpose are: studies of the existing pumps in the university laboratory of agricultural machines, SWOT analysis.

RESULTS AND DISCUSSIONS

Centrifugal pumps

A centrifugal pump is a rote-dynamic pump, using a rotating impeller to increase the velocity of a fluid. The fluid enters the pump impeller along or near the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber, from where it exits into the downstream piping system [5]. Centrifugal pumps are commonly used to move liquids through a piping system and are therefore frequently used for handling liquid manure and slurries.

Pressure displacement pumps

For the transport of thick liquid feedstock, with high dry matter content, pressure displacement pumps (rotary piston and eccentric screw pumps) are often used.

The quantity of transported material depends on the rotation speed, which enables better control of the pump and precise dosing of the

pumped feedstock.

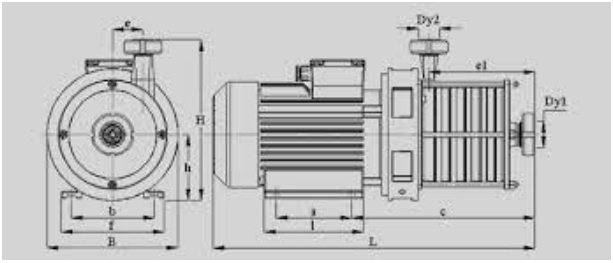

Fig. 1. Centrifugal pump
Source [www.indpower.ro]

Displacement pumps are self-sucking and more pressure stable than centrifugal pumps. For this reason, the piping performance is less dependent on difference in height. As pressure displacement pumps are relatively prone to problems caused by high fibre content in pumped materials, it makes sense to equip them with cutters and separators, to protect them from large particle size and fibrous materials.

The selection of appropriate pumps and pumping technology depends on the characteristics of the materials to be handled by pumps (type of material, particle size, and level of preparation). Biogas plants use the same pumps that are used for liquid manure, which proved to be suitable for feeding the digester and for handling the digested substrate. Practical experience indicates that formation of plugs at inlet and outlet can be prevented by a sufficient diameter of the pipes. Pressure pipes, for filling or mixing, should have a diameter of at least 150 mm, while pressure free pipes, like overflow or outlet pipes, should have at least 200 mm for transporting manure and 300 mm if the straw content is high.

The transfer of pumpable feedstock substrate from the storage tank into the digester is done by pumps. Two types of pumps are frequently used: the centrifugal and the displacement pumps. Centrifugal (rotating) pumps are often submerged, but they can also be positioned in a dry shaft, next to the digester. For special applications, cutting pumps are available, which are used for materials with long fibres (straw, feed leftovers, grass cuttings). Displacement pumps (turning piston pumps, eccentric screw pumps) are more resistant to pressure than rotating pumps. They are self-sucking, work in two directions and reach relatively high pressures, with a diminished conveying capacity. However through their lower price, rotating pumps are more frequently chosen than displacement pumps.

All movable parts of the pumps are subjected to high wear and must therefore be replaced from time to time. This should be feasible without interrupting biogas production. For this reason, the pumps must be equipped with stop-valves (Figure 2), which allow feeding and emptying of digesters and pipelines. Pumps and pipes should be easily accessible and ensure sufficient working room, to perform the maintenance work.

Fig. 2. Stop-valves [1]

Fig.3. Pumping station in a biogas plant [1]

The function of pumps, and by this the transport of pumpable substrate, is controlled

automatically, using process computers and timers. In many cases the entire feedstock transport within the biogas plant is realised by one or two pumps, located in a pumping station (Figure 3).
Stackable feedstock like grass, maize silage, manure with high straw content, vegetable. must be transported from a storage facility to the digester feed system. This is usually done by loaders or tractors (Figure 4) and the feedstock is fed into the digester using a screw pipe transporting system, like the one shown in figure 5.

Fig.4. Feed-in container system for dry feedstock - maize silage and solid poultry manure [1]

The feed-in system includes a container, where stackable feedstock is poured by tractor, and transport system, which feeds the digester. The transport system is controlled automatically consists of scraper floors, walking floors, pushing rods and conveyor screws. Scraper floors and overhead push rods are used to transport feedstock to the conveyor screws. They are capable of transporting nearly all stackable feedstock, either horizontally or with a slight incline, and are therefore used in very large, temporary storage containers, but they are not suitable for dosing. Conveyor screws can transport feedstock in nearly all directions. The only precondition is the absence of large stones and other physical impurities. For optimal function, coarse feedstock could be crushed, in order to be gripped by the screw and to fit into the screw windings.

Fig. 5. Conveyor screws [1]

The insertion of the feedstock into the digester has to be air-tight and should not allow leak of biogas. For this reason, the feed-in system inserts the feedstock below the surface layer of digestate (Figure 6). Three systems are commonly used: wash-in shaft, feed pistons and feed conveyor screws.
Feeding solids to the digester through wash-in shafts or sluices, using front or wheel loaders, allows large quantities of solids to be delivered any time, directly to the digester.

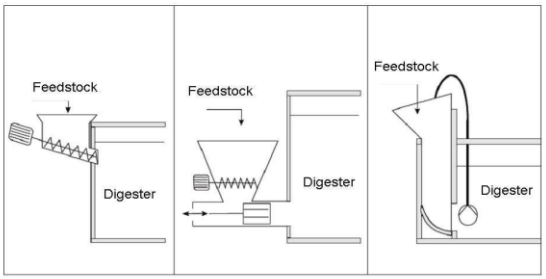

Fig.6. Wash-in shaft, feed pistons and feed conveyors system for feedstock insertion into the digester [2]

When using feed pistons, the feedstock is inserted directly into the digester by hydraulic cylinders, which push the feedstock through an opening in the wall of the digester. This ground level insertion means that the feedstock is soaked in the liquid content of the digester, reducing the risk of floating layer formation. This system is equipped with counter rotating mixing rollers, which transport co-substrates to the lower horizontal cylinders and, at the same time, crush long fibre materials.

Feeding co-substrates to the digester can be done by using feed screws or conveyor screws In this case, the material is pressed under the level of the liquid in the digester, using plug screws. The method has the advantage of preventing gas leaking during feeding. The simplest way to do it is to position a dozer on the digester, so that only one insertion screw is necessary. For feeding the screw, temporary storage containers, with and without crushing tools are used.

Fig.7. Feed-in system for silage [3]

CONCLUSIONS

A biogas plant is a complex installation, which is more and more used in rural areas as an alternative of bio-energy.

From all the components of a biogas plant: transport, delivery, storage and pre-treatment of feedstock, biogas production and storage of digestate, we concentrated over the transport and feeding system.

We analised the centrifugal pumps, which are reliable and are therefore frequently used for handling liquid manure and slurries. We also analised pressure displacement pumps, which are used for the transport of thick liquid feedstock, with high dry matter content.

The function of these pumps, and the transport of pumpable substrate, is controlled automatically, using process computers and timers. In many cases the entire feedstock transport within the biogas plant is realised by one or two pumps, located in a pumping station, as it was presented in the paper.

REFERENCES

[1]Al Seadi, T., Rutz, D., Prassl, H., Tobias M., Janssen, R., 2008, Biogas handbook, University of Southern Denmark Esbjerg, Denmark

[2]Al, Seadi, T., 2001, Good practice in quality management of AD residues from biogas production. Report made for the International Energy Agency, Task 24- Energy from Biological Conversion of Organic Waste. Published by IEA Bioenergy and AEA Technology Environment, Oxfordshire, United Kingdom

[3]Al Seadi, T., Holm Nielsen J., 2004, Utilisation of waste from food and agriculture: Solid waste: Assessment, Monitoring and Remediation; Waste management series 4; Elsevier; ISBN 0080443214, 735-754.

[4] Al Seadi,, T., Moeller, H., B., 2003, Separation of slurry - A potential option for the animal production sector. Proceedings report of European Biogas Workshop "The Future of Biogas in Europe III", October 2-4, Esbjerg, Denmark.

[5]Dumitru, M., 2006, Tractoare agricole, Ed. Alma Mater, Sibiu

[6]Neagu, C., 2013, Waste management generated from agriculture in Călărași county. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 13 (3):171-174.

[7]Víquez, C. S., 2013, Biogas as an alternative energy source to promote indigenous communities development. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 13(1): 345-352.