Biogas and Energy Production by Utilization of Different Agricultural Wastes

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Abstract- **Sustainable agricultural development and increasing the rate of renewable energy sources have become an economic issue after Hungary joined the EU. Under the present economic conditions the private sector cannot solve in its complexity the problems of environment protection and energy from its own sources. . However, the amount of organic materials currently available for biogas production is limited and new substrates as well as new effective technologies are therefore needed to facilitate the growth of the biogas industry all over the world. Hence, major developments have been made during the last decades regarding the utilization of lignocellulosic biomass, the development of high rate systems, and the application of membrane technologies within the anaerobic digestion process in order to overcome the shortcomings encountered. The degradation of organic material requires a synchronized action of different groups of microorganisms with different metabolic capacities. Recent developments in molecular biology techniques have provided the research community with a valuable tool for improved understanding of this complex microbiological system, which in turn could help optimize and control the process in an effective way in the future.**

I. INTRODUCTION

Producing and utilizing renewable energy – both in a global and a national context is necessitated by the synergistic effect of climate change and the long term, continuous price rise of fossil fuels. The main reasons for the spread of renewable energy sources are to increase the security of the energy supply or, in optimal case, to realize total energy independence. Our paper deals with production and utilization of biogas for energy. The importance of biogas is, in addition to energy aspects, justified environmentally by EUrequirements and by economic considerations, because conservation of the state of our environment and efficient, economically satisfying energy demands can be solved by the harmonized application of traditional and renewable energy sources. Biogas is a colourless, flammable gas produced via anaerobic digestion of animal, plant, human, industrial and municipal wastes amongst others, to give mainly methane (50-70%), carbon dioxide (20-40%) and traces of other gases such as nitrogen, hydrogen, ammonia, hydrogen sulphide, water vapour etc. . It is smokeless, hygienic and more convenient to use than other solid fuels. Biogas production is a three stage biochemical process comprising hydrolysis, acidogenesis/acetogenesis and methanogenesis.

$(C_6H_{10}O_5)_n + nH_2O \rightarrow n\,(C_6H_{12}O_6)$ - Hydrolysis

$n\,(C_6H_{12}O_6) \rightarrow n\,CH_3COOH$ - Acetogenesis/Acidogenesis

$3nCH_3COOH \rightarrow n\,CH_4 + CO_2$ - Methanogenesis

Biogas technology amongst other processes (including thermal, pyrolysis, combustion and gasification) has in recent times also been viewed as a very good source of sustainable waste treatment / management, as disposal of wasteshas become a major problem especially to the third world countries.

II. METHODS

Through the simultaneous presentation of the research into biogas production and utilization, we wished to present the connection between agriculture and energy; we looked at the waste-problem of pig-farms with a few hundred pigs and the possibility of the treatment of liquid pig manure and, further, to the feasibility of building a stable energy-production unit. The results of our research work, undertaken at the Mezőtúr Campus of Szolnok College, demonstrate the quantity and composition of the generated biogas via fermentation of liquid pig-manure and different kinds of additives. The results reveal further how the fermenters can be operated to produce the proper quantity of biogas with a composition that complies with added utilization potentialities in plants with similar technology.

A. Methods Concerning the Biogas Production

At the Mezőtúr Campus of Szolnok College, we undertook biogas producing experiments based on liquid pig-manure to develop variants for intensifying biogas yield. The task performed during the research were:

- Planning of the biogas producing experiments, and the preparation of an applied fermentation technology and unit.
- Constructing and continuously developing the instruments for the experiments.
- Undertaking biogas producing experiments for the energy utilization of biogas.
- Evaluating the results (quantity, composition, energy content, etc.) of the biogas producing experiments.

We created 30 experimental variants using different kinds of plant additives to produce biogas based on liquid pig manure. The dry matter content of the liquid pig manure was 4%, and our experiments lasted 43-50 days. The increase did not influence quality (methane content), but methane stability depended on the additives.

B. Biogas Utilization Researches

We undertook research work in the GyörgyJendrassik Heat Engineering Laboratory at the Budapest University of Technology and Economics, Department of Energy Engineering. The objective of the gas engine tests was to get to know how biogases – as the different kind of experimental variants – influence the operation of gas engines. The experimental gas engine is not a special biogas engine but rather a conventional natural gas engine. the test engine are:

- 24.6 kW, 4 cylinder Wisconsin Motors Continental TM27 type gas
- engine
- 26.4 kW, 4 pole Marelli CX IM B3 180M type asynchronous
- dynamometer
- controller box (starter button, mode switch, locking switch etc.)
- indication system
- emission analyzer
- data collecting system After your paper has been accepte

III.RESEARCH AND TASK OBJECT

This paper presents the complexity of the production and utilization of biogas. The research work was done at the Budapest University of Technology and Economics, Department of Energy Engineering, and at Szolnok University College, Technical and Machinery Department. In the course of our research work, we supposed that there is an energy-producing and energy-utilizing technology which can be suitable for the circumstances and initial conditions. The objective of the research task was to support the approach that it is necessary to examine the biogas producing and utilizing technological processes together as a complex system. It is needed to analyze these, considering that the principle of the complex optimization focuses just on the environment and waste disposal. The tasks performed during the research were:

- Proving with experiments the yield-increasing and quality improving effects of different kinds of plant additives added to pig manure in the fermenters (mesophylic- bioreactors).
- Testing the utilization of biogases from different kinds of liquid pig manure and additives for energy gaining in gas engines, with particular regard to the emission.

A. Current biogas process technologies.

The production of biogas through AD offers major advantages over other forms of bioenergy production. In fact, it has been defined as one of the most energy-efficient and environmentally beneficial technology for bioenergy production (Deublein and Steinhauser, 2011).The degradation process can be divided into four phases: hydrolysis, acidogenesis, acetogenesis, and methanogenesis; and in each individual phase, different groups of facultative or obligatory anaerobic microorganisms are involved. (Merlin Christy et al., 2014; Chasnyk et al., 2015; Abdeshahian et al., 2016). Beside energy production, the degradation of organic waste also offers some other advantages including the reduction of odour release and decreased level of pathogens. Moreover, the nutrient rich digested residue could be used as organic fertilizer for arable land instead of mineral fertilizer, as well as an organic substrate for green house cultivation (De Vries et al., 2012; Abdeshahian et al., 2016). Among the raw substances, organic materials obtained from farm and animal waste streams, as well as from industrial and household activities are pivotal sources for biogas production.

Although all these different waste fractions are suitable for biogas production, their biogas potential varies significantly. The biogas yield mainly depends on the composition and the biodegradability (under anaerobic conditions) of the waste. Theoretically, the highest biogas yield can be achieved from lipids (1.01 Nm3 CH4/ kg VS), followed by proteins (0.50 Nm3 CH4/ kg VS), and carbohydrates (0.42 Nm3 CH4/ kg VS) (Møller et al., 2004). On the other hand, biodegradability defines how much of a given material is actually utilized during the process.

B. Pretreatment for enhanced biogas production.

The growing global energy demand together with the limited availability of fossil fuels, unstable energy prices, and environmental problems necessitate the use of renewable energies. The currently used feedstocks for AD are limited, and therefore, it is important to explore new substrates for their utilization in AD to reserve the growing needs. The abundance and availability of lignocellulosic biomasses worldwide as well as their high carbohydrate content make these materials an attractive feedstock for biofuel production. Lignocelluloses have been accounted unted for approximately 50% of the biomass in the world and the production of lignocelluloses can count up to about 200 billion tons per year (Claassenet al., 1999; Zhang, 2008). Currently, the utilization of lignocellulosic residues as feedstock for methane production is not widespread(Lehtomäki, 2006; Seppälä et al., 2007) due to their recalcitrant structure, which is the main challenge (Hendriks and Zeeman, 2009).

IV. PRACTICAL APPLICATION OF THE RESULTS

We supposed that there are 500-800 pigs on a pig farm, and therefore the quantity of liquid pig manure is 1277.5 ton/year. The pig (liquid) manure is not enough alone to produce the necessary biogas quantity and fuel quality for the energy supply needs of the farm, so it is necessary to use different kinds of agricultural by-products and wastes, and it is necessary to add a biomass plant. Since biogas plants are in continuous operation, it is necessary to provide a yield enhancing organic matter in the annual production cycle. We applied agricultural by-products and wastes as organic additives during the development of the experimental variants. On the farm, the disposal options for organic wastes played an important role in selection alongside enhanced biogas yield (methane yield). Table 2contains the annual quantity of pig liquid manure and organic additives for developing the experimental variants.

Table.2 “Energy” from organic wastes

organic wastes for energy production	quantity of organic wastes	average quantity of produced methane
pig (liquid) manure	1277.5	Σ 130.7*
fruit marc	219	
maize marc	43.8	
Sweet sorghum residue	18.25	

Most of the organic wastes in the table can be produced on the farm and are available outside the harvest period (August-November) as well, and so the operation of system can be provided for by agricultural wastes which are stored. But other organic matter (organic waste) is available through agriculture or can be obtained from the alcohol industry.

Based on the above, it can be stated that all organic matter can be biodegraded in the biogas plant, but that due to aspects of biogas production we should consider for energy production only organic matter which biodegrade rapidly and is available in sufficient quantity in the farm.

.V. CONCLUSION

A complex biogas production and utilization system was created by developing experimental biogas variants, and in such a way both the energy and the environmental goals can be achieved together, as the applied variants can provide favourable conditions for the production and the utilization of biogas. The methane content of biogas satisfies the conditions of utilization so that the heat engines can operate properly. Simultaneously, waste disposal can also be realized. In the interest of a near optimal solution, it is necessary to analyze the production and utilization functions together, considering that the principle of the complex optimization focuses just on the environmental-friendly energy utilization. Thus, if the quantity and/or quality of the input material necessary for developing variants cannot be provided, the energy output can decrease and waste disposal can be overshadowed too.

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