BIOGAS

TECHNOLGY BRIEF

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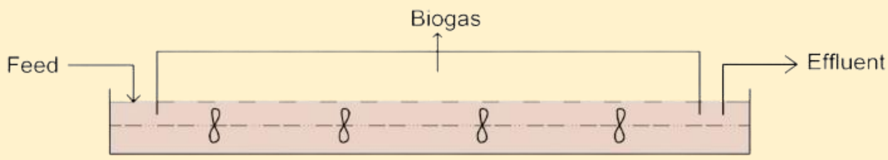
Anaerobic Plug Flow Reactors (APFR)

Introduction

Plug flow digesters are long and narrow, with a tubular cross section along the length. These are usually concrete enclosures with a rigid or flexible cover. APFR is classified as a 'low-rate' system. Some other names used for APFRs are piston flow reactor, pipe flow reactor, and continuous tubular reactor.

Operating Principle

The operation of a APFR is somewhat similar to that of continuous flow fixed dome biogas reactors. There is a feed inlet for the influent substrate and an outlet for the affluent digestate. The substrate flows as a plug from the inlet to the outlet which are located at the opposite ends. There is no longitudinal mixing of the substrate unless mixing is introduced to the system along the length of the digester to enhance contact between substrate and microorganisms. The substrate is decomposed during the long journey along the movement. The influent displaces an equal amount of digestate out of the digester as effluent following the 'first-in first-out' principle. The bottom of the digester is built with an angle to the horizontal plane from the inlet to the outlet. This inclination facilitates the flow from the inlet to the outlet and to separate acidogenesis and methanogenesis phases, like in a 2-phase system. The influent substrate is thick enough (like manure) to keep particles from settling to the bottom. The generated biogas is collected at the upper part of the digester. This digester design has a constant volume, but produces biogas at variable pressures.



APFR with axial mixing

Key Assumptions

- Material passes through the reactor in incremental slices (each slice is perfectly mixed radially, but there is no forward or backward mixing between slices
- Reactor operates at steady state
- There is no difference in concentration radially at any cross section of the (tubular) digester

Technical Details

- This has a suspended growth system where microorganisms are in suspension
- Solid content ~ 10 - 15%
- Process temperature ~ 35°C - 55°C
- Length to Width ratio ~ 3 - 5 : 1
- Hydraulic Retention Time ~ 15 - 30 days

Applications

- Can be used to decompose semi-solid biomass with higher solid contents
- Farms and facilities with consistent waste characteristics
- Widely used in Brazil to treat swine waste, and in Sweden, China, India, Vietnam, & Nepal
- Efficient for semi-solid substrates (municipal solid waste, biomass, straw, and other high-solids content waste)

Advantages

- Allows treatment of a higher amount of waste per unit digester volume.
- Simple design- doesn't need major expert intervention
- Ability to optimize energy production in many climate (warm & low temperature) conditions
- Lower water requirement compared to traditional wet biogas systems
- Easy installation & handling, & lower capital costs

Challenges

- Solid sedimentation, floating matter & scum formation. Removal of the sediment solid is difficult
- Can create 'dead zones' near the corners due to lack of microorganism activity, reduced effective volume of reactor & increasing hydraulic retention time
- Lack of flexibility to the variability of the influent
- Longer hydraulic retention time due to linear flow of material
- Need for periodic cleaning

References

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