

ABSTRACT

of the thesis on «ENERGY EFFICIENT GENERATION OF MOTOR AND ENERGY FUELS BASED ON THE PROCESSING OF ORGANIC COMPONENTS OF SOLID WASTE UNDER THE CONDITIONS OF THE ENTERPRISE JSC "TARTYP"», submitted for the degree of doctor of Philosophy (PhD) in the specialty 6D071700 «Thermal Power engineering»

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Solid waste management and disposal is considered one of the major major challenges facing urban communities around the world. Currently, many different technologies for processing solid household waste have been developed in the world, but in many countries, including Kazakhstan, waste disposal, despite all the significant negative environmental, medical and economic consequences associated with this method, is the most commonly used method.

Effective solid waste management involves the use of various approaches, technologies and concepts of their treatment, including processing methods such as: fermentation, ethanol fermentation. With such technologies, solid household waste can be a source of energy. The analysis showed that the method of hydrothermal treatment with the selection of appropriate ratios of biochemical enzymes and other compounds is quite acceptable for the composition of the organic fraction of solid household waste of Tartip JSC.

Today, the energy problem is very acute in the Republic of Kazakhstan. Heat supply to large-scale and medium-sized production facilities and the residential sector can be carried out from small boiler houses that run on imported fuel, the delivery of which requires huge economic and energy costs. In agriculture, the problem is growing with a shortage of energy capacity, as well as an insufficient level of centralization of electricity supply. The need to save energy and reduce environmental pollution makes it more optimal to use well-known traditional energy resources, and also justifies the search for various alternative, namely renewable and cheap energy sources. The issues of saving materials and fuel and energy resources, protection of the surrounding atmosphere are of great importance. The advantages of non-traditional renewable sources are that they can be inexhaustible, as well as environmentally acceptable. Modern technologies of urban wastewater treatment are mainly associated with the consumption of considerable amounts of electrical and thermal energy. In the conditions of the energy balance crisis, there is a problem of

reducing these energy costs by replacing them with non-traditional energy sources. In the 1970s, with the beginning of the crisis in the oil industry, alternative fuels became the subject of all kinds of research and development. A diverse number of assumptions were presented regarding the feasibility of using more acceptable fuels that can be found in every part of the world. Methyl and ethanol, compressed natural gas, liquefied petroleum gas, natural gas, vegetable oils, gasoline and diesel fuel are considered as alternative fuels. The main method of waste disposal in our country is still landfill disposal. The main disadvantages of the method of solid waste disposal at landfills include: long-term negative local impact on the environment, as well as the state and health of the population; high rates of greenhouse gas emissions into the atmosphere – carbon dioxide, as well as especially highly carcinogenic greenhouse gas - methane, which in turn must be used as a raw material for conversion into energy; alienation of large territories for landfills, which, due to the lack of isolation, spread pollution to larger and larger areas; decomposition and degradation of organic matter, which can be further used to improve soil quality.

A large increase in the volume of solid household waste in developed and large cities of developing countries and countries with economies in transition leads to an increase in public concern with emerging problems and consequences for human health and the environment. Effective management of organic components of solid waste implies the use of a variety of approaches, technologies and treatment concepts to ensure the health of the city's population and the preservation of the environment. Alternative methods such as pretreatment of organic components of solid household waste, ethanol fermentation with alcoholic yeast and anaerobic digestion attract increased attention. Therefore, this liquid can be used in thermal and electrical installations as the main or additional fuel. Thus, municipal solid waste can be a viable source of energy and fuel, rather than a source of pollution, if it is properly used. In the Republic of Kazakhstan, 72% of electricity is generated from coal, 12.1% can be attributed to hydro resources, 10.7% - gas and 4.9% - oil. In the modern world, the production of ethanol from abundant and cheap waste, for example, agricultural waste, solid household and food waste, is of great interest. Organic solid household waste among these inexpensive substrates is an abundant raw material with zero cost, and also due to the excessive concentration of the population in cities, the emergence of large megacities, the waste situation is deteriorating. Today, about 70% of solid household waste is sent to landfills or uncontrolled landfills, which often pollute surface water, groundwater, soil and greenhouse gases are released. It is necessary to note the excessive disposal of these on is the composition and formation of the

morphology of the preliminary organic given solid gases of household waste itself if the environmentally different waste factors, including lipids lipids culture, such as location, surface conditions of the preliminary environment and climate, as well as the level of economy and development of the society. Every year, municipal solid waste generated in developing countries contains 40-88% of food waste. The organic fraction of waste consists of starch, lignocellulose, lipids. Starch and lignocelluloses have a great potential for conversion to ethanol, while other lipids cannot be converted to ethanol without prior treatments, however, these biodegradable components can be converted to biogas by anaerobic digestion. Pretreatment involves increasing the bioavailability of lignocellulose, using the enzyme cellulase. Hydrothermal pretreatment reduces the formation of fermentation inhibitors, which are formed as a result of the breakdown and degradation of sugar. Pretreatment is an environmentally friendly process, since no chemicals are used, through this treatment the formation of hemicellulose is reduced and the availability of the enzyme for cellulose is improved.

Object of research: organic fraction of solid household waste of JSC "Tartip"

The purpose of the work is:

-development of optimal modes of hydrothermal processing of organic components of solid household enterprises of JSC "Tartip" using various enzymes and other compounds;

-determination of the concentrations of these additives at which the production of various compounds suitable for use either as fuel or as fuel additives will be achieved;

To achieve this goal, the following tasks are solved:

-analysis of modern types of processing of organic fraction of solid household waste and search for technology acceptable for the conditions of the landfill of JSC "Tartip", as well as concepts of environmental engineering;

-creation of model fractions for the development of hydrothermal treatment, fermentation and ethanol fermentation processes, the use of natural organic fraction of solid household waste;

-development of a method for obtaining ethanol from the organic fraction of solid household waste using a complex of enzymes for hydrolysis, pretreatment and ethanol fermentation for the conditions of the Tartip landfill;

-construction of mathematical and simulation models using Anylogic software for various scenarios of fermentation and hydrolysis processes for the organic part of solid waste of Tartin JSC;

-determination of thermal technical parameters of ethanol obtained from solid household waste landfill JSC "Tartip", according to the developed technology for various process parameters.

Research methods. To solve the tasks, experimental methods were used to study the processes of anaerobic fermentation of the organic fraction of solid household waste.

The qualitative experiment includes the following main stages: preliminary hydrothermal treatment, enzymatic hydrolysis with enzymes such as: amylase, glucavamarin, amylosubtilin, cellulase), ethanol fermentation (using alcoholic yeast) of the liquid fraction of waste. Method of application of membrane technologies of a combined water treatment plant for water purification for hydrothermal pretreatment. Determination of the specific heat of combustion on a calorimetric installation, the main part of which is a calorimetric self-sealing bomb type B-08 MA PU1.470 000, consisting of its own calorimeter and recorder. The method consists in the complete combustion of the mass of the tested liquid fuel in a calorimetric bomb in an environment of compressed oxygen saturated with water vapor, without sealing, in measuring the amount of heat released during the combustion of fuel and auxiliary substances, as well as during the formation of aqueous solutions of nitric and sulfuric acids under test conditions, and calculating the specific heat of combustion of fuel. Mathematical and simulation modeling was performed using the AnyLogic software product.

Scientific novelty of the dissertation work:

-the technology of processing the organic fraction of solid household waste from the landfill of JSC "Tartip" has been developed with the determination of:

-optimal temperatures of preliminary hydrothermal treatment to improve the enzymatic digestibility of lignocellulose fractions;

-an optimal set of enzymes (amylosubtilin, glucavamarin, cellulase, amylase) to activate the hydrolysis process and further ethanol fermentation, which is much more energy efficient;

-the ethanol composition of the processed product was obtained according to the developed technology at different ratios of enzymes and other compounds, suitable for use as additives or as fuel;

the technology of converting the resulting ethanol into a crystalline structure (alcohol tablets) was used;

the thermal performance of the resulting ethanol fuel was determined.

The practical significance of the work consists in developing and obtaining:

- generation of energy-efficient fuel from solid household waste;

-simulation of anaerobic fermentation processes;

The experimental data obtained on the use of the organic part of solid household waste allow us to conclude that this type of raw material is competitive along with traditional energy sources.

Reliability of the work. The reliability of the obtained results is ensured by the use of a chromatograph, a calorimeter, as well as the obtained results of mathematical modeling and experiments are consistent with the results of other authors.

Provisions submitted for protection:

-Modern types of processing of organic fraction of solid household waste and the search for a technology acceptable for the conditions of the landfill of JSC "Tartip", as well as the concept of environmental engineering are analyzed;

-model fractions have been created for the development of hydrothermal treatment, fermentation and ethanol fermentation processes, the use of natural organic fraction of solid household waste;

-a method has been developed for the production of ethanol from the organic fraction of solid household waste using a complex of enzymes for hydrolysis, pretreatment and ethanol fermentation for the conditions of the Tartip landfill;

-a mathematical and simulation model was built using Anylogic software for various scenarios of fermentation and hydrolysis processes for the organic part of solid waste of Tartin JSC;

-thermal engineering parameters of ethanol obtained from solid household waste from the landfill of JSC "Tartip" were determined according to the developed technology with various process parameters.

The author's personal contribution consists of:

- substantiating the relevance of the work;
- in the analysis and generalization of literary data;
- in conducting mathematical and simulation modeling;
- in conducting and processing the results of experimental studies;

The dissertation work is the result of the author's work, as well as the materials used in the dissertation were obtained independently and in collaboration with the scientific consultants of the work.

Approbation of the results of the dissertation. The results of the dissertation work were presented and discussed at International scientific-practical and scientific-technical conferences:

1. Temirbekova M.N. "Energy efficient generation of energy fuels based on organic components of solid waste of JSC "Tartyp"" XI International Scientific and Technical Conference "Energy, information and communication technologies and higher education" NAO AUES named after G.Daukeev

2. Temirbekova M., Madina Aliyarova, Iliya Iliev, Aliya Yelemanova and Saule Sagintayeva "The generation of a mathematical model of the biogas production process from organic municipal solid waste" E3S Web of Conferences 180, 02019 (2020) TE-RE-RD 2020 Volume 180, 2020 9th International Conference on Thermal Equipment, Renewable Energy and Rural Development (TE-RE-RD 2020), 1-6 p. (Scopus)

The validity and reliability of scientific statements, conclusions and recommendations is ensured by the use of instruments and modern research methods, as well as the results of mathematical modeling and experiments are consistent with the results of other authors.

Publications. 8 publications have been published on the topic of the dissertation, including 2 articles in the Journal of Ecological Engineering, included in the Scopus

database (percentile 39), 1 article in the Proceedings of the National Academy of Sciences of the Republic of Kazakhstan, indexed in the Scopus database (percentile 37), 3 articles published in publications recommended by the Quality Assurance Committee in the field of education and science of the Ministry of Education and Science of the Republic of Kazakhstan, 2 works in international conferences E3S Web of Conferences 180, 02019 (2020) TE-RE-RD 2020 Volume 180, 2020 9th International Conference on Thermal Equipment, Renewable Energy and Rural Development (TE-RE-RD 2020), (Scopus) and the XI International Scientific and Technical Conference "Energy, Info communication Technologies and Higher Education" of the NAO AUES named after G.Daukeev.

The introduction reveals the relevance and novelty of the scientific work, the purpose and objectives of the study, the provisions submitted for defense, and the problem under study. The main idea, the personal contribution of the author, as well as the approbation of the results and publications are given.

The first section of the dissertation presents a literary review of the current state of the issue and the main tasks of energy fuel research. The development and establishment of renewable energy sources, as well as the problems of solid household waste are reflected. An overview of anaerobic fermentation as a way to activate alternative energy is presented. The general characteristics of the landfill, the composition and methods of solid waste disposal are given. Microbiological processes of decomposition of organic matter of waste in landfills of solid household waste and the impact of landfills of solid household waste on the environment. The literature review also covers thermal methods of solid waste processing at incinerators and general information about biotechnological methods of solid waste processing. Disposal of the organic part of solid household waste at sanitary landfills and bioreactor landfills. The problem of processing the organic fraction of municipal solid household waste using modern methods.

The second section provides an overview of the basic principles of environmental engineering.

The third section reflects a systematic analysis of theoretical approaches and processes of bioethanol production, presents the results of mathematical and simulation modeling of the process of conversion into biofuels from organic household waste.

The fourth section describes the program and methodology for conducting experiments and measurements of the main parameters.

The fifth section presents the results of experimental studies by gas chromatography with mass spectrometric detection, pretreatment, and the results of determining the calorific value of ethanol obtained from organic components of solid household waste.

The conclusion reflects the main results and conclusions of the dissertation work.