ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 8, August 2023

Justification of the Technical-Economic Efficiency of the Device for Thermal Processing of Municipal Solid Waste

Toshmamatov B.M. , Valiev S.T.

Senior Lecturer, Department "Alternative energy sources". Karshi engineering-economics institute, Karshi, Uzbekistan
Student, 5312400-Alternative energy sources (by type) educational direction. Karshi engineering-economics institute, Karshi, Uzbekistan

ABSTRACT: The article proposes achieving energy efficiency in municipal solid waste (MSW) processing through heliothermic processing. A heliothermic municipal solid waste processing unit has been developed and is equipped with an active and passive solar heating system. It was determined that the working capacity of the device depends on the physical and thermal properties of municipal solid waste.According to the results of the conducted research, it was shown that 1800 m^3 of waste gas (with a methane content of 50÷70%) was obtained in one working cycle of the proposed device. Heliothermic solid waste processing unit technical and economic efficiency determination for empiric equations received.

KEYWORDS: Municipal solid waste, heliothermic again performance, temperature mode, waste gas, alternative fuel, technical and economic efficiency.

1. INTRODUCTION.

The rational use of natural fuel and energy resources is one of the global problems of the countries of the world, and its successful solution will be crucial not only for the further development of the world community but also for maintaining environmental stability. One of the promising ways to solve this problem is using new energy-saving technologies using renewable energy sources [1,2].

The depletion of traditional fossil fuels (coal, oil, and gas) and the environmental consequences of burning them has led to a significant increase in interest in energy devices and technologies based on renewable energy sources in almost all developed countries of the world in recent years [3-20].

"GREEN" technologies that provide savings on traditional energy sources: natural gas, liquid, solid organic fuels, and electricity.

Therefore, the issue of reconstruction of the energy base and finding ways to use environmentally friendly renewable energy sources is urgent.

Municipal solid waste (MSW) is waste produced as a result of daily human activity, with different morphological composition, consisting of metall+solid+organic+hydrocarbon compounds. MSW is an environmental, energy and social disaster that poses a global threat to humanity and nature not only in our country, but also in the countries of the whole world.

The number of MSWs is increasing, especially in today's time when resources are limited and needs are endless. This is why solid waste is a wasteful, cheap raw material base that, if processed, is a huge source of wealth and energy. Today, the level of recycling of solid household waste in our country does not exceed 40% on average.

II.MATERIALS AND METHODS

The southern regions of our republic, especially the Kashkadarya region, are distinguished by the high potential of renewable energy resources (solar energy, biomass energy). In particular, the well-developed agricultural and horticultural sectors of the Kashkadarya region mean that it has a high concentration of cheap raw materials (solid household, organic and agro-industrial waste) for the production of waste gas. In such regions, there is a possibility of a

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 8, August 2023

continuous and stable supply of agro-industrial complexes, social sector facilities with absolutely cheap, ecologically clean energy resources, alternative fuel (biogas, waste gas), and energy units equivalent to heat and electricity.

Installation of bioenergetic devices, and waste reactors designed for the processing of solid household and organic waste under the influence of solar energy in agro-industrial complexes and social sector objects, firstly to the development of energy devices based on renewable energy sources, and secondly to the energy independence of the above objects provides, thirdly, there is high energy and resource saving and technical-economic efficiency [3,4,5].NO_x, SO_x and CO_2 gases in the composition of combustion products released into the environment decrease by 2-3 times compared to the burning of traditional natural fuels. also leads to a decrease in the formation of the greenhouse effect. Another advantage of these devices is that the residual mass after exhaust gas production can be used as organic fertilizer for agricultural land [4,5].

The solar energy potential of the Kashkadarya region is high, that is, 300÷320 *days* are considered as sunny days, and the duration of solar radiation is 2950÷3050 *hours* $Q_{rad} = 1600 \div 1800 \frac{kW \cdot hours}{m^2 \cdot year}$ $q_i = 6850 \div 7050 \frac{MDj}{m^2}$. Based on this, the technical potential of solar energy of Kashkadarya region is equal to 26.5 million tons of conventional fuel.

Under the influence of high solar radiation and ambient temperature, waste gas is released from solid household waste into the environment. Therefore, covering the temperature regime required for thermal processing of municipal solid waste under the influence of solar energy at the expense of solar energy allows saving natural fuel and energy resources.

A heliothermic solid waste processing device was developed on the basis of the “Solar and bioenergetic devices” scientific laboratory of the Karshi Engineering Economics Institute (Fig. 1), and thermal-technical, pilot-research tests were conducted.

Figure 1. Device for heliothermal treatment of municipal solid waste.
1-waste reactor; 2-flat reflector solar air heating collector with heat accumulator; 3-hinged flat reflector; 4-flat reflector, 5-passive solar heating system.

Heliothermic solid waste processing unit consists of the following systems.

- The waste reactor for anaerobic processing of municipal solid waste by heliothermic method is designed in the form of a parallelepiped in two layers, with a size of 1.2x1.0, a mechanical mixer is installed inside and a gas holder is provided.

- The side and bottom parts of the waste reactor consist of air ducts and are connected to a solar air heating collector with a heat accumulator with a useful surface of 1.8 m^2.In order to increase the energy efficiency of the solar air heating collector, flat reflectors with a useful surface of 1.8 m^2 are installedparallel to its sides. As a heat accumulator, water and transformer oil are used. As a result, a flat-reflector solar air heating collector with a heat accumulator serves as an active solar heating system for processing solid household waste in the waste reactor in the temperature range of 50÷55℃.

- A transparent cover (glass, polycarbonate glass and 1, 2, 3 layers of polyethylene film) is installed from the top of the waste reactor in a triangular shape, which acts as a passive solar heating system for the waste reactor. In order to increase the energy efficiency of the device, from the back side of the waste reactor, parallel to it, 1.2x1.0 m. flat reflectors are installed in the size.

Heliothermic processing of municipal solid waste works in the following order.

Municipal solid waste (waste+water) with different morphological compositions is loaded into the waste reactor. A transparent cover (mirror) is installed in the upper part of the waste reactor in a triangular shape, which acts as a passive solar heating system. As a result, direct and scattered solar radiation passes through the transparent coating and turns into thermal energy, and heats the mass loaded into the waste reactor. In addition to the waste reactor, a flat reflector is installed parallel to it from the rear side of the reactor, which breaks the incident solar radiation and increases the efficiency of the passive solar heating system. To provide the waste reactor with stable heat energy, the bottom and side air channels of the waste reactor are connected with a flat reflector solar air heating collector with a heat accumulator. In the solar air heating collector, the air is heated to a temperature range of 85÷95℃ under the influence of solar energy, and due to the heat accumulator (water and transformer oil are used as heat accumulators, their heat capacity is 3÷4 times higher than air and is considered as an additional heat source) provides a stable temperature regime necessary for the processing of the waste mass due to heat conduction through the bottom and side walls of the waste reactor along the air channels. The mass loaded into the waste reactor undergoes anaerobic digestion under the influence of the given temperature for 12÷15 days, and the waste gas (with a methane content of 50÷70%) is released and collected in the gas holder. In a one-time operation cycle of this device, 75÷120 m^3 of waste gas is produced from 300 kg of solid household waste [7,8,9].

II.RESULTS.

Based on the results of the conducted research, we calculate the heat-technical and technical economic efficiency of the heliothermic waste processing device using the following empirical equations.

For the processing of solid domestic waste (MSW) by anaerobic fermentation, water should be added in a ratio of 1:3, for which the daily water consumption is calculated based on the following equation [10]:

$$V_{water} = \frac{B_{MSW}}{3} = \frac{300}{3} = 100l.$$

Here, $B_{MSW}$is the amount of daily generation of solid household waste, *kg/day*.

The mass of the given water is approximately equal to the following volume:

$$V_{water} = 100l$$

We determine the working volume of the waste reactor. Anaerobic fermentation (digestion) takes place as a result of providing solid domestic waste with a specified temperature regime in the waste reactor for 12÷15 days, density of solid domestic waste + water $\rho_{MSW} = 700\ \frac{kg}{m^3}$:

15-day municipal solid waste mass [11]:

$$M_{MSW} = 15 \cdot (B_{MSW} + V_{water}) = 15 \cdot (300 + 100) = 6000,\ kg$$

The working volume of the waste reactor V_{WR} is determined as follows [18]:

$$V_{WR} = \frac{M_{MSW}}{\rho_{MSW}} = \frac{6000}{700} = 8{,}6,\ m^3$$

The amount of waste gas produced in a device designed for the heliothermic processing of solid household waste depends on various parameters (the amount of waste, morphological composition, temperature regime of processing, etc.) and in most cases is determined based on an empirical equation [10-15].

The average daily amount of exhaust waste gas production $V_{WG}$is calculated accordingly by the following equation:

$$V_{WG} = (B_{MSW} + V_{water}) \cdot \eta_e = 400 \cdot 0{,}3 = 120,\ m^3$$

where, η_e=0.3 - $(B_{MSW} + V_{water})$ the amount of exhaust gas released from 1 kg,*m^3/kg.*

The exhaust gas production during 1 operating cycle (15 days) of the average device is calculated accordingly by the following equation:

$$V_{WG} = M_{MSW} \cdot \eta_e = 6000 \cdot 0{,}3 = 1800,\ m^3$$

where, η_e=0.3 - $M_{MSW}$the amount of exhaust gas released from 1 kg, *m^3/kg.*

We calculate the average annual exhaust waste gas.

$$V_{WG}^{Y} = 360 \cdot V_{WG} = 360 \cdot 120 = 43\ 200,m^3$$

is equal to the value of 28,080÷30,240 m^3 of natural gas.

The amount of heat required for the thermal processing of MSWs by the anaerobic fermentation (AF) method using the following equation, *kW [16-24]*.

$$Q_{AF} = M_{MSW} \cdot c_{MSW}(t_{AF} - t_{MSW}) \cdot 3.6 \cdot 10^{-3} = 6\ 000 \cdot 2700 \cdot (55 - 20) \cdot 3{,}6 \cdot 10^{-3} = 2\ 041{,}2,\ kW$$

For the processing of municipal solid waste by the anaerobic fermentation method, warm water with a temperature of 35°C should be added in a ratio of 1:3 [24-28], for which additional heating of water is required, and we calculate it as follows:

$$Q_{water} = V_{water} \cdot s_{water} \cdot (t_2 - t_1) \cdot 3.6 \cdot 10^{-3} = 1500 \cdot 4200 \cdot (35 - 20) \cdot 3.6 \cdot 10^{-3} = 340{,}2, kW$$

MSWs we determine the amount of waste gas used to produce the amount of heat required for thermal processing in the anaerobic fermentation method using the following equation[29-30].

$$V_{HE} = \frac{Q_{AF}+Q_{water}}{Q^{I}_{MSW} \cdot \eta_{HB}} \cdot \tau = \frac{2\,041{,}2+340{,}2}{22000 \cdot 0{,}95} \cdot 360 = 41, m^{3}$$

where Q^{I}_{com} - combustion het of exhaust gas , *kJ/m*^{3}, η_{HB} - energy efficiency of water heating boiler , *%*, τ −fermentation time, *hours.*

III. CONCLUSION

It is possible to produce 1800 *m*^{3} *of* waste gas from 6000kg of wastegas in one working cycle of the device designed for thermal treatment of solid household waste. In the device, 41 *m*^{3} of exhaust gas is used for thermal treatment of municipal solid waste by anaerobic fermentation method and to ensure the temperature regime. In addition to the private needs of the device, 1759 m^3 of waste gas will be used.

In the proposed heliothermal municipal solid waste treatment plant, the amount of heat required for the treatment of solid waste is covered by solar energy, so the entire volume of waste gas obtained remains beneficial or is used to provide sustainable energy to consumers. As a result, it reduces the impact of solid waste on human health, ecological sustainability and the environment.

REFERENCES

Toshmamatov B, Davlonov Kh, Rakhmatov O, Toshboev A, Rakhmatov A 2023 Modeling of thermal processes in a solar installation for thermal processing of municipal solid waste. AIP Conference Proceedings 2612 050027.

Toshmamatov BM, Shomuratova SM, Mamedova DN, Samatova SHY, Chorieva S. 2022 Improving the energy efficiency of a solar air heater with a heat exchanger – Accumulator. 1045(1), 012081.

Kodirov IN, Toshmamatov BM, Aliyarova LA, Shomuratova SM, Chorieva S. 2022 Experimental study of heliothermal processing of municipal solid waste based on solar energy. IOP Conference Series: Earth and Environmental Science. 1070(1), 012033.

Ebrahimian, F., Karimi, K., Kumar, R., 2020. Sustainable biofuels and bioplastic production from the organic fraction of municipal solid waste. Waste Manage. 116, 40–48.

Tashmamatov B, Davlonov Kh , Rakhmatov O, Toshboev A 2021 Recycling of municipal solid waste using solar energy IOP Conf. Series: Materials Science and Engineering 1030 012165.

Jiayao Wu and at al. Influence of different loads on PCDD/F removal by SCR during municipal solid waste incineration. Chemosphere. Volume 338, October 2023, 139516.

Toshmamatov B., Kodirov I. and Davlonov Kh. 2023 Determination of the energy efficiency of a flat reflector solar air heating collector with a heat accumulator. E3S Web of Conferences 402, 05010.

Toshmamatov B., Shomuratova S., Safarova S. 2023 Improving the energy efficiency of a solar air heater with heat accumulator using flat reflectors. E3S Web of Conferences 411, 01026.

Ramzan, N., Ashraf, A., Naveed, S., Malik, A. (2011). Simulation of hybrid biomass assimilation using Aspenplus: A comparative performance analysis for food, municipalsolid and poultry waste // Biomass and Bioenergy.2011. No. 35. P. 3962–3969.

Aliyarova LA, Uzakov GN, Toshmamatov BM 2021 The efficiency of using a combined solar plant for the heat and humidity treatment of air IOP Conf. Series: Earth and Environmental Science.

Uzakov G N, Shomuratova S M and Toshmamatov B M 2021 Study of a solar air heater with a heat exchanger – accumulator IOP Conf. Ser ies: Earth oath Environmental Science.723 (2021) 052013.

Hosseinzadeh-Bandbafha, H., Nazemi, F., Khounani, Z., Ghanavati, H., Shafei, M., Karimi, K., Lam, S.S., Aghbashlo, M., Tabatabaei, M., 2022. Safflower-based biorefnery producing a broad spectrum of biofuels and biochemicals: A life cycle assessment perspective. Sci. Total Environ. 802, 14984.

Joglekar, S.N., Pathak, P.D., Mandavgane, S.A., Kulkarni, B.D., 2019. Process of fruit peel waste biorefnery: a case study of citrus waste biorefnery, its environmental impacts and recommendations. Environ. Sci. Pollut. Res. 26, 34713–34722.

Faizyev T A and Toshmamatov B M 2021 Mathematical model of heat accumulation in the substrate and ground of a heliogreenhouse IOP Conf. Series: Earth and Environmental Science. 723 032006.

Toshmamatov BM, Valiev STStudy of the efficiency of anaerobic fermentation of municipal solid waste . Eurasian journal of academic research. Volume 2 Issue 11, October 2022.

Toshmamatov BM, Valiev STArziev BRFrom local organic waste to biogas: energy efficiency, safety aspects relating to biogas plants. International bulletin of engineering and technology. IBET | Volume 3, Issue 2, February. 37-42 p.

Tashmamatov B. (2022). Solar energy application in municipal solid waste: experience, results and efficiency. Alternative Energy , 1 (04), 84–96.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 10, Issue 8, August 2023

Muradov I., Toshmamatov, B M, Kurbanova NM, Baratova SR, Temirova L. (2019). Development of A Scheme For The Thermal Processing Of Solid Household. International Journal of Advanced Research in Science, Engineering and TechnologyVol. 6, Issue 9, September 2019, India, 10784 - 10787 pp.
Khoshnevisan, B., Tabatabaei, M., Tsapekos, P., Rafee, S., Aghbashlo, M., Lindeneg, S., Angelidaki, I., 2020. Environmental life cycle assessment of different biorefnery platforms valorizing municipal solid waste to bioenergy, microbial protein, lactic and succinic acid. Renew. Sust. Energy Rev. 117, 109493.
UzakovGN, ToshmamatovBM, Shomuratova SM, Temirova LZ (2019).Calculation of energy efficiency of the solar installation for the processing of municipal solid waste . International Journal of Advanced Research in Science, Engineering and TechnologyVol. 6, Issue 12, December 2019.
Toshmamatov B.M, Uzakov G.N. Kodirov I.N & KhatamovIA (2020). Calculation of the heat balance of the solar installation for the thermal processing of municipal solid waste. International Journal of Applied Engineering Research and Development (IJAERD) ISSN (P): 2250–1584; ISSN (E): 2278–9383 Vol. 10, Issue 1, June 2020, 21–30.
Sultanguzin AV, Gyul'maliev I A, Sergeev AM (2017). Biomass Pyrolysis and Gasification ComprehensiveModeling for Effective Power Generation atCombined Cycle Power Plant // Eurasian Chemico -Technological Journal. 2017. No. 19(3). P. 245–253.
Bashkov OV, Romashko RV, Bashkov IO, Zaikov VI, Khon H, Solovev DB 2020 Sensitivity Analysis of Adaptive Holographic Fiber-Optic Acoustic Emission Sensors during the Registration of Acoustic Waves In a Plate IOP Conf. Ser.: Earth Environ. Sci. 459 Paper No. 062104. [Online].
Smith J. M. Barlaz P. Jain, S. Luettich, and Huang X. Modeling Thermal Changes at Municipal Solid Waste Landfills: A Case Study of the Co-Disposal of Secondary Aluminum Processing Waste. US Environmental Protection Agency , Washington , DC, EPA/600/R-16/174, 2016.
Pleșca A. Considerations about Maximum Temperature of Toroidal Transformers in Steady-State Conditions. Journal of Advanced Thermal Science Research [Internet]. 2020 Oct 20 [cited 2021 Mar 26]; 7(1):22–9.
Toshmamatov B, Davlonov Kh, Rakhmatov O, Toshboev A, Rakhmatov A 2023 Modeling of thermal processes in a solar installation for thermal processing of municipal solid waste. AIP Conference Proceedings 2612 050027
Rashad AM, Mansour MA, Gorla RS, Siddiqa S, Salah T. Unsteady MHD Natural Convection Flow of Nanofluid in a Cavity Containing Adiabatic Obstacle with Heat Corners. Journal of Advanced Thermal Science Research [Internet]. 2019;6 (1):43–50.
Ekren O. Performance Evaluation of a Modified DC Compressor Powered by Solar Energy. Journal of Advanced Thermal Science Research [Internet]. 2017 ;4 (1):20–30.
B.M. Toshmamatov, G.N. Uzakov, S.M. Shomuratova, L.Z. Temirova, "Calculation of energy efficiency of the solar installation for the processing of municipal solid waste", *International Journal of Advanced Research in Science, Engineering and Technology*, Vol. 6, Issue 12, pp 12097-12102, December 2019, India.
ToshmamatovB.M., UzakovG.N., BaratovaS. Utilizatsiyatverdыxbытovыxotxodovsispolzovaniemsolnechnoyenergii. Mejdunarodnыynauchnыyjurnal «Nauchnыegorizontы». №2 str. 255-260.