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PROCESSING OF CARBON-CONTAINING WASTE FOR THE PRODUCTION OF GASEOUS FUELS

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Abstract
The paper describes the laboratory stand of the Gas Institute of the National Academy of Sciences of Ukraine, designed for gasification of hydrocarbon-containing waste and presents the results of their work. The possibility of producing gaseous fuels for replacing natural gas in fuel-using units is shown.
Key words: *waste recycling, gasification, substitution of fossil fuels, thermal destruction.*

Waste generation accompanies most types of societal activity. Those types of waste for which effective recycling technologies have been developed for beneficial use become a resource. Thus, the creation of a technology aimed at the beneficial utilization of waste provides a dual effect when implemented.

At the Gas Institute of the National Academy of Sciences of Ukraine, work is being conducted on the gasification of waste of various origins and physical states, with the aim of producing combustible gases—both as a resource for thermal equipment and for supporting chemical transformations.

The gasification of liquid hydrocarbons enables the processing of liquid waste from sunflower oil production, including soapstock, hydrofuze, tank sediment, and foots. The volume of such waste reaches up to 7,000 tons per year. The energy potential of these effluents—currently requiring resource-intensive treatment—could substitute approximately 840,000 m³ of natural gas annually [1]. The economically justified energy potential of solid agricultural waste exceeds 11 million tons of oil equivalent [2]. Other significant resources for processing include dried sludge from wastewater treatment, used car tires, and more. [3,4]

Main goal of this research was to develop waste processing technologies to realize the energy potential of wastes. To achieve this goal, a series of test rigs has been created at the Institute, enabling the thermal destruction of carbon-containing feedstock under conditions of air and oxygen-enriched air blasting. The processing of liquid waste is carried out using a stand designed for studying the process of plasma reforming of waste (Figures 1, 2).

The working section of the stand (Figure 1) consists of a cylindrical metal discharge chamber and a sealed metal reaction chamber isolated from the atmosphere. A cylindrical T-shaped electrode (1) is inserted into the chamber through a dielectric sleeve (2) located in the upper metal flange. This electrode functions as the anode and is supplied with a high energy potential. The anode's vertical position can be adjusted, allowing the distance between the electrodes to vary from a minimum of 2 mm to a maximum of 10 mm. The flange (3) serves as a grounded cathode. A spark discharge is initiated between the T-shaped cylindrical electrode (1) and the upper metal flange (3), which has a replaceable sleeve (4) in its center; the discharge end slides through an opening in this sleeve.

The oxidizer is injected under high pressure through channel (5), where calibrated nozzles are installed tangentially to the reaction chamber wall, creating a vortex flow (6) directed toward the spark discharge. The plasma jet (7) enters the reaction chamber (8). Two thermocouples are mounted on the outer wall of the working chamber—one at the top, one at the bottom—to measure wall temperature: T_t (wall temperature at the top) and T_β (wall temperature at the bottom). The hydrocarbon-steam mixture is fed through opening (9), and the oxidizer through opening (10). As in the spark discharge chamber, material flows are tangentially injected at high pressure into the working chamber via channels (11) with nozzles, forming a reverse vortex flow (12). Centrifugal force drives the mixture of hydrocarbons, steam, and oxidizer along the wall to the upper part, where oxidizer activated by the spark discharge is introduced.

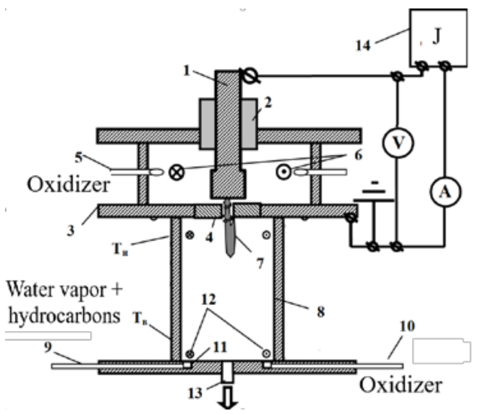

Fig. 1. *Schematic diagram of the working section of the plasma reforming unit for liquid carbon-containing waste*

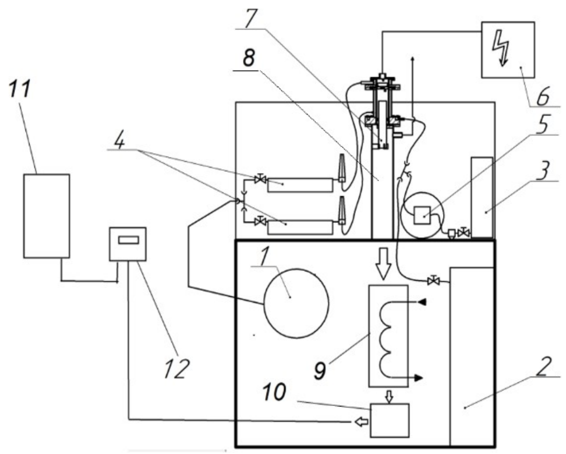

Fig. 2. *Schematic diagram of the plasma hydrocarbon gasification stand*

The mixture then slows down and is displaced toward the central axis of the reaction chamber, descending with the oxidizer flow. The resulting gaseous gasification products exit the working chamber through opening (13) for further use.

The process is stabilized by the high-voltage transformer (14), the power pulse of which can be adjusted to influence the composition and properties of the gaseous products generated from hydrocarbon oxidation.

Designation on Figure 2: 1 – air compressor; 2 – steam superheater; 3 – hydrocarbon tank; 4 – air receiver tank; 5 – high-pressure pump; 6 – high-voltage transformer; 7 – plasma initiator; 8 – working section of the gasifier; 9 – cooler; 10 – condensate collection chamber; 11 – hot water boiler; 12 – gas meter.

The composition of the producer gas produced from sunflower oil and liquid pyrolysis furnace fuel in the process of thermal decomposition of these liquid hydrocarbons is given in Table 1.

Table 1. Composition of generator gas

Substance	Composition of gaseous fuel									Q_{lower}, MJ/m^3
	H_2	N_2	CO	CH_4	CO_2	C_2H_4	C_3H_8	C_4H_{10}	H_2O	
Sunflower oil, % (vol.)	7,8	40,91	11,15	7,67	23,6	2,87	0,82	1,22	2,41	8,89
Stove fuel, % (vol.)	9,2	34,31	14,46	9,14	19,72	4,04	3,67	0,44	3,34	13,75

The conducted studies on liquid fuel reforming have shown the following:

- the calorific value of the producer gas generated from sunflower oil is 8.89 MJ/m³, and from liquid furnace fuel — 13.75 MJ/m³; the efficiency of the gasification process is 80–84%; the efficiency of thermal energy production by combusting the gaseous fuel in a boiler, after prior gasification of the liquid fuel, does not exceed 72%.
- In comparison with calorific value of natural gas, produced gas, generated from 1 kg of liquid wastes, can replace 0.75 m³ of natural gas. Thus, creating a way to realize the energy potential of liquid wastes.
- With the help of synthesis gas, it is possible to replace natural gas or part of it in existing water heating boilers; heat up boilers during the start-up of a thermal power plant in order to save on more expensive energy carriers; replace part of the natural gas used in boiler rooms; increase the combustion efficiency of traditional fuels.

References

1. Mahlovanyiĭ Ye.V., Nevchas D.M., Pyanykh K.Ye. Processing of liquid high-energy products to produce gas mixtures of a given composition. // «Enerhotekhnolohii ta resursozberezhennia», №4, 2023, page.113–123. DOI: 10.33070/etars.4.2023.09.
2. Tetiana Zhelezna, Assessment of the total energy potential of biomass in Ukraine // International Technical Assistance Project "Economic Support to Eastern Ukraine" Online training on the energy potential of biomass for the production of 1st and 2nd generation motor biofuels, October 3, 2023. Chrome extension: //efaidnbmnnnibpcajpcglclefindmkaj/ https://uabio.org/wpcontent/uploads/2023/10/ZHelyezna_Seminar-USAID_03-10-2023.pdf.
3. Wang, B.; Gupta, R.; Bei, L.; Wan, Q.; Sun, L. A review on gasification of municipal solid waste (MSW): Syngas production, tar formation, mineral transformation and industrial challenges. Int. J. Hydrogen Energy 2023, 48, 26676–26706.
4. Lee, D.-J. Gasification of municipal solid waste (MSW) as a cleaner final disposal route: A mini-review. Bioresour. Technol. 2022, 344, 126217.

ПЕРЕРОБКА ВУГЛЕЦЕВМІСНИХ ВІДХОДІВ ДЛЯ ВИРОБНИЦТВА ГАЗОПОДІБНОГО ПАЛИВА

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Анотація

У статті описано лабораторний стенд Інституту газу Національної академії наук України, призначений для газифікації вуглеводневмісних відходів, та представлено результати його роботи. Показано можливість виробництва газоподібного палива для заміщення природного газу в паливовикористовуючих установках.

Ключові слова: переробка відходів, газифікація, заміщення викопного палива, термічна деструкція.