Exploration of the possibility for using animal manure as alternative fuel in pig farm

Konstantin Kostov [1]
Faculty of Engineering and Pedagogy of Sliven, Technical University of Sofia[1]

kostov_77@abv.bg

Abstract: *The increasing demand for local products is forcing farmers to expand their production, which also increases the waste generated by the animal husbandry process. The utilization of organic waste from livestock farms is a serious task for farmers, and they need to look for alternative methods of treatment. In this paper, we consider the possibility of applying sludge from a pigs farm for fattening. Samples of dried to room humidity sludge taken from a pig manure metal lagoon were examined. The purpose of the study is to evaluate the prospect of sludge as an alternative fuel for the pig farm. A thermogravimetric (TD) and differential thermal (DTG) analysis method was used to investigate the sediment. These methods of analysis were used because of the wide range of information provided and the possibility of qualitative and quantitative analysis. The types of phase transitions in the processes of heating and cooling, the temperature interval, the time for their flow and the amount of heat absorbed or released are investigated.*

Keywords: DUNG, THERMOGRAVIMETRIC, DIFFERENTIAL - THERMAL ANALYSIS, ALTERNATIVE FUEL

1. Introduction

In Bulgaria, pig farming is industry with traditions which, after a long period of decline, are already one of the most promising branches of livestock breeding. At present, domestic production accounts for around 40% of domestic demand, with all prerequisites for this share to exceed 60% in the coming years and to continue to grow [1], [2]. The basis of this upward development, is the strong domestic demand and the relatively high prices of local produce. High investment activity, low production facilities and appropriate conditions can be used to attract new investment in the sector. However, in line with EU legislation, investors face the issue of the generated sludge from livestock farming, creating a new environmental problem that needs to be addressed. Although sludge is traditionally treated as a waste management problem in most EU countries, sludge deposition is gradually declining, as the sludge reuse trend, as a fuel, gains value. The industrialization of pig production comes hand in hand not only with improved efficiency but also with serious environmental challenges. A larger farm also means more bio-waste to be collected, stored safely and utilized. Unfortunately, agricultural land that can be enrichment with livestock manure is constantly decreasing in the world and the management of this waste is becoming more and more problematic [3], [4], [10].

Modern equipment for removal the manure at pig farms in Bulgaria meets the requirements of European legislation (Directive 91/676 / EEC) and usually includes a fertilizer pump and a fertilizer storage lagoon. Dewatering wet the fertilizer, is mechanically via screw presses. To remove the chemically bound water at dewatering of the sludge, takes place processing with organic polymer (flocculants). Polymers are supplied in powder form and are prepared in the form of a rare aqueous solution, which is dosed to the slurry at the inlet of the presses. Organic polymers used in mechanical dewatering bind the particles of the sediment with long molecular chains and cause an effect "fluidity" of the dewatered sludge. The obtained mixture with a jelly-like consistency is deposited on dehumidifying fields and although it initially accumulates at "stacks" after one to three days it "slops" to a flat surface [5], [6]. The main purpose of sludge dewatering is to reduce their volume, which facilitates their transportation and, accordingly, recovery or incineration.

2. Materials and experimental procedure

The object of the present study are samples of dried sludge (humidity 7%) taken from a fertilizer metal lagoon in the village of Mechkarevo, municipality Sliven. The pig farm was built in 2014 and has a capacity of 1400 animals. The fertilizer metal lagoon has a capacity of 1100 m^3, its capacity being designed in a way that there is no spillage.

The Thermogravimetric (TD) and Differential - Thermal (DTG) method of analysis was used for sludge analysis. Thermogravimetric (TD) method can be used to investigate any process that changes the mass of the sample when heated without melting. The change in mass is used for quantitative analysis and the temperature the change at which occurs for qualitative analysis. The Differential Thermal (DTG) method of analysis is applicable for qualitative and quantitative analysis of all types of materials. The processes of melting, boiling sublimation are investigated.

The type of phase transitions, in the heating and cooling processes, the temperature interval, the time of their flowing and the amount of absorbed or separated heat are studied [7]. The aim of the study is to assess the prospect for the sludge as an alternative fuel for the needs of the pig farm.

The general appearance of the laboratory installation is shown in figure 1. Differential thermal analysis is the most commonly used thermal analysis method due to the wide range of information provided [8], [9]. The high temperature analyser is designed to provide maximum calorimetric sensitivity, short time constants, and a non-condensing sampling chamber.

The thermal impact of the samples is from 23^0C to 800^0C in an atmosphere $N_2/O_2/N_2$ at heating rate 10^0C/min. It is investigated of sludge from the holding's wastewater was examined, upon entering the fertilizer metal lagoon.

Fig.1. *DTA analyzer*

3. Results and Discussion

Figure 2 shows (TG) and (DTG) curves for the sample. Stand out are three characteristic stretches.

The first one starts at room temperature and ends at a temperature 225^0C. As a result of heating in an inert environment, the (TG) curve shows a loss of mass 7,011%. This is explained by the evaporation of a different in origin moisture. The most intense moisture loss was observed at $72{,}23^0$C from 1,23%/min. It can be assumed that the release of moisture ends up $175{,}9^0$C, then by the end of the temperature range of mass loss is negligible. Understandably, the dehydration process is accompanied by a pronounced endothermic effect reported on the (TG).

The second region is in the temperature range of 225^0C to 550^0C. It is characterized by an intense mass loss due to combustion of combustible components. Curve (TG) clearly can be divided into two regions with an inflection point at $381{,}1^0$C. Until this temperature is recorded mass loss 29,78% with extreme at 277,9 ^{0}C by 2,97 %/min. There follows a second stretch, at the end of which the loss of mass reaches 58,43% with a maximum of $504{,}5^0$C by 3,82 %/min. Understandably, incineration is accompanied by a pronounced exothermic effect. The curve of (DT) in this temperature range has two characteristic peaks - one at $339{,}1^0$C by 1,95 mW/mg and second at $501{,}6^0$C by 13,3 mW/mg, as between the two extreme exothermic values at $390{,}3^0$C there is a local minimum of 1,0103 mW/mg. Obviously it is about two parallel processes, the kinetics of which overlap in this temperature range. It seems plausible to explain that the first peak is associated with combustion of the volatiles, while the second, where the exothermic effect is much more pronounced, is related to the burning of the coke residue. It is known that the volatiles burn in a distinct front at a rate determined by molecular diffusion, whereas the burning of the coconut residue proceeds through the significantly slower sorption and adsorption process of the oxidant on the surface of the coke particle. It can be grounded assumed that the endo effect between the two peaks is due to pyrolysis and thermal destruction in the remainder of the material after the burning of the volatiles.

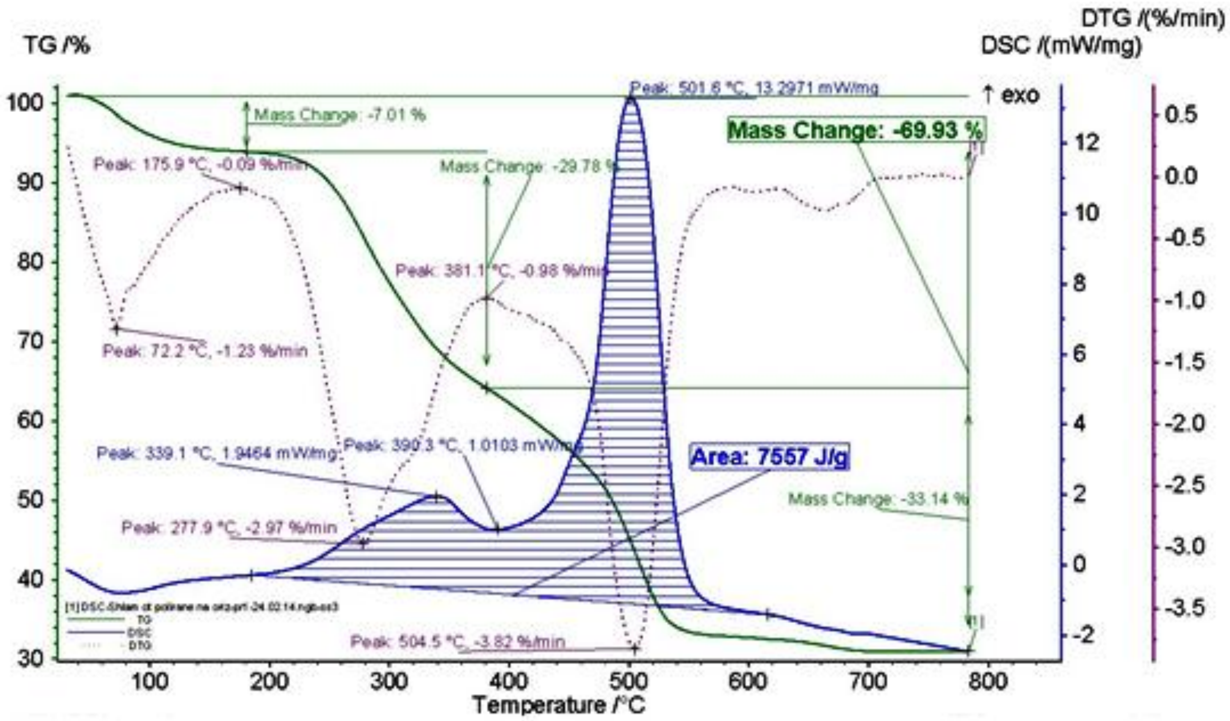

Fig.2. *TG and DTG curves of the test sample*

The last stretch of 560^0C to 790^0C runs at a moderate rate of mass reduction. The explanation is that after 560^0C in the sample there is left only a non-combustible mineral mass, the destruction of which proceeds with an endothermic effect. The determined calorific value of the sample is 7557 J/g.

The calorific value of sludge obtained is commensurate with that of lignite coal, but it should be noted that the moisture content of the sludge is 90% and that of coal reaches 40%. The high amount of moisture is a prerequisite for finding another way to utilize them. Extraction of biogas from manure is a good alternative [11]. The introduction of a biogas plant, despite the large initial investment, expands the use of renewable energy sources. The process of processing animal manure is fermentation in an anaerobic environment, in which the incoming organic materials are broken down into their constituent units. The process is carried out in a bioreactor and the final result of the fermentation is the production of biogas and other organic products.

There are several ways to utilize the biogas from pig farms. The easiest way on use the biogas is the burn it directly in boilers to provide hot water for the farm's technological needs, as well as for heating the buildings.

Another way to apply biogas is a cogeneration, based on an internal combustion engine. This type of installation allows farmers to generate on-site electricity and heat that can largely meet their own energy needs. Essential to the technical efficiency of cogeneration systems is the requirement of a constant heating load, which ensures the design operation of the engine and generator. Recently, schemes are being developed to allow the utilization of part of the high-temperature (up to 150 ° C) production gases in air-conditioning and industrial installations with absorption, sorption and / or compressor refrigeration machines - the so-called three-generation schemes. They guarantee a constant heat load in the summer and increase the usability of the cogenerator.

4. Conclusions

The development of animal husbandry in Bulgaria necessitates the improvement of the systems and methods of treatment of sludge from animal husbandry. The methods of manure treatment considered are applicable, but in carrying out a thorough technical and economic analysis and taking into account the specific features of each livestock farm. The design and construction of the facilities must take into account the capacity of the farm, the way the animals are kept, the amount of litter used.

Based on the results of thermogravimetric (TG) and differential thermal (DTG) analysis, it can be concluded that the use of sludge as an alternative fuel is possible, since their calorific value is commensurate with that of the lignite coal , but it is should be noted that the moisture in the working mass is 90% and for coal it reaches 40%. The dehydration of the sludge will bring additional costs to farmers and it would be more appropriate to use sludge in agriculture as organic fertilizer and to reclaim disturbed land. However, this treatment leads to the accumulation of manure in the holding, as it must remain for 6 months before being introduced into the soil.

The implementation and use of biogas plants for combined heat and power production are of great potential, as they solve several major problems of livestock facilities - the accumulation of manure, meeting the hygiene requirements for animal husbandry, and energy independence and energy efficiency.

References

1. Mitova D., Pig Breeding - before and after Bulgaria’s Accession to the EU, Economy and Management of Agriculture, Volume 57, Issue 5-6, 2012, pp 03-14

2.Vasileva Z., Evolution and status of pedigree process in pig breeding, Agricultural Sciences, Volume V, Issue 13, 2013, pp 21-26

3. Hernández D., J. Fernández, C. Plaza, A. Polo, Water-soluble organic matter and biological activity of a degraded soil amended with pig slurry, Science of the Total Environment, Volume 378, 2007, pp 101–103

4. Flotats X., A. Bonmatí, B. Fernández, A. Magrí, Manure treatment technologies: On-farm versus centralized strategies. NE Spain as case study, Bioresource Technology, Volume 100, 2009, pp 5519–5526

5. Melse R., M. Timmerman, Sustainable intensive livestock production demands manure and exhaust air treatment technologies, Bioresource Technology, Volume 100, 2009, pp. 5506–5511

6. Makara A., Z. Kowalski, Selection of pig manure management strategies: Case study of Polish farms, Journal of Cleaner Production, Volume 172, 2018, pp. 187-195

7. Fikirov S., Thermal analysis methods, Publishing house of the Sofia University, 1989

8. Tondl G., L. Bonell, C. Pfeifer, Thermogravimetric analysis and kinetic study of marine plastic litter, Marine Pollution Bulletin, Volume 133, 2018, pp. 472–477

9. Ua J., C. Bian, Thermogravimetric Analysis of Arson Evidence, Procedia Engineering, Volume 211, 2018, pp. 456–462

10. Chen G., X Wang, J. Li, B. Yan, Y. Wang, X. Wu, R. Velichkova, Z. Cheng, W. Ma, Environmental, energy, and economic analysis of integrated treatment of municipal solid waste and sewage sludge: A case study in China, Science of the Total Environment, Volume 647, 2019, pp. 1433 – 1443.

11. Kostov, P., K. Atanasov., I. Ivanov, K. Peychev, R. Georgiev, Investigation of some energy characteristics of pig farm, Agricultural science and technology, Volume 8, Number 1, 2016, pp. 70-74.