The summary of the doctoral thesis

Agnieszka Graczyk-Pawlak M. Sc.

„EFFICIENCY OF AGRICULTURAL BIOGAS PLANTS DEPENDING ON PHYSICAL AND CHEMICAL PARAMETERS OF SUBSTRATES WITH HIGH ENERGETIC YIELD"

The aim of the research work was to determine by empirical inference the influence of selected analytical parameters, such as dry organic matter content, unit biogas yield and methane concentration, characterizing selected high energy substrates on the possibility of increasing biogas production efficiency.

The energy yield of biogas resulting from the methane content as well as in the theoretical amount of energy contained in the substrates was also evaluated.

In order to carry out the experiment by means of dynamic feeding of the fermentation mixture, test stand was designed in a thermostated eudiometer system with fermentation bottles equipped with tappings allowing to inject a portion of substrates without unsealing the measuring apparatus.

As the research material were selected high-energy liquid and solid components in three quality classes:

- sugar: molasses and dried sugar beet pulp
- protein: hydrolyzate and heparin paste
- fat: waste oil and sludge from degreasing

The research plan was based on assumptions of multivariate and multi-parameter analysis for selected independent variables: substrate category and consistency as well as mass and frequency of dosing. Further steps to change the experiment factors were planned and implemented, aiming at gathering the set of data resulting from the relationship between the set of fixed parameters and independent variables. The obtained data - dependent variables: volume of biogas, methane concentration, temperature and atmospheric pressure, were used to calculate the results of the experiment, i.e. net volume of biogas from the sample, unit yield of biogas, unit methane recovery and theoretical energy. The dynamics of the fermentation process, the duration of the process and differences in the volume of biogas between control samples: the fermentation mixture fed with a mixture of cow slurry and

maize silage and experimental, fermentation mixture fed with portions of selected high energy components were assessed.

Measurements including the volume of biogas and the concentration of methane obtained during the fermentation of the tested substrates were carried out on a weekly basis with the randomization of the samples. Over the following days, a portion (10g 1x 24h) of the base feeding mixture was altered for portion of high energy components in the following doses: 2.5g 1x per 24h; 1.25 4x for 24h; 2.5 2x per 24h.

The assessment of the impact of selected technological parameters and independent variables on dependent variables was performed after a statistical analysis of the level of relevance and the correlation between the obtained results. The statistical analysis carried out for received data showed that the categories of substrates selected for the research in a highly significant way affect the yield of biogas and the methane concentration in biogas. The consistency of the tested substrates had a significant impact on the efficiency but it had no significant effect on the methane content in the biogas. As shown by the collected values, the dosing method of the tested substrates considered in the experiment remained without significant influence on the obtained results of the biogas yield assessment.

The most balanced and stable volume increase of biogas was characterized by the tested fatty substrates: waste oil and sludge from degreasing. Also for these substrates, the highest net biogas yields were recorded in the range of 0.28-0.38 Nl h^{-1} for a total weight of 5g per day, with a simultaneous average methane concentration of 64.1-66.5%, respectively.

Protein substrates with the highest recorded concentration of methane in the range of 67.8-70.4% showed an average variable dynamics of efficiency. The protein paste was characterized by a stable volume increase, with peaks in the range of 0.15-0.25 Nl h^{-1}. On the other hand, the liquid protein substrate (Bp) - hydrolyzate, was characterized by a variable volume increase, with peaks in the range of 0.12-0.24 Nl h^{-1} with a predominance of 0.21Nl h^{-1}.

In order to assess the research problem which was to determine the impact of the combination of selected factors on gaining momentary increase in biogas efficiency, while maintaining further stability of the installation's work, tests were performed on a semi-technical scale. The presented dependences were tested on the example:

70 liters of stable fermentation mixture was fed once with a portion of protein paste 490g 1x 24h with a 3.5h shift forward to obtain an efficiency increase from 8.00, then molasses 245g 2x 24h in 4.5 hour intervals. For the test portion used, a net result of 416.9 Nl kg fm^{-1} with an average content of 61.4% CH_4 was obtained. Comparison of control and experimental

values indicates that eight times more theoretical energy was obtained after swapping the feeding portion.

The results of the evaluation of the obtained parameters of fermentation of high energy substrates confirmed by the test on a semi-technical scale allow to ensure the expected dynamic and short-term increase in biogas production efficiency in energy peaks depending on the mass of the portion and dosing frequency of high energy substrates.