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Feasibility of Applying a Hydrodynamic Cavitation Generator as a Method for Intensification of Methane Fermentation Process of Virginia Fanpetals (Sida hermaphrodita) Biomass

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Abstract : The anaerobic degradation of substrates is limited especially by the rate and effectiveness of the first (hydrolytic) stage of fermentation. This stage may be intensified through pre-treatment of substrate aimed at disintegration of the solid phase and destruction of substrate tissues and cells. The most frequently applied criterion of disintegration outcomes evaluation is the increase in biogas recovery owing to the possibility of its use for energetic purposes and, simultaneously, recovery of input energy consumed for the pre-treatment of substrate before fermentation. Hydrodynamic cavitation is one of the methods for organic substrate disintegration that has a high implementation potential. Cavitation is explained as the phenomenon of the formation of discontinuity cavities filled with vapor or gas in a liquid induced by pressure drop to the critical value. It is induced by a varying field of pressures. A void needs to occur in the flow in which the pressure first drops to the value close to the pressure of saturated vapor and then increases. The process of cavitation conducted under controlled conditions was found to significantly improve the effectiveness of anaerobic conversion of organic substrates having various characteristics. This phenomenon allows effective damage and disintegration of cellular and tissue structures. Disintegration of structures and release of organic compounds to the dissolved phase has a direct effect on the intensification of biogas production in the process of anaerobic fermentation, on reduced dry matter content in the post-fermentation sludge as well as a high degree of its hygienization and its increased susceptibility to dehydration. A device the efficiency of which was confirmed both in laboratory conditions and in systems operating in the technical scale is a hydrodynamic generator of cavitation. Cavitators, agitators and emulsifiers constructed and tested worldwide so far have been characterized by low efficiency and high energy demand. Many of them proved effective under laboratory conditions but failed under industrial ones. The only task successfully realized by these appliances and utilized on a wider scale is the heating of liquids. For this reason, their usability was limited to the function of heating installations. Design of the presented cavitation generator allows achieving satisfactory energy efficiency and enables its use under industrial conditions in depolymerization processes of biomass with various characteristics. Investigations conducted on the laboratory and industrial scale confirmed the effectiveness of applying cavitation in the process of biomass destruction. The use of the cavitation generator in laboratory studies for disintegration of sewage sludge allowed increasing biogas production by ca. 30% and shortening the treatment process by ca. 20 - 25%. The shortening of the technological process and increase of wastewater treatment plant effectiveness may delay investments aimed at increasing system output. The use of a mechanical cavitator and application of repeated cavitation process (4-6 times) enables significant acceleration of the biogassing process. In addition, mechanical cavitation accelerates increases in COD and VFA levels.

Keywords : hydrodynamic cavitation, pretreatment, biomass, methane fermentation, Virginia fanpetals
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