UDC 697.92

V.M. Zhelyh, Ch.R. Kozak, Yu.V. Furdas, N.A. Spodiniuk, O.I. Dzeryn
Lviv Polytechnic National University,
Department of неat and gas supply and ventilation

ENERGY SAVING TECHNOLOGIES IN PRODUCTION COMPLEXES FOR AGRICULTURAL PURPOSE

The basic power problems of current time both in the world and in Ukraine in general are submitted. Combined of the farms heating supply system based on module with infrared heating, bioreactor and air solar collector is proposed. Research on studying the possibility of using the thermosyphon solar collector for thermal control in a bioreactor is presented.

Key words: energy saving; combined heating system; infrared heating; bioreactor; biomass; thermosyphon solar collector.

Висвітлено нинішні основні енергетичні проблеми в світі та в Україні загалом. Пропонуються комбіновані системи опалення, основані на модулі з інфрачервоним обігрівом, біореактором і сонячним колектором. Досліджено можливості використання термосифонного сонячного колектора для теплового контролю в біореакторі.

Ключові слова: енергозбереження; комбінована система опалення; інфрачервоне опалення; біореактор; біомаса; термосифон сонячного колектора.

Introduction

At present, in all over the world, the problems of using available and ecological energy is of rising unterest. Reserves of oil and coal are limited, a significant rise in price of conventional energy sources undermines the global economy. Currently, one of the major challenges in the energy sector of Ukraine is the application of significant efforts to improve energy security, increased use of its own renewable energy resources, reduce the harmful effects of energy on the environment.

The most economical and efficient for livestock heating is air heat generator by which the premises are heated by excessive circulation of air masses. These systems can be used to heat the premises, which hold adult animals. However, this method is not suitable for plants where young animals are, as created high excess air velocity is harmful for animals and birds.

One of the most effective and proven ways to solve this problem is to install combined heating systems.

Currently, the combined systems are often used to provide heating and hot water for administrative and residential buildings. However, a significant proportion of the energy are consumed by agricultural complexes and farms, due to the need for continuously maintenance of comfortable conditions in livestock buildings. Infrared heating systems that maintain a comfortable temperature in the premises for growing young animals, and in places of detention for adult animals are widely spread among the systems providing microclimate.

Additional economy of energy resources can be achieved by installation of recuperators, heat exchangers, solar air heaters for background reheating of external forced air and etc. When designing agro-industrial complexes it should also pay attention to the problem of disposal of animal waste. This can be solved by use of bioreactors for the production of biogas as a source of heat infrared emitters.

The purpose and objectives of the study.

Theoretical and experimental justification for the use of solar heaters to maintain the thermal regime in the biogas plant.

Analytical research.

In Fig. 1 it is presented a principle scheme of the proposed combined heat supply system of livestock buildings.

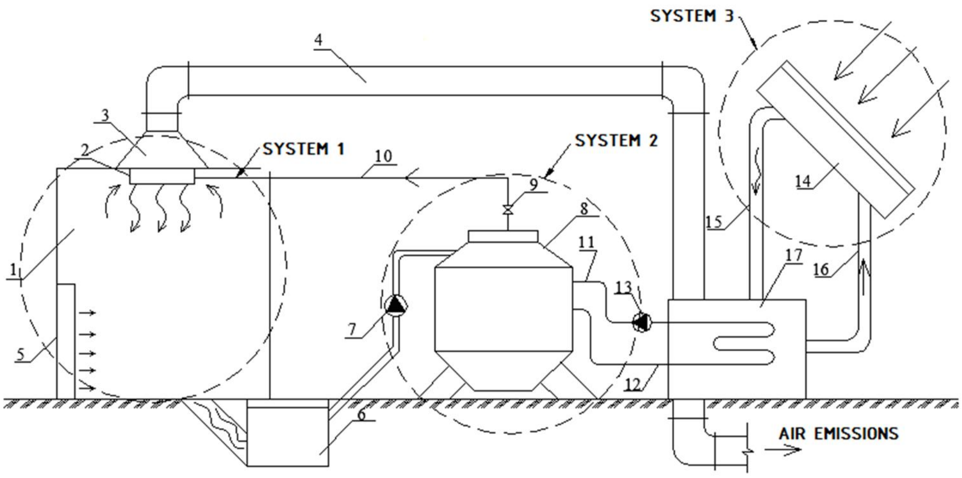


Fig.1 Scheme of combined heat supply of livestock buildings
SYSTEM 1 – infrared heating system; SYSTEM 2 – biogas plant; SYSTEM 3 – thermosiphonsolar collector.
1 – growing module , 2 – infrared heater, 3 – exhaust hood, 4 – discharge air duct, 5 – air diffuser, 6 – homogenizer, 7 – fecal pump, 8 – bioreactor, 9 – valve, 10 – gas pipeline, 11 – supply conduit; 12 – return pipeline,13 – pump, 14 – thermosiphon solar collector, 15 – warm air, 16 – cold air, 17 – heat exchanger

Principle of operation of the proposed system (fig. 1) consists in following:

Heating in the module of growing 1 is carried out with an infrared heater 2. Heat-, moisture- and gas-revenues from the module removed through the exhaust hood along the discharge air duct 4. The movement of air in the module is provided by air diffusers 5. Waste from animals who are in the module enters in a homogenizer 6, from where fecal pump 7 enters it into the bioreactor 8, where due to the anaerobic fermentation produced biogas, which is fed through the gas pipeline 10 to infrared heater 2. The process of biogas formation requires the maintenance of a specific temperature in the tank of bioreactor. For this purpose uses air solar collector 14 and the heat exchanger 17. Heated in the solar collector and volume of module air flows into the heat exchanger 17 where it gives off heat to the coolant and by the pump 13 through the supply conduit 11 flows into a biogas plant. Cooled air returned to the thermosiphon solar collectors for reheating.

In traditional systems infrared heaters run on natural gas, and in the biogas plants biomass heating is carried out by means of the boiler. The proposed system is fully energy-efficient. One of its advantages is the use of waste products of animals and birds for the bioreactor work, which contributes not only the production of biofuels, but also solves the problem of disposal of organic waste.

The results of research.

In this paper the possibility of using thermosyphon solar collectors for for ensuring thermal regime in the bioreactor during the year is considered.

Fig. 2, a shows a mathematical model of household experimental bioreactor with a volume of 1 m^3. Principle of operation and design features of the proposed biogas plant are described in detail in [2].

Computer model of the thermosyphon solar collector is shown in Fig. 2, b. The principle of solar air heater operation is based on the greenhouse effect and the principle of thermosyphon, i.e. system works due to the natural gravitational forces [3].

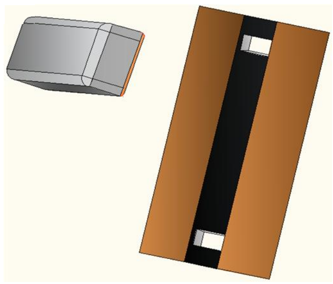
a)  в) 

Fig. 2 Computer model of biogas plant (a) and thermosyphon solar collector (b)

Fig. 3 shows the dependence of the heat capacity of a vertically mounted thermosyphon solar collector from the intensity of solar radiation in June to 48 ° N [4]. Under these conditions, the maximum amount of the produced heat was 335 W at 9 a.m. at the intensity of the heat flux 535 W/m^2.

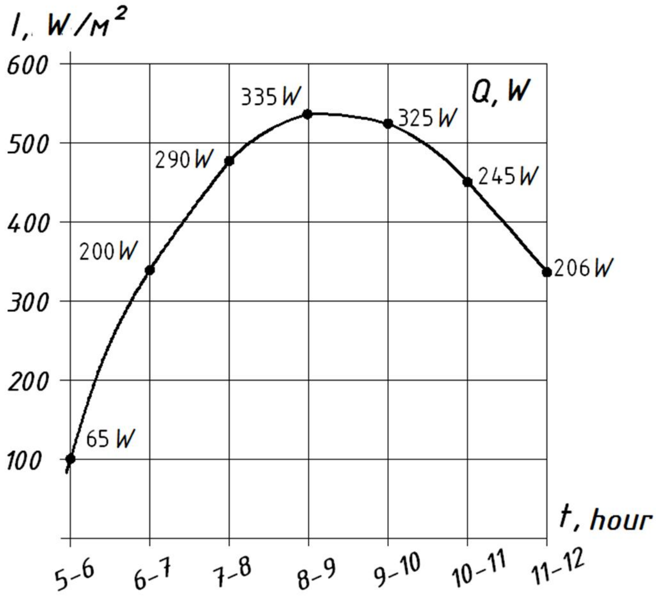


Fig. 3. Dependence of the thermal power of air solar collector from solar radiation intensity, I, W/m^2, in the range from 5 to 12 hours a day in June

The nature of the values is explained by changing the position of the sun relative to the vertical plane of the absorption plate of thermosyphon air heater.

Fig. 4 shows the typical dependence of heliocollector`s power, *Q*, W, from the temperature difference of cold air in the experimental modules and heated air after heliocollector, *Δt*, ° C, and its volumetric flow rate, *L*, m^3/hr.

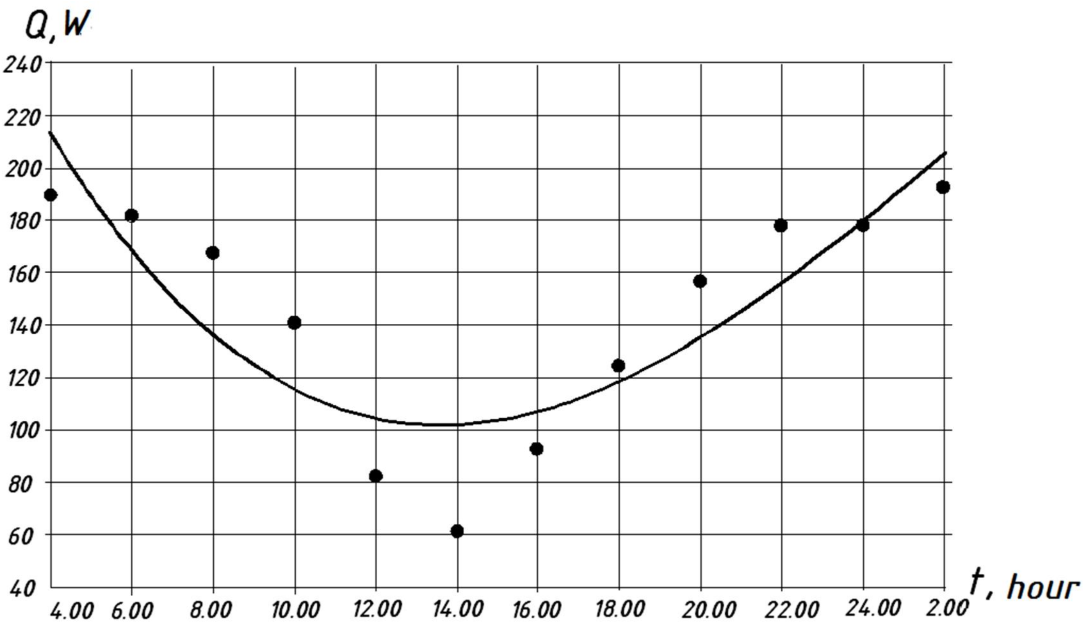


Fig. 4. Bioreactor heat loss during a day in June

Comparing the obtained data of the amount of heat required for the anaerobic fermentation of biomass and thermal power of thermosyphon solar collectors with a total area of 6 m^2, the graph shown on Fig. 5 was received.

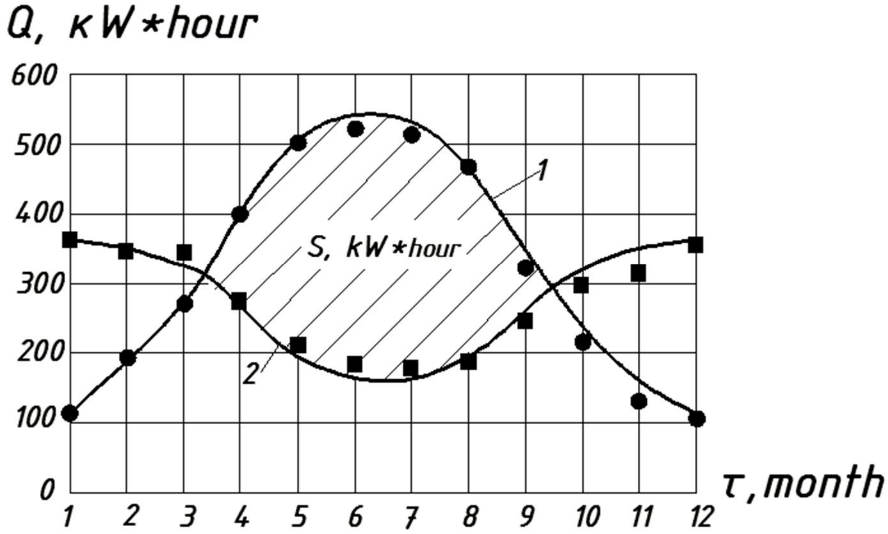


*Fig.5 Comparison of the thermal power of air solar collector with absorption area 6 m^2 with the need of heat for the bioreactor during the year 1 – thermal power of thermosyphon solar collector, kW, 2 – the total need in warm for bioreactor, kW, S – the amount of stored energy, kW*h.*

Note, that the thermal power of solar air heaters fully cover the needs of bioreactor in warm during 6 months. As can be seen from the graph in the period from april to september it has been an influx of excess heat, therefore it is expedient to install accumulator of energy for consumption of the stored heat at night.

To determine the amount of accumulated heat it is necessary to find the area of a shape S. Shaded figure is bounded by functions $y = -29.6 \cdot x^2 + 372.72 \cdot x - 631.4$ and $y = 10{,}5 \cdot x^2 - 145.8 \cdot x + 680.2$ in the range [3.5; 9.5]. Integrating of the above mentioned dependencies gives their difference:

$$\int_{3,5}^{9,5} (-29{,}6 \cdot x^2 + 372{,}7 \cdot x - 631{,}4 - (10{,}5 \cdot x^2 - 145{,}8 \cdot x + 680{,}2))dx = 3090 \ \ кW \cdot hour$$

Thus, the amount of stored for 6 months energy is equal to 3090 kW·h. Accumulated heat can be used at night time and cloudy days when the amount of solar radiation is insufficient.

Conclusions

Energy-saving system of combined heat supply to livestock buildings are proposed.The possibility of using the solar heaters to maintain the thermal conditions in the bioreactor is confirmed by analytical way.

1. D. V. Zerkalov: Эnerghetycheskaja bezopasnostj [Эlektronnыj resurs] : Monoghrafyja/ D. V. Zerkalov. - Эlektron. dan. – K. : Osnova, 2012. 2.V.Zhelykh, Ju.V.Furdas : Patent na korysnu modelj # 57360 – Bioghazovyj reaktor.3. V.Zhelykh, Kh.Lesyk : Patent na korysnu modelj # 68773 – Termosyfonnyj gheliokolektor .4.SNyP 23-01-99. Stroyteljnыe normы y pravyla. Stroyteljnaja klymatologhyja. – M.: Ghosstroj SSSR, 1999. – 10 s. 5. http://www.epochtimes.com.ua/life/life/pasyvnyj-budynok-energetychna-nezalezhnist-71513.html. 6. P. Kapalo: Analysis of Ventilation Rate and Concentrations of carbon Dioxide in the Office. - Lviv Politekhnick Publ. №756, 2013.*