INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071

Volume: 5 Issue: 6 | Jun 2023

Autonomous Energy Supply System of a Mobile Home Based on Pyrolysis and Biogas Devices

A. Rakhmatov

1st year student for Master's degree, Karshi Engineering Economics Institute, 180100, Karshi, Uzbekistan

---***---

Annotation: This article is devoted to the analysis of the application of loading energy with integrated pyrolysis and biogas devices in a mobile home with an energy supply system based on alternative energy sources. Thermal technical parameters of pyrolysis and biogas devices required for energy supply of a mobile home with an average volume of 40 m3, heat balance equations and heat-technical sources of energy supply of this mobile home based on alternative energy sources.

Keywords: biomass, biogas, pyrolysis, heat balance equation, biowaste, autonomous heat supply, bioreactor.

Introduction. In the social sphere, it can be observed that the energy capacity of the heat energy supply systems of rural settlements and residential buildings is high, and the level of use of alternative energy sources is low. Currently, up to 40-50% of natural organic fuels (natural gas, coal and fuel oil) are used for heat supply of buildings. In particular, energy saving through the continuous supply of rural houses with energy and natural gas, improvement of hot water and heating systems is an urgent problem [1,2].

One of the classic types of alternative energy sources is biomass, by processing biomass and various organic wastes, it is possible to obtain biogas, generate methane gas by processing it, and then start producing heat and electricity from it. As a result of the introduction of pyrolysis and biogas devices into practice, it is possible to solve environmental problems simultaneously with the use of methane gas, which is wasted from waste, and energy production. Accordingly, it is an important task to create energy-efficient technologies, develop and implement systems for using alternative energy sources with high energy efficiency [3].

Biomass is an alternative source of energy obtained by processing animal and plant waste. Liquid, gaseous and solid alternative fuels can be obtained from biomass energy through practical processing. Biomass includes dried trees or their branches, roots and stems of woody plants, bark and shavings, and cattle manure. In addition, sources of biogas include solid domestic and industrial wastes, municipal sludge and wastewater, and livestock, plant residues, forest products, and other wastes [4].

The main source of biological energy is biomass, which is developed and collected at the expense of nature. This is based on the process of photosynthesis, which means that solar energy is converted into chemical energy and stored in plants. Biogas is a mixture of various gases, its composition is 65-70 % methane, about 30-35 % CO_2 and 1 % H, O, N and C gases. It has been determined experimentally that the heat-giving ability of biogas is around 20-26 MJ/m^3 [5].

Currently, the largest biomass contribution is forest and agricultural products. Forests cost 75 billion per year. produces tons of biomass, its energy equivalent is several times greater than the annual energy consumption. Another source of biomass is grasses and agricultural plants. Herbs cost 2,500 billion. species growing on a hectare of land can serve as a source of energy. Among agricultural plants, the most important can be sugarcane, cotton stalks and other industrial wastes [6].

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY
https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 6 | Jun 2023

Pyrolysis is a process of thermal destruction (decomposition) of primary raw materials, materials or substances (biomass, organic waste) at high temperatures by providing heat in an oxygen-free environment. As a result of pyrolysis of plant biomass, products such as combustible pyrolysis gas (biogas) and high-energy liquid and coke are formed. Research conducted by experts in the world shows that the amount of output of pyrolysis products is affected by the thermal-physical properties of raw materials and the temperature regime of the process.

Pyrolysis is a process of thermal destruction (decomposition) of primary raw materials, materials or substances (biomass, organic waste) at high temperatures by providing heat in an oxygen-free environment. As a result of pyrolysis of plant biomass, products such as combustible pyrolysis gas (biogas) and high-energy liquid and coke are formed. Research conducted by experts in the world shows that the amount of output of pyrolysis products is affected by the thermal-physical properties of raw materials and the temperature regime of the process [7,8].

Method and materials. The biogas technological device enables the use of biogas as the main fuel in the heating system of rural houses in rural settlements. The process of turning manure into biogas through anaerobic digestion is carried out in special biogas devices that are tightly closed. Figure 1 below illustrates the solar biowaste pyrolysis process and the resulting products:

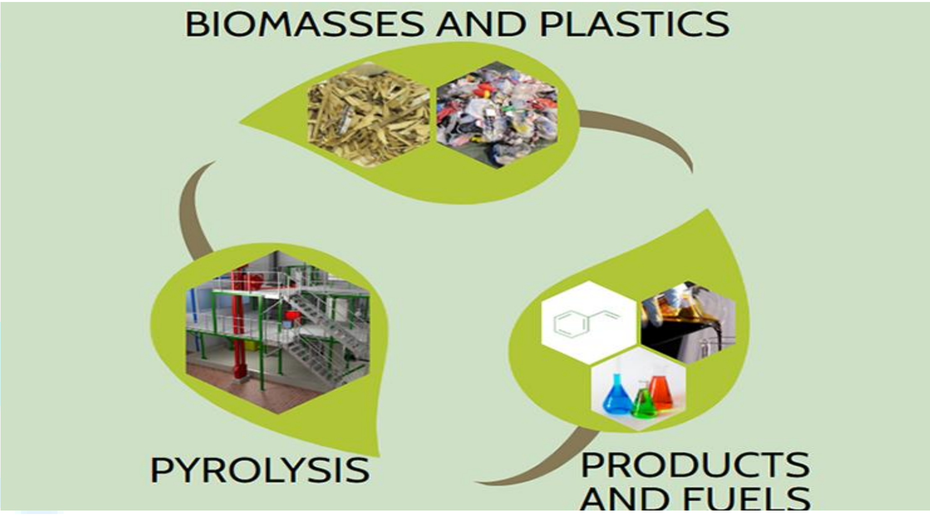

Figure 1. The process cycle of the technological device for obtaining biogas, liquid fuel and solid fuel (coke) through pyrolysis and biogas devices.

A certain amount of thermal energy is required for the thermal processing of biomass in the reactor of the pyrolysis device. The thermal energy supplied to the reactor is used to create the temperature regime necessary for pyrolysis of biomass. By obtaining this required heat from the biogas plant, we can increase the energy efficiency of the pyrolysis plant. On the basis of the mathematical modeling of the heat balance of the reactor, important issues of optimization of bioenergy plant reactors and energy saving are solved [9,10]. The total heat input (supplied) to the bioreactor, useful heat used in the reactor, and the amount of heat losses are expressed by the heat balance equation of the reactor. That is, the general form of the heat balance equation for a tubular (cylindrical) bioreactor is as follows:

$$Q_{enter} = Q_{spend} \qquad \frac{kJ}{kg} \qquad (1)$$

where Q_{enter} is the heat input to the reactor, *kJ/kg;* Q_{spend} - the heat spent in the reactor, *kJ/kg;*

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY
https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 6 | Jun 2023

The heat required to establish the required temperature regime of the pyrolysis process in the reactor is equal to the sum of the heat used to heat the loaded biomass from the initial temperature to the pyrolysis temperature and the heat lost due to heat transfer from the reactor surface to the environment. That is:

$$Q = Q_1 + Q_2 \tag{2}$$

where Q is the total heat used for the pyrolysis process, *kJ*;

Q_1 is the heat used for heating biomass from initial temperature to pyrolysis temperature, *kJ*;

Q_2 is the heat lost for heating biomass from initial temperature to pyrolysis temperature, *kJ;*

The heat used to heat the loaded raw material (biomass) is determined as follows:

$$Q_1 = m_b C_b (t_2 - t_1) \tag{3}$$

where, m_b is the loaded biomass mass, kg; C_b is specific heat capacity of biomass; kJ/kg ^{0}C; t_1 – initial temperature of biomass, ^{0}C; t_2 - biomass pyrolysis temperature, ^{0}C;

Results and discussion. Pyrolysis is considered a modern thermochemical technology of energy use of plant biomass, and it is the most effective, environmentally friendly and safe method of obtaining solid, liquid and gaseous alternative fuel from any hydrocarbon raw materials. The energy costs of such a thermochemical process do not exceed 20-30% of the obtained energy product.

Theoretical and practical research of biomass pyrolysis has been successfully developed in England, USA, India and a number of other foreign countries. The use of pyrolysis technology significantly reduces the energy capacity of the thermal processing of waste and reduces the consumption of natural organic energy carriers. Another important feature of pyrolysis technology is that it replaces organic fuels, significantly reduces the amount of greenhouse gases released into the environment and the amount of heat and gas emissions from direct combustion of organic and biomass. These demonstrated technological advantages are a strong impetus to the development of pyrolysis technology [11].

Biomass and local organic waste (cattle manure, poultry, horse, Experiment on combined 1 m^3 pyrolysis and 0.5 m^3 biogas devices for thermal processing of small horned cattle excrement, plant waste, cotton stalks, straw, etc.) and obtaining alternative solid, liquid, gaseous fuel the principle scheme was developed. Figure 2 below shows this schematic diagram:

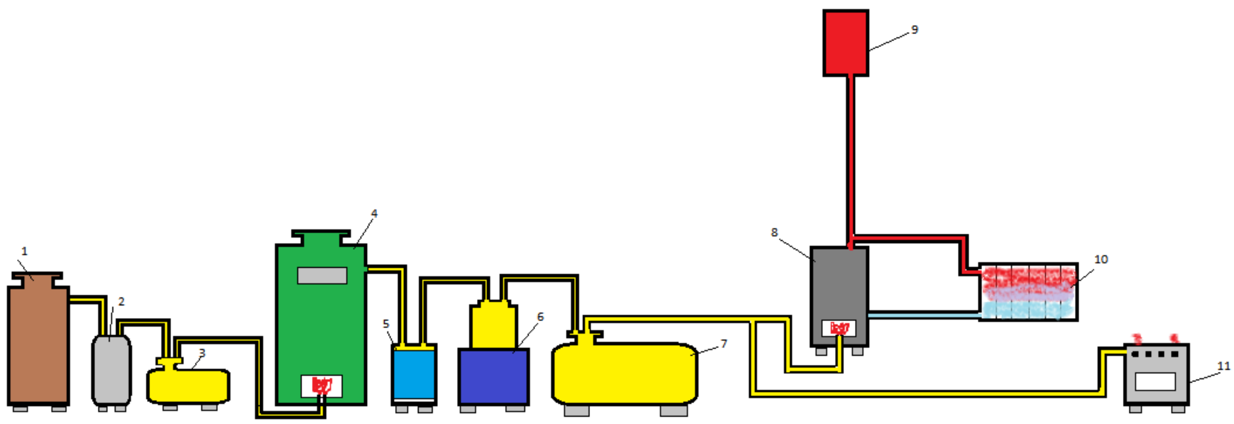

Figure 2. Heat-technical scheme of a mobile home with an energy supply system based on alternative energy sources.

1-biogas reactor, 2-methane tank, 3-gasholder (for biogas), 4-pyrolysis reactor, 5-filter, 6-condenser, 7-gasholder (for pyrolysis), 8-heating boiler, 9-hot water tank-accumulator, 10-heating system, 11-gas stove.

If we pay attention to the technical potential of the biogas device, a gas holder that collects 0.5 m^3 of gas produces 6-8 m^3 of biogas per day, which replaces firewood and organic fuel for average household needs. This system also has the capacity to produce 100-120 l of fertilizer per day. Also, the use of manure for the technological device of biogas production improves sanitation, and fertilizer increases soil fertility. Replacing organic fuel with biogas and energy produced by solar devices helps to reduce greenhouse gas emissions to a certain extent [12].

A large amount of manure and plant residues and various waste accumulates in every house in the villages. When they break down (anaerobic fermentation), a mixture of gases is released: methane - 55-70 %, carbon dioxide - 28-43 %. On average, when 1 kg of organic matter is 70 % biodegradable, 180 grams of methane are released. In other words, about 300 m^3 of biogas can be obtained from 1 ton of dry animal manure. The spent mass retains a high amount of nitrogen and can be used as a ready-made fertilizer. The cost of the device pays for itself in one year at most. For example, a family of 3-5 people needs about 15-20 m^3 of gas per day to cook food, make tea and heat 15 m^2 of space and meet the need for hot water [13].

It is necessary to set a temperature regime of 50-55 ^{0}C in the reactor of the biogas plant to create processes of waste digestion. Studies show that a head of large black cattle weighing 200-250 kg produces an average of 10-20 kg of manure per day. So, 2-2.5 tons of raw materials are produced per day from 100 head of black cattle. In one month, about 60-75 tons of raw materials for obtaining biogas are produced. On average, 75-100 m^3 of biogas can be obtained from 1 ton of manure. Therefore, it is possible to obtain 4500-7500 m^3 of biogas per month from the manure obtained from 100 oxen [14,15].

It is known that various biomass, industrial and agricultural waste can be used as raw materials for the pyrolysis process. Biomass is a widespread renewable energy resource and has a fairly high calorific value: the calorific value of dry firewood is 15-18 MJ/kg, and that of straw is 14-15 MJ/kg.

In the process of pyrolysis, the liquid product with a high combustion heat at a high heating rate and a moderate temperature (500 ^{0}C) is the main one, and its composition consists of a complex organic compound and water. At a high temperature and during a period of great decomposition, the organic compounds of the pyrolysis liquid are decomposed, and the main product is pyrolysis gas, the basis of which is CO, CO_2, H and light gases. A large amount of solid residue (coke) is obtained during slow and ultra-slow (carbonization) pyrolysis [15].

On Earth, 120 billion are produced per year through photosynthesis. tons of dry organic matter, which is about 40 billion is the energy equivalent of a ton of oil. Studies have shown that 1 ton of biomass is equivalent to 0.625 tons of conventional fuel. Therefore, thermal processing of biomass, obtaining fuel and thermal energy from it is highly effective in providing energy to consumers in areas far from centralized energy supply [16].

The analysis of the heat balance of the reactor shows that the specific need for heat energy of the device is mainly determined by the amount of heat used to heat the biomass up to the pyrolysis temperature. Because the heat lost from the surface of the reactor can be minimized by thermal insulation or disposal [17].

Conclusion. There is insufficient research on the creation of a continuous and high-quality energy supply system for consumers located far from the centralized energy supply system (farms, farms, fisheries, beekeeping complexes). Therefore, in order to create a sufficient energy supply system for this type of consumers, it is advisable to use pyrolysis and biogas devices in combination.

The integrated use of pyrolysis and biogas devices capable of supplying an average of 2500-3200 m^3 of biogas per year for the energy supply of a mobile home with a volume of 40 m^3 has a number of economic and social

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071
Volume: 5 Issue: 6 | Jun 2023

advantages. For example, it is possible to have autonomous heat energy supply and create a clean ecological environment.

Through the introduction of "green energy" in our republic, in particular, through a photoelectric battery with a capacity of 1 *kWh* installed in a mobile home, 3-4 *kWh* of electricity during the day, and by heating biomass with biogas energy in a pyrolysis device up to 10-15 m^3 of natural gas can be obtained. This fully satisfies the demand of consumers for heat and electricity.

References:

1. G. N. Uzakov, Applied Solar Energy (English translation of Geliotekhnika), 48(1), 60–61 (2012)
2. Uzakov G.N., Toshmamatov B.M., Kodirov I.N., Shomuratova S.M. On the efficiency of using solar energy for the thermal processing of municipal solid waste. Journal of critical reviews. ISSN- 2394-5125 VOL 7, ISSUE 05, 2020.
3. **Toshmamatov B., Davlonov Kh., Rakhmatov O., Toshboev A.** Recycling of municipal solid waste using solar energy. IOP Conf. Series: Materials Science and Engineering. 1030 (2021) 012165. doi:10.1088/1757-899X/1030/1/012165.
4. Elliott D. C., Baker E. G., Beckman D. Technoeconomic Assessment of Direct Biomass Liquefaction to Transportation Fuels. In Forestry, Forest Biomass, and Biomass. Elsevier, London-New York, 1990; Vol. 22, Issue 1−4, pp 251−269.
5. Toshmamatov B.M., Uzakov G.N., Baratova S.R.. “Solid Waste Management Using Solar Energy”. “Scientific Horizons” International Scientific Journal. – 2019.-№2 . -255-260-pp.
6. G. N. Uzakov, H. A. Davlonov and K. N. Holikov, Applied Solar Energy (English translation of Geliotekhnika), 54(6), 481–484 (2018)
7. Toshmamatov B.M., Raxmatov A.R., Boyitova A., Baratova S.R., Safarova S.U. (2022). Research on the process of obtaining alternative fuels from solid household waste based on pyrolysis devices. Innovative approaches to the development of education-production cluster in the oil and gas field. Tom 1, Tashkent - 2022, pp 125-127.
8. Onarheim, K.; Solantausta, Y.; Lehto, J. Process simulation development of fast pyrolysis of wood using AspenPlus. Energy Fuels 2015, 29 (1), 205−217.
9. Lappas A.A., Kalogiannis K.G., Iliopoulou E.F., Stefanidis S.D. Catalytic pyrolysis of biomass for transportation fuels. WIREs Energy Environment 2012, 1, 285−297.
10. Rossi, C. The Bastardo pyrolysis plant for bio-oil production from biomass. PyNe Newsl. 1996, 2, 6−7. https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2016/10/PyNe-Issue-2.pdf
11. Sadikov Usmanxuja Khasanovich (2022): The development of renewable energy sources is a guarantee of strength in the energy sector. Science and Innovation International Scientific Journal Volume Issue 6. UIF-2022: 8.2 | ISSN: 2181-3337.
12. Zakhidov R.A., Tajiyev U.A., Kiseleva E.I., Saliev G.S., Gorobtsov S.I. On the Possibility of Sustainable Energy and Water Supply of Low-Rise Residential Buildings Located in Areas with an Arid Climate using Combined Wind and Solar Photovoltaic Power Complexes of Low Power. Applied Solar Energy (English translation of Geliotekhnika)this link is disabled, 2022, 58(1), pp. 159–164

INTERNATIONAL JOURNAL ON ORANGE TECHNOLOGY

https://journals.researchparks.org/index.php/IJOT e-ISSN: 2615-8140 | p-ISSN: 2615-7071

Volume: 5 Issue: 6 | Jun 2023

13. Uzakov G., Khamraev S., Khuzhakulov S. Rural house heat supply system based on solar energy. IOP Conference Series: Materials Science and Engineering, 2021, 1030(1), 012167.

14. Advanced Technology Combined Cycles / R.W. Smith, P. Polukort, C.M. Jones, B.D. Gardner //GE Power Systems. GER-3936A. 2001. May.

15. Matta R.K. Power Systems for the 21st Century — «H» Gas Turbine CombinedCycles / R.K. Matta, G.D.Mercer, R.S. Tuthill // GE Power Systems. GER-3935B. 2000.October.

16. Baglan Bay begins // Power Generation. 2003. November.

17. Ratliff P. The New Siemens Gas Turbine SGT5-8000H for More Customer Benefit /P. Ratliff, P. Garbett, W. Fisher // VGB PowerTech. 2007. № 9.