Dry Anaerobic Bioreactors in All4Waste Circular Economy Park

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Introduction

The major objective of All4Waste park is to enable primarily private organizations to carry out their innovative research activities connected to wastewater management, usage, and treatment within the context of the Circular Economy. The All4Waste park has the needed environmental licensing for waste and wastewater treatment, according to the current EU legislation (3982/2011). Energy and food production must have minimal environmental impact in order to meet the demands of the growing world population. In order to manage organic wastes, anaerobic digestion uses biological processes to break down proteins, lipids, and carbohydrates without the use of oxygen in order to produce biogas. Dry anaerobic digestion has a variety of advantages to wet anaerobic digestion, including less fresh water use and a more favorable energy balance. Agricultural waste, like lignocellulosic biomass, has a high TS content.

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.

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.

This article describes the two types A and B pilot anaerobic bioreactors that are situated in the All4Waste park and operate solidly under intermittent conditions with a useful volume of 3 m^3.

All4Waste park: Dry Anaerobic Bioreactors

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 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 have 4 safety valves while the biogas removes with the help of a decompression valve.

Results & Discussion

The bioreactors have a sensor and an automation system. The development of software and automation 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 covers 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 in All4Waste, 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

These pilot scale dry anaerobic bioreactors in All4Waste allow the private organizations to carry out their innovative research activities connected to waste management, usage, and treatment within the context of the Circular Economy.

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