UGC 620.91

PROSPECTS OF COMBINING IN COMPLEX USAGE OF DIFFERENT TYPES OF RENEWABLE ENERGY AND CREATION OF RENEWABLE ENERGY SOURCES

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Current technical solutions for combining in complex usage of different types of renewable energy and creation of renewable energy sources have been thoroughly analyzed. A pilot plant for the investigation of the effectiveness of combining the work of a heat pump and solar collectors has been described. The advanced schemes of combining technologies for the creation of renewable energy sources have been considered. Prospects of prior cavitation treatment of cyanobacteria in order to increase the effectiveness of the process of methanogenesis have been shown.

Combining, renewable energy sources, cyanobacteria, methanogenesis.

When building the scheme of power supply with the use of renewable energy sources (RES), one should take into consideration, that energy from these sources is not concentrated in some places, but scattered, changeable in time and place, thus, it is not stable. These sources can be used rationally only in case of ultimate closeness to a consumer without far distance energy transfer, and the stability of energy supplied by RES can be provided by means of combining the mutual work of two or more RES (wind energy + solar collectors; solar collectors + biomass; solar collectors + heat pump; heat

pump + biomass etc.), or by combining renewable and traditional energy sources (wind energy + power supply; solar battery panels + power supply; solar collectors + heat pump + power supply; solar collectors + heat pump + natural gas).

As for the problems of the creation of such renewable energy sources as biomass and biogas, the technologies of their production (synthesis) and prior preparation usually involve the use of traditional energy sources, and their partial or complete replacement with renewable sources can provide additional economical and ecological advantages. Besides, it is worth considering combination and introduction of some new stages in the technologies of their production: prior preparation of biomass before the synthesis of biogas, the use of natural cementing materials in the process of biogranule production etc.

Analysis of recent research works and publications. The change in the structure of the resources, which were used for heating in Sweden in 1970-2005, is demonstrated in Figure 1.

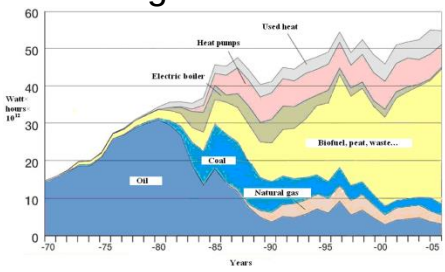

Fig.1. Use of energy sources in Sweden (1970-2005).

As it can be seen in Figure 1, there is a tendency for the decrease in the part of non-renewable sources of energy and the increase in the part of RES. The same tendency for the change in the structure of the resources, used for heating and energy production can be prognosticated in Ukraine. That is why, searching the ways of optimization for the creation of renewable energy sources and their use (first of all in terms of economical efficiency and the indicators of power stability) is urgent for ensuring energy independency of the country.

The principles of combining, which allow providing the stability of power indicators, are traditionally used in heliowind energy systems; there are numerous research works on this problem [1,5,7]. The analysis of wind and solar conditions indicates that there is a decrease in solar radiation and an increase in average wind speed in winter, and a decrease in wind speed and an increase in solar radiation in summer. That is why, the combination of wind and solar energy smoothens the irregularity of energy production, increases reliability of power supply for consumers during the year. Heliowind plants can be used in the scheme of heat or energy supply. The effectiveness of power supply for independent consumers in case of using a heliowind plant can be increased by means of its mutual work with a heat pump. Such units can work both in summer (cooling) and winter (heating).

Different schemes of combining RES in agriculture (namely on farms, which have a high degree of self-sufficiency and numerous energy potential wastes) are analyzed and proposed by a number of scientists [6,14,15].

Combined usage of solar collectors, heat pumps and biomass (often also a source of electrical energy and natural gas) in the scheme of power supply as being some independent modules combined in one energy plant has been thoroughly investigated and widely used in practice [2 - 4]. Plant operation is managed by a processor, which alternately connects up other modules to the basic one (the energy of which is the cheapest) in case of the lack of energy ascending its cost. The number of energy modules can be changed according to the region, infrastructure, consumers' wishes, and the cost of different types of energy. However, in spite of wide practical application of the above described strategy, systematic scientific research of the effectiveness of such combining (which is closely connected with the economy and weather conditions of a certain region) are not numerous, which makes it necessary to systematize and integrate the knowledge.

In terms of combining in the technologies of the production (synthesis) of renewable energy sources, one should consider the use of heliowind plants for the generation of biogas [17].

As for the combination and the introduction of new stages in the technologies of producing renewable energy sources, it is considered to be perspective [11,16] to introduce the stages of grinding and delignification into the technology of biogas production with the use of agriculture wastes as raw materials. In the process of delignification at high temperatures there is the process of lignin net degradation, the extraction of lignin and a bigger part of hemicellulose and also the disruption of chemical bonds between lignin and the molecules of hydrocarbon. This results in the increase in the surface of mass exchange, which becomes available to celluloselytic enzymes of microorganisms. Grinding of substrate using grinding machines gives considerable increase in the surface of mass exchange, which is available to the enzymes of microorganisms as well. This accelerates enzymatic hydrolysis and intensifies the process of the synthesis of methane [12].

When combining in the technology of the production of pellets with the use of wooden wastes, the compression of fine-dyspersated wastes is done with the help of pressing or extrusion. To provide a proper strength of pellets, pressing is done at 100-200 MPa. The disadvantages are as follows: a complex structure, considerable energy consumption, and that is it impossible to use low quality waste as raw materials. In an extrusion unit pressure is created due to forced and continuous moving of the material along a screw thread in the process of its rotation. In order to decrease energy consumption in the process of the production of granules and to provide their high strength, it is worth adding cementing additives to fine-dyspersated parts of wastes, which can result in the decrease of the force needed for the extrusion of lignin

from wooden wastes into interparticle space. Scientists [8 - 10] suggest using sulphatic soap, which is a by-product in wood-pulp industry, as a cementing material. Also, paraffin, synthetic plastic materials and biological oil can be used. The main requirements for the additives are as follows: small number, absence of any influence on the process of burning and absence of troublesome and poisonous gases. In case of using cementing additives, one can get pellets of similar quality at 1,2 ÷ 2,2 MPa.

Biomass is a perspective type of renewable energy sources, but in some regions growing and using plants as raw materials for producing energy sources caused critical decrease in the production of agricultural goods and provoked protests among the citizens of these countries (Mexico, Latin America). That is why, recently scientists have been working on finding technologies of cultivation and utilization for producing energy of such types of biomass, using of which cannot influence prospective possibilities of agricultural production and cannot affect the environment. A number of investigations (Israel, firm Seambiotic, Japan, firm Gas and NEDO, the USA, corporation GreenFuel Technologies) has shown, that such biomass can be alga – both cultivates on special farms and gathered from the surface of hydrosphere objects. In Ukraine such perspective biomass is cyanobacteria (blue-green algae), which have been causing considerable ecological threats because of progressive water bloom in surface basins. Water bloom is a biological signal indicating bad conditions of hydroecosystems. The dominating agents for water bloom in the Dnipro reservoir are the representatives of the genera of *Microcystis, Phormidium, Aphanizomenon, Anabeana and Oscillatoria*. Among numerous mechanical, physical and chemical, biological and ecological methods to prevent mass development of cyanobacteria, the most effective are the last two ones, because they allow overcoming causes but not just consequences of water [13]. As for the prospects of using them in order to produce energy, the most perspective utilizers of solar energy are microalga: the value of the efficiency of photosynthesis is up to 20 %.

Methods of research. The development of the strategy of systematic research of the effectiveness of combining the work of a heat pump with the work of solar collectors and the development of the systems of combining in the technologies of the creation of renewable energy sources.

Presentation of the main results. In order to conduct systematic research of the effectiveness of combining the work of a heat pump with the work of solar collectors, at National University “Lviv Polytechnics” within the framework of the grant with Krakow Polytechnics, which was financed by the Ministry of International Affairs of Poland, a plant, the operation of which (a heat pump of “air – water” type and solar collectors) is managed on-line via the Internet, was implemented. Heat energy, which is received from RES, is transferred to two accumulators of hot water with the volume

of 500 liters each. In the first accumulator, which is heated by solar collectors of vacuum type NSC 12-58 GREENEN, which are equipped by the pipes HEAT-PIPE, prior heating of water takes place. The heat, produces by the collectors, can be transferred directly to the first accumulator through a heat-exchanger – coil, which is mounted in it, or directly to the next accumulator through a high speed flat heat-exchanger, which is mounted on the plant. A heat pump with the capacity of 10 kilowatt is joined with the second accumulator. The heated water is delivered to a consumer (the kitchen, which serves students' canteen). The devices, which control the parameters of the operation of the accumulators of hot water, are operated with the help of a controller DigiENERGY, which is equipped by the counters of produced and used energy with the possibility of recording and looking over the parameters of the plant (outside temperature, the quantity of solar radiation, the quantity of the heat energy, which is produces, the value of losses of a heat carrier in heating devices etc.) at real time via the Internet. A heat carrier in the system of solar collectors and a heat pump is water-glycolic mixture. Figure 2 represents a screenshot of the temperatures of the flows of the heat carrier and water at real time.

Graphs are created for the temperatures ranging from -30 ° C to +90 ° C. Along the axis x the time length from 0:00 to 24:00 is indicated. The recorded data are represented in 7.5-minute intervals, which provide eight control points during one hour. The graph is divided into two fields of white and grey colors. The white space on the left represents current state, the grey one on the right shows the state on the day before.

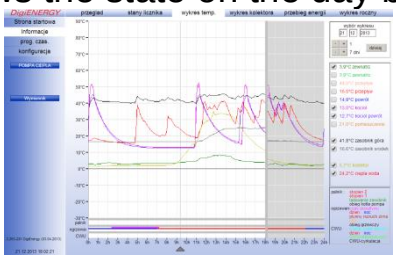

Figure 2. A screenshot of the temperatures of the flows of the heat carrier and water in the plant at real time.

The data, received as a result of plant operation, show greater effectiveness of the use of a heat pump when compared to solar collectors. Starting from December 2013 to September 2014, the heat pump produced 6 417 kilowatt of heat energy, the quantity of heat, received from the solar collectors is 2 436 kilowatt. Such a great difference in the quantity of the produced heat can be explained by the irregularity of solar energy during the day and the dependence on weather conditions, which reduces the effectiveness of the use of solar collectors. At the same time the operation of a heat pump shows uniformity during the day and little dependence on weather conditions.

Two variants of the use of cyanobacteria in order to get renewable energy sources have been investigated:

1. Extraction of fats, which can be used for the production of biodiesel.

2. Biogas production.

Since cyanobacteria have quite solid cell membrane, the processes of extraction and biodegradation can be of low intensity. In order to break a cell membrane, a method of hydrodynamic cavitation was chosen, in the process of which zones of high and low pressure are created and they break cell membranes. Hydrodynamic cavitation was conducted in the plant, where a three bladed impeller of a wedge like section with sharp front and blunt back edges is used as a cavitation unit; the frequency of rotation of the working wheel was 4000 revolutions per minute. One liter of cyanobacteria suspension was poured into the working tank, the time of treatment was 10 minutes.

In order to determine the maximum quantity of fat, which can be extracted from the cyanobacteria under study, the extraction was conducted with hexane from the suspension of alga and dried at 80^0C and grinded in a mortar alga (total content). The quantity of fat in each trial was determined gravimetrically. The results of the investigation show, that the total content of fat in the trail with cyanobacteria was 1.27 %, in the trial without any pretreatment the quantity of the extracted fat was 0.32 % of the dry matter of the alga, and in the trial after the cavitation treatment – 1.01 %. The result confirms that cell membranes of untreated alga are difficult to penetrate and their use for energy production without any pretreatment is complicated. Cavitation treatment breaks membrane walls and leads to more complete extraction, after such treatment 80% of the whole fat can be extracted.

During the experiments of biogas production, aimed at the imitation of the composition of the upper layer of a storage reservoir, which contains a lot of anaerobic bacteria, the trials were mixed with the initial sludge from sewage disposal plants and were put into the reactors, the construction of which allowed fixing the quantity of the produced biogas. pH in the reactors was regulated up to 7.5 by adding a small amount of the solution of NaOH. The reactors were wrapped with black polyethylene in order not to allow sunlight and were put into a water bath, where the temperature was set to be 34 °C (mesophilic conditions). The content of the reactors was stirred during 1 minute every 2 days. The total duration of the experiment was 52 days.

The results of the investigation show, that in the trials without any pretreatment it was possible to synthesize 2370ml of biogas and in the trials after cavitation treatment – 3310 ml of biogas.

Conclusions and prospects of further investigation. The analysis of the operation of the plant for combining the work of a heat pump and solar collectors during a long time period of its exploitation under different

weather conditions and seasons makes it possible to give some recommendations about the designing and exploitation of the plants of such type for the region under study.

The perspective raw material for renewable energy sources is cyanobacteria, which are suitable for the production of biodiesel and biogas. The content of fat in the gathered culture of blue-green algae is low (1,27 %), that is why with the help of extraction in renewable sources is it possible to extract only insignificant part of energy from the potential one, which is contained in biomass. The influence of cavitation field makes it possible to significantly increase the extraction of fats. The experiments with biogas production confirm that pretreatment with cavitation breaks cell walls of cyanobacteria, as the quantity of the produced gas from these alga is quite larger (for 40 %).

We consider a complex technology, which consists of the following stages, to be a perspective one for obtaining renewable energy source from cyanobacteria:

1. Cavitation treatment in hydrodynamic cavitation field.
2. Extraction of fats with hexane with the following production of biogas from them.
3. Anaerobic degradation of biomass wastes with the production of biogas.
4. Centrifugation of the used biomass with the following usage of the wastes as raw material [17].

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В статье проанализированы текущие технические решения для объединения в комплексном использовании различных типов возобновляемых источников энергии и создания возобновляемых источников. Была представлена и описана пилотная установка по исследованию эффективности совмещение работы теплового насоса и солнечных коллекторов. Рассмотрены передовые схемы сочетания технологий для создания возобновляемых источников энергии. Представлены и проанализированы перспективы предварительного кавитационной обработки цианобактерий в целях повышения эффективности процесса метаногенеза.

Возобновляемые источники энергии, цианобактерии, метаногенез

У статті проаналізовано поточні технічні рішення для застосування в комплексному використанні різних типів відновлюваних джерел енергії та створення поновлюваних джерел. Була представлена і описана пілотна установка з дослідження ефективності поєднання роботи теплового насоса і сонячних колекторів. Розглянуто передові схеми технологій для створення відновлюваних джерел енергії. Представлено і проаналізовано перспективи попереднього кавітаційної обробки ціанобактерій з метою підвищення ефективності процесу метаногенезу.

Поновлювальні джерела енергії, ціанобактерії, метаногенез