Pilot Scale Design: Dry Anaerobic Bioreactors

N. Papastefanakis[1], A. Maragkaki[1], G. Daskalakis[1], N. Markakis[1], E. Michalodimitraki[3], E. Stafilarakis[2], C. Tsompanidis[3], T. Manios[1]

[1]Laboratory of Solid Waste & Wastewater Management, School of Agricultural Science, Hellenic Mediterranean University - Educational and Research Committee, Heraklion, 71401, Crete, Greece

[2]Stafilarakis E., Industrial Park Chania, 73200, Crete, Greece

[3]ENVIROPLAN SA, Estauromenos, Heraklion, 71401, Crete, Greece

(Presenting author email: tmanios@hmu.gr)

Introduction

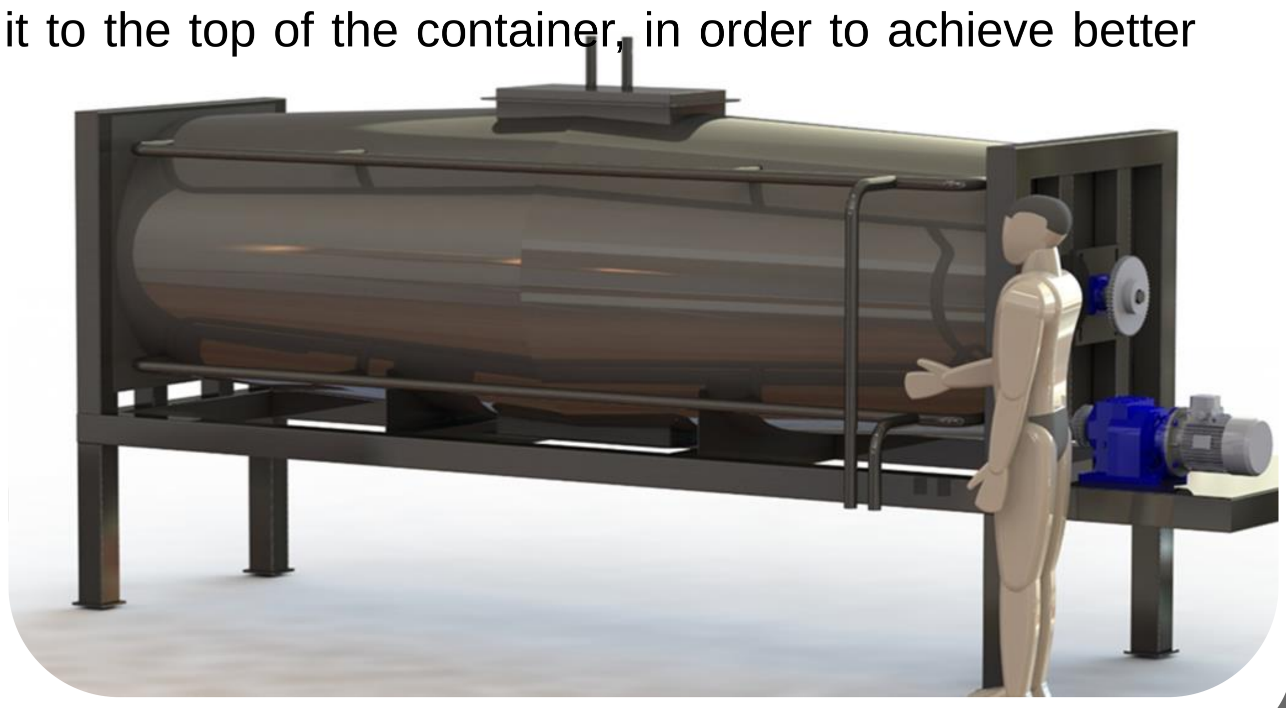
Anaerobic digestion (AD) is one of the most efficient processes to treat various kinds of raw biomasses into clean energy. The main goal of this process is to efficiently convert a waste in renewable biofuel, biogas.
In order to meet the demands of the expanding global population, it is vital to provide energy and food with little environmental impact. Anaerobic digestion is a method for managing organic wastes that can break down proteins, lipids, and carbohydrates biologically in the absence of oxygen to generate biogas. Operation at TS concentration greater than 15% is categorized as dry (solid-state) anaerobic digestion, in contrast to wet anaerobic digestion. Compared to wet anaerobic digestion, dry anaerobic digestion has a number of benefits, including less fresh water use and a more favorable energy balance. Agricultural waste has a high TS content, such as lignocellulosic biomass.

By using lignocellulosic biomass as a renewable feedstock to make energy and useful products, we can increase the viability of agricultural systems while lowering our reliance on fossil fuels and greenhouse gas emissions. On the other, solid-state anaerobic digestion (SS-AD), has gained popularity in the past decade as an environmentally friendly and cost-effective technology for extracting energy from various types of lignocellulosic biomass.
It is clear that the arid or semi-arid regions of the Mediterranean basin have a lot of residues with this characteristic, i.e., a relatively high concentration of solids, including food residues, for which traditional liquid anaerobic digestion has significant limitations, as does the alternative energy utilization process, combustion (or gasification). As long as technologies are created that enable the process efficiency to be maximized, SS-AD actually presents itself as an option. According to the above, this article presents the design of 2 types A and B pilot, solid, intermittent operation, anaerobic bioreactors, with working volume of 3 m^3.

Pilot Dry Anaerobic Bioreactors

Type A
The Type A bioreactor is a horizontal reactor, with an internal horizontal mixing shaft equipped with specially designed fins. The basic design consists of a double cone container. The design with such a basic shape, guides the concentration of the produced gas, in one point. Specifically, this point is in the center of the reactor, where there is a hatch with gas extraction equipment. The main chamber consists of double-walls. Hot water flows between the walls and keeps the temperature constant and controlled for the main chamber of the bioreactor.

The fins of the stirring shaft, are fully adjustable (both in length and in shape. In this way, it is possible to stir the processed mixture and at the same time to climb it to the top of the container, in order to achieve better mixing.
The rotation of the shaft will be controlled and guided both in terms of rotational speed and in terms of intermittent operation.



Type B
The Type B bioreactor is a horizontal cylindrical rotating reactor. It is a different approach with a different mixing logic as a key element, with all the materials being stirred as the reactor body rotates.
The reactor will have 4 safety valves while the biogas will be removed with the help of a decompression valve.

Results & Discussion

The bioreactors have a sensor and an automation system. The development of software and automation will allow the commercial and sustainable development of these units and the maximization of their efficiency, with the least possible requirement for personnel, skilled and unskilled.
The software will cover the entire process, i.e. both the selection and mixing of residues based on their availability (a Decision Support System - DSS), as well as the control and operation of each bioreactor, based on raw materials and operating conditions.
The initial tests are mainly related to technical issues and not performance issues, as the aim will be to establish the ease of operation control and in general the behavior of the systems in terms of leaks, automation, control of coking operating conditions.

In order to evaluate the operation of the two reactors, the following technical parameters were set:
1. The collection of the biogas,
2. The method used for heating the bioreactor,
3. The way of feeding and emptying the materials.
According to the above parameters, the produced biogas from Type A bioreactor is collecting continuously. On the contrary, Type B bioreactor should be stopped temporarily in order to collect biogas. In addition the two types of reactor have different heating system. The main chamber of Type A reactor consists of double-walls and hot water flows between the walls. This has as a result the uniform heating of the materials in the chamber compared to Type B where hot water flows through a spiral tube located on the axis of rotation. Finally, both reactors are operated in batch mode. Feeding and emptying of Type A bioreactor could be done without stopping the operation of the reactor conversely Type B bioreactor should be stopped temporarily.

Conclusions

The development of these pilot scale dry anaerobic bioreactors will allow the commercial and sustainable development of these units and the maximization of their efficiency, with the least possible requirement for personnel, skilled and unskilled.

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