

## ANNOTATION

**dissertations for the degree of Doctor of Philosophy (PhD) in the educational program «8D05303-Thermophysics and theoretical thermal engineering»**

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**Researches of thermophysical features of recycled organic waste by electrohydroimpulse technology and ways of their use in an industrial setting**

**The relevance of the topic.** Currently, work is actively underway to obtain new types of raw materials through the processing of waste from the agro-industrial complex and the development of methods for their use in production. The main goals of any processing industry are the tasks of efficient use of raw materials, reduction of production waste, expansion of the product range and improvement of the quality of products. This is especially true of fats and proteins, valuable raw materials that, if used correctly, are renewed but depleted. The widespread use of waste organic raw materials in the production of various products, including a large amount of highly digestible proteins, fats, phosphorus-calcium salts, macro- and microelements, vitamins and amino acids. In most cases, acid and alkaline treatment is carried out to isolate valuable components from the waste of organic raw materials. One of the valuable components is the triglyceride fraction, a substance that complicates any processing technology. The triglyceride fraction is an indispensable source of raw materials not only in the food industry, but also for medicine, construction and industry (for lubricating machine parts and measuring instruments).

Today, the growth of production and increasing its efficiency in industries processing agricultural raw materials largely depends not only on raw materials and their quality, but also on the possibility of allocating valuable components to the greatest extent. Reducing the loss of valuable components by using optimal methods and techniques for the production of products produced in production, for example, in the production of sugar, starch, oil, can significantly increase the value of finished products. Therefore, an urgent technological task is to find new effective solutions for the extraction of valuable components from the mass of organic waste using alternative methods, including shock waves caused by underwater spark discharge.

To date, the thermophysical properties of organic raw material residues have not been fully studied. In connection with this problem, various samples were prepared and experimental work was carried out to study the thermophysical properties.

**The purpose of the work.** The purpose of the dissertation is to improve the process of processing waste organic raw materials by the electrohydroimpulse

method and to scientifically substantiate the possibilities of effective isolation of valuable components.

**Research objectives.** The main tasks for achieving this goal are formulated as follows:

1. To analyze the types and composition of organic raw material waste, determine their physico-chemical properties and study the patterns of mass transfer and heat exchange processes occurring during the release of valuable components.;

2. To develop a measurement methodology with a description of a laboratory facility for processing organic waste;

3. To consider the mechanism of influence of underwater electric discharge on the phase separation of organic compounds and to determine the influence of temperature and energy parameters on the efficiency of the electrohydroimpulse treatment process.;

4. To analyze the results of experimental studies and propose optimal technological parameters for efficient processing of organic waste;

5. Performing spectrophotometric and atomic absorption analysis to determine the amount of organic and mineral parts in recycled samples;

6. Study of the thermodynamic functions of the object of study before and after treatment with electrohydroimpulsive shock waves (heat capacity, entropy, enthalpy, Gibbs energy, reduced thermodynamic potential) and thermophysical changes.

**The subject of the study** is waste from organic raw materials (bones of cattle have been studied).

**Research methods.** The various objects needed for research were prepared based on the sample preparation methodology. The samples are crushed mechanically, and the weights of the samples are determined on an electronic scale. The fat content in the samples of organic raw materials was determined on the basis of the standard GOST 23042-86. "meat and meat products methods of fat determination" and by the method of weight loss. The spectrophotometry method was used to determine the amount of protein contained in the studied samples. The inorganic part of the waste treated with an electrohydroimpulse unit was determined based on the atomic absorption spectroscopy method. The additive method was used to determine the thermodynamic functions of the processed raw materials. The effectiveness of optimal conditions of the electrohydroimpulse installation was determined on the basis of differential thermal analysis.

**Scientific novelty of the main results:**

1. The dependences of the release of valuable components from waste organic raw materials have been established depending on the basic electrophysical parameters of the plant generating shock waves. The effective parameters were considered to be: the amount of energy in the switching device 120-240 J, the length of the discharge interval of the air arrester installation  $l = 9$  mm, the battery capacity of the capacitor  $C = 0.4 \mu\text{F}$ , and the discharge voltage  $U = 25$  kV.;

2. It has been established that to isolate valuable components from organic waste with a fraction size below  $f=10$  mm, it is sufficient to maintain the temperature of the mixture in the temperature range of 36-50 °C.;

3. Using an atomic absorption spectrometer, the values of macro- and microelements found in the mineral part of the processed samples were studied, and it was found that in the waste of organic raw materials treated with the electrohydroimpulse method, the values of Ca, Fe, Mn increase, and the values of K, Na decrease;

4. Using a two-beam scanning spectrophotometer, the protein concentration in organic raw materials before and after processing and the change in the hydrocarbon composition of the samples were determined using a Fourier spectrometer; 5. For the first time, a differential thermal analysis of organic raw material waste treated with a shock wave was carried out. The analysis data showed that electrohydroimpulse technology actively separates valuable components used in industry from organic waste up to 100 ° C, and at 200-340 ° C, heavy hydrocarbon compounds decompose, while mass losses increase by 6% due to mineral compounds formed in processed raw materials;

5. For the first time, the thermodynamic functions of the organic mass of recycled waste (heat capacity, entropy, enthalpy, Gibbs energy, reduced thermodynamic potential) with an input energy value in an electrohydroimpulse installation of 120-240 J, a capacitor capacity of 0.4  $\mu$ F, and a voltage of 25 kV were determined based on the additive method. Thermodynamic analysis showed that a change in enthalpy between 300-1000 K corresponds to the breakdown of collagen and the release of triglycerides, while a decrease in enthalpy in the treated sample indicates the destruction of part of the organic matrix. This makes collagen available for cleavage, increases the speed and efficiency of protein extraction, and a moderate increase in Gibbs energy has proven that physical and chemical processes are active.;

6. For the first time, a differential thermal analysis of organic raw material waste treated with a shock wave was carried out. The analysis data showed that electrohydroimpulse technology actively separates valuable components used in industry from organic waste up to 100 ° C, and at 200-340 ° C, heavy hydrocarbon compounds decompose, while mass losses increase by 6% due to mineral compounds formed in processed raw materials.;

7. A patent was obtained for a utility model (No. 9548 "Method of degreasing crushed bone") that maintains a constant temperature of the working cell for processing waste organic raw materials.

#### **The main provisions submitted for defense:**

1. The amount of energy in the switching device of an electrohydroimpulse installation is 120-240 J, with a sample fraction size of 2-10 mm, the value of valuable components released from the remaining organic raw materials increased from 36.4% to 60%.

2. The capacitor capacity in the installation is 0.4  $\mu$ F, at a mixture temperature of 36 ° C to 50 ° C. With the organic part of the processed raw materials completely decomposed, the content of macro- and microelements in the inorganic part of Ca increases from 43.74% to 50.11%, and the K content decreases from 0.058% to 0.008%, the Na content decreases from 0.774% to 0.144%.

3. At the installation voltage causing an underwater electric discharge of 25 kV, the intermediate length of the electrodes of the air arrester is 9 mm, the mass

loss due to mineral bonds formed in the processed raw materials increases by 6%, the heat capacity ( $C_p$ ), the reduced thermodynamic potential (F) and the entropy value (H) of the sample remains unchanged, Gibbs energy increases 1.5 times.

**The relationship of the topic with the plans of scientific research programs.** The research of this work was carried out within the framework of the research project plan of the grant financing of the Ministry of Education and Science of the Republic of Kazakhstan for 2023-2025 "Development and creation of an alternative inertial hydrodynamic installation for heating coolants", state registration number No. AP19678501.

**Approbation of the obtained results.** The main results of the work were reported and discussed at the conference: "Modern technologies in education, work and science" (Krakov, Poland, 2025).

**Publications.** Based on the results of the dissertation, 4 publications were published: 2 articles in the journal included in the Thomson Reuters and Scopus database (1st article-Eastern-European Journal of Enterprise Technologies, 2024, Q3, percentile-41, 2nd article - Eurasian physical technical journal, 2025, Q4, percentile-25), the journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Education and Science of the Republic of Kazakhstan have published 1 article and 1 article on the materials of international conferences. In addition, utility model patent No. 9548 (06/14/2024) "Method of degreasing crushed bone" (Appendix A), the act of introduction into the educational process and the monograph "Using a heat generator for heating organic mixtures" were published.

**Scientific and practical significance of the work.** Valuable components extracted from organic waste using powerful spark discharges in a liquid medium can be used to lubricate production facilities, as the main source of raw materials needed for the production of food and technical gelatin and glue. The results of the study make it possible to obtain the most efficient type of raw materials for the construction, food and medical industries using raw materials processed by the electrohydraulic method, one of the environmentally friendly technologies for the efficient use of energy and mineral resources. The electrohydroimpulse unit uses high-voltage electrical discharges to create shock waves in a liquid medium, which allows it to destroy the cellular structures of organic material and extract valuable components such as fat and protein.

The validity and reliability of the data obtained are confirmed by a sufficiently large volume of accumulated and repeated experimental data, the approbation of the main results at conferences, published scientific articles and the act of implementation.

**Personal contribution of the author.** The research results presented in the dissertation were obtained by the author himself. The formulation of the problem, the formation of tasks and the search for ways to solve them, the preparation of the studied samples, conducting experiments, scientific conclusions and practical recommendations were carried out by the author personally. The results of the experimental measurements were subjected to computer processing. The analysis

of the research results and the overall results of the work were carried out jointly with scientific consultants.

**The volume and structure of the dissertation.** The structure of the thesis is determined by the tasks, the solution of which is necessary to achieve the purpose of the thesis. The dissertation consists of an introduction, 4 sections, conclusions, a list of 119 references and an appendix, and contains 103 pages of typewritten text. The work is illustrated with 58 figures and includes 12 tables.