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Section 1. Information technology

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THEORETICAL BASES OF FUZZY POLYNOMIAL EQUATIONS

Abstract. In the article the formal theory of equations based on fuzzy matches is proposed. The necessary and sufficient conditions for the existence of solutions of inverse problems - problems of fuzzy diagnostics are given.

Keywords: equations with fuzzy matches, inverse problems.

Introduction

The present stage of evolution of artificial intelligence systems is defined by rapid implementation of decision support systems with knowledge bases and inference machines, based on empirical and hard-to-classify knowledge of experts in various subject areas.

One of the key areas in the research and synthesis of knowledge-based systems is the problem of developing expert fuzzy diagnostic systems, whose theoretical basis is the concepts of fuzzy and linguistic variables and fuzzy relations, a generalization of which are fuzzy matches.

Therefore, the purpose of this study is to create a formal theory of fuzzy equations that constitute the conceptual basis for the synthesis of intelligent systems of fuzzy diagnostics.

Key concepts and definitions

A fuzzy matching $\tilde{A}(A, B) = \tilde{A}(A \times B)$ is a fuzzy subset of the Cartesian product where A and B re non-empty (crisp) sets..

Let A×B and B×C be given fuzzy matches $\tilde{A}$ and $\tilde{X}$:

$$\tilde{A} = \iint\limits_{A \times B} \frac{\mu_{\tilde{A}}(a,b)}{(a,b)}; \tilde{X} = \iint\limits_{B \times C} \frac{\mu_{\tilde{X}}(b,c)}{(b,c)}.$$

A composition of fuzzy matches is a fuzzy matching in the following form:

$$\tilde{A} \circ \tilde{X} = \iint\limits_{A \times C} \frac{\mu_{\tilde{A} \circ \tilde{X}}(a,c)}{(a,c)},$$

defined at A×C by a membership function:

$$\mu_{\tilde{A} \circ \tilde{X}}(a,c) = \begin{bmatrix} \sup T \\ \inf I \\ {}_{b \in B} \end{bmatrix} \left(\mu_{\tilde{A}}(a,b), \mu_{\tilde{X}}(b,c) \right), \quad (1)$$

where T is t-norm, I is the induced implicator.

A fuzzy (relational [1]) equation is the following equation:

$$\tilde{A} \circ \tilde{X} = \tilde{Y}, \quad (2)$$

where $\tilde{A}(A,B), \tilde{X}(B,C), \tilde{Y}(A,C)$ are fuzzy matches. Or in matrix notation: $A \circ X = Y$.

A direct problem for equation (2) is the problem of finding a fuzzy correspondence Y given A, X and the composition rule. In this case $Y = A \circ X$ and the solution of the direct problem is trivial and can be found by (1).

The inverse (right) problem for equation (2) is the problem of finding a representation of a fuzzy match X given A, Y the composition rule. The inverse problem is fundamentally complex (can have interval solutions or no solutions at all).

The simplest fuzzy equation is the following equation:

$$\begin{bmatrix} T \\ \cdots \\ I \end{bmatrix}(a,x) = y.$$

where $a, x, y \in [0,1]$.

A polynomial fuzzy equation is the following equation: $a \circ x = y$, where

$$a = (a_1 \quad a_2 \quad \cdots \quad a_n), x = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}; a_i, x_i \left(i = \overline{1,n}\right), y \in [0,1]$$

A polynomial equation system is the following fuzzy equation:

$$\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1p} \\ a_{21} & a_{22} & \cdots & a_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mp} \end{pmatrix} \circ \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_p \end{pmatrix} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_m \end{pmatrix}.$$

Main subject

1. Analysis of the simplest equations

Let us examine equations with triangular norms:

$$T(a,x) = y. \quad (3)$$

Assertion. For the equation (3) to have a solution x^0 it is necessary and sufficient to satisfy the condition $a \geq y$ (the proof is trivial).

For example, the equation $T(0.5,x) = 0.8$ has no solutions.

For an equation with implicators:

$$I(a,x) = y. \quad (4)$$

Assertion. For the equation (4) to have a solution x^0 it is necessary and sufficient to satisfy the condition $1 - a \leq y$ (the proof is trivial).

For example, the equation $I(0.5,x) = 0.3$ has no solutions.

2. Analysis of polynomial equations

Let us examine the following equation:

$$\max_{i=1,n} \left(T(a_i, x_i) \right) = y. \quad (5)$$

Assertion. For the equation (5) to have a solution

$$x^0 = \begin{pmatrix} x_1^0 \\ x_2^0 \\ \vdots \\ x_n^0 \end{pmatrix}$$

it is necessary and sufficient to satisfy the condition:

$$\exists j \left(1 \leq j \leq n\right) : a_j \geq y.$$

For example, the equation $(0.2 \quad 0.4 \quad 0.5 \quad 0.6) \circ$

$$\circ \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} = 0.7$$ has no solutions.

Proof.

Necessity.

Let x^0 – be the solution of the problem (5). This means that there exists at least one number $1 \leq j \leq n$, for which the equation $T(a_j, x_j^0) = y$, is satisfied, and this means that $a_j \geq y$ (see solution of simple equations).

$$\max_i \left(T(a_i, x_i) \right) = \max \left(T(a_1, x_1) \leq y, T(a_2, x_2) \leq y, \ldots, T(a_j, x_j) = y, \ldots \right) = y.$$

It has been proved that $\exists \underset{[1,n]}{j} : a_j \geq y \Rightarrow \exists \begin{pmatrix} x_1^0 \\ x_2^0 \\ \vdots \\ x_n^0 \end{pmatrix}$.

Let $u = \begin{bmatrix} y & \vdots & T_m \\ y/a_i & \vdots & T_p \\ y - a_i + 1 & \vdots & T_w \end{bmatrix}$, then the components of the maximal solution are found as follows:

$$\overline{x}_i^0 = \begin{bmatrix} 1 & \vdots & a_i \leq y \\ u & \vdots & a_i > y \end{bmatrix} \left(i = \overline{1,n} \right),$$

Where Tm, Tp and Tw are the logical, algebraic and drastic products.

Let us consider $Q = \{ i : a_i \geq y \}$.

The components of the minimal solutions are:

$$\underline{x}_i^0(k) = \begin{bmatrix} 0 & \vdots & a_i < y \\ \hline u & \vdots & i \in Q \\ \hline 0 & \vdots & i \notin Q \end{bmatrix} \left(k = 1, |Q|, i = \overline{1,n} \right).$$

Let us analyse the equations with implicators:

$$\min_{i=1,n} \left(I(a_i, x_i) \right) = y \qquad (6)$$

Assertion. For equation (6) to have a solution

$$x^0 = \begin{pmatrix} x_1^0 \\ x_2^0 \\ \vdots \\ x_n^0 \end{pmatrix},$$

$$\min_i \left(I(a_i, x_i) \right) = \min \left(I(a_1, x_1) \geq y, I(a_2, x_2) \geq y, \ldots, I(a_j, x_j) = y, \ldots \right) = y$$

Therefore, the following is true:

It has been proven that $\exists x^0 = \begin{pmatrix} x_1^0 \\ x_2^0 \\ \vdots \\ x_n^0 \end{pmatrix} \Rightarrow \exists \underset{[1,n]}{j} : a_j \geq y.$

Sufficiency.

Let $\exists \underset{[1,n]}{j} : a_j \geq y$, then at least one of the equations $T(a_j, x_j) = y$ has a solution, then (for (5)):

it is necessary and sufficient to satisfy the condition:

$$\exists j \left(1 \leq j \leq n \right) : a_j \geq 1 - y.$$

For example, the equation $(0.2 \quad 0.4 \quad 0.5 \quad 0.6) \circ$

$$\circ \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} = 0.3$$ For example, the equation

Proof.

Necessity. Let us consider x^0 to be the solution of the problem (6). This means that there exists at least one number $1 \leq j \leq n$, for which the equation $I(a_j, x_j^0) = y$, is satisfied, and this means that $a_j \geq 1 - y$ (see solution of simple equations).

Therefore, the following is true:

$$\exists x^0 = \begin{pmatrix} x_1^0 \\ x_2^0 \\ \vdots \\ x_n^0 \end{pmatrix} \Rightarrow \exists \underset{[1,n]}{j} : a_j \geq 1 - y.$$

Sufficiency.

Let $\exists \underset{[1,n]}{j} : a_j \geq 1 - y$, then at least one of the equations $I(a_j, x_j^0) = y$ has a solution, therefore (for (6)):

Let $u = \begin{bmatrix} y & I_m \\ \dfrac{a_i + y - 1}{a} & I_p \\ a_i + y - 1 & I_w \end{bmatrix}$, then the components

of the minimal solution will be found as follows:

$$\underline{x}_i^0 = \begin{bmatrix} 0 & a_i \le 1 - y \\ u & a_i > 1 - y \end{bmatrix} \left(i = \overline{1,n}\right).$$

Here *Im*, *Ip* and *Iw* are the implicators induced by the norms Tm, Tp and Tw using a standard inverter.

Let $Q = \{i : a_i \ge 1 - y\}$.

The components of the maximal solutions:

$$\bar{x}_i^0(k) = \begin{bmatrix} 1 & a_i < 1 - y \\ \hline u & i \in Q \\ \hline 1 & i \notin Q \end{bmatrix} \left(k = 1, |Q|, i = \overline{1,n}\right).$$

3. Principles for solving systems of polynomial equations

Inverse problems for systems of polynomial equations are solved according to the following:

$$\begin{bmatrix} \left\{ \max_k \left(T\left(a_{ik}, x_k\right)\right) = y_i \\ \left\{ \min_k \left(I\left(a_{ik}, x_k\right)\right) = y_i \end{bmatrix} \left(i = \overline{1,m}\right)$$

For example, the well-known (classical) fuzzy car fault diagnosis problem [2] is formulated as follows:

$$\begin{pmatrix} 1.0 & 0.8 & 0.7 & 1.0 \\ 0.1 & 0.9 & 0.8 & 0.5 \\ 0.2 & 1.0 & 0.5 & 0.2 \end{pmatrix} \circ \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{pmatrix} = \begin{pmatrix} 0.9 \\ 0.1 \\ 0.2 \end{pmatrix}$$

The equation system using the max-min composition in this case is as follows:

$$\begin{cases} \max\left(\min(1.0, x_1), \min(0.8, x_2), \min(0.7, x_3), \min(1.0, x_4)\right) = 0.9 \\ \max\left(\min(0.1, x_1), \min(0.9, x_2), \min(0.8, x_3), \min(0.5, x_4)\right) = 0.1. \\ \max\left(\min(0.2, x_1), \min(1.0, x_2), \min(0.5, x_3), \min(0.2, x_4)\right) = 0.2 \end{cases}$$

The table shows the solutions to the three equations and the system as a whole.

Table 1.– Solution to the diagnostic problem

i	x^0	$\bar{x}^0$	$\underline{x}^0$
1.	$\begin{bmatrix} 0 \le x_1^0 < 0.9 & 0 \le x_2^0 \le 1 & 0 \le x_3^0 \le 1 & x_4^0 = 0.9 \\ \hline x_1^0 = 0.9 & 0 \le x_2^0 \le 1 & 0 \le x_3^0 \le 1 & 0 \le x_4^0 \le 0.9 \end{bmatrix}$	$\begin{pmatrix} 0.9 & 1 & 1 & 0.9 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 & 0.9 \\ \hline 0.9 & 0 & 0 & 0 \end{pmatrix}$
2.	$\begin{bmatrix} 0 \le x_1^0 < 0.1 & \begin{bmatrix} 0 \le x_2^0 < 0.1 & \begin{bmatrix} 0 \le x_3^0 < 0.1 & x_4^0 = 0.1 \\ \hline x_3^0 = 0.1 & 0 \le x_4^0 \le 0.1 \end{bmatrix} \\ \hline x_2^0 = 0.1 & 0 \le x_3^0 \le 0.1 & 0 \le x_4^0 \le 0.1 \end{bmatrix} \\ \hline 0.1 \le x_1^0 \le 1 & 0 \le x_2^0 \le 0.1 & 0 \le x_3^0 \le 0.1 & 0 \le x_4^0 \le 0.1 \end{bmatrix}$	$\begin{pmatrix} 1 & 0.1 & 0.1 & 0.1 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 & 0.1 \\ \hline 0 & 0 & 0.1 & 0 \\ \hline 0 & 0.1 & 0 & 0 \\ \hline 0.1 & 0 & 0 & 0 \end{pmatrix}$
3.	$\begin{bmatrix} 0 \le x_1^0 < 0.2 & \begin{bmatrix} 0 \le x_2^0 < 0.2 & \begin{bmatrix} 0 \le x_3^0 < 0.2 & 0.2 \le x_4^0 \le 1 \\ \hline x_3^0 = 0.2 & 0 \le x_4^0 \le 1 \end{bmatrix} \\ \hline x_2^0 = 0.2 & 0 \le x_3^0 \le 0.2 & 0 \le x_4^0 \le 1 \end{bmatrix} \\ \hline 0.2 \le x_1^0 \le 1 & 0 \le x_2^0 \le 0.2 & 0 \le x_3^0 \le 0.2 & 0 \le x_4^0 \le 1 \end{bmatrix}$	$\begin{pmatrix} 1 & 0.2 & 0.2 & 1 \end{pmatrix}$	$\begin{pmatrix} 0 & 0 & 0 & 0.2 \\ \hline 0 & 0 & 0.2 & 0 \\ \hline 0 & 0.2 & 0 & 0 \\ \hline 0.2 & 0 & 0 & 0 \end{pmatrix}$
$\{:$	$x_1^0 = 0.9 \quad 0 \le x_2^0 \le 0.1 \quad 0 \le x_3^0 \le 0.1 \quad 0 \le x_4^0 \le 0.1$	$\begin{pmatrix} 0.9 & 0.1 & 0.1 & 0.1 \end{pmatrix}$	$\begin{pmatrix} 0.9 & 0 & 0 & 0 \end{pmatrix}$

In this case, the maximum solution of the system $(0.9 \vdots 0.1 \vdots 0.1 \vdots 0.1)$ is equal to the intersection of three partial maximum solutions $(0.9 \vdots 1 \vdots 1 \vdots 0.9) \cap (1 \vdots 0.1 \vdots 0.1 \vdots 0.1) \cap (1 \vdots 0.2 \vdots 0.2 \vdots 1)$ (the system is joint).

The semantic interpretation of the resulting solution is presented quite fully in [2].

Conclusion

Theoretical bases of the formal formulation and methodology for finding solutions of fuzzy polynomial equations have been developed. The influence of compositions of fuzzy matches with standard triangular norms and implicators induced on their basis on the existence criteria and components of the synthesized solutions is investigated.

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Section 2. Technical sciences

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FIRE PREVENTION AND FIGHTING FOR SEAPORTS IN VIETNAM – THEORETICAL ISSUES AND EXPERIENCE OF ORGANIZATIONAL MANAGEMENT

Abstract. In Vietnam, fire prevention and fighting is always concerned and identified as the responsibility of all individuals, agencies and organizations. For seaports in Vietnam, this work is given top priority, in order to ensure fire prevention and fighting safety, to meet the requirements of economic development and international integration. The article focuses on clarifying theoretical issues related to the organization and management as well as Vietnam's experiences in this work.

Keywords: fire prevention and fighting; seaport; Vietnam.

1. Make a problem

Habour in general and seaports in particular have a very important role: They are the driving force for the development of the marine economy in particular and the country's economy in general. This is the gateway to trade in import and export goods, the focal point for converting sea transport to rail, road and inland waterway transport. As a coastal country, our country has nearly half of the provinces and cities with the sea, with a total length of coastline of over 3,260 km running along the length of the country; has a wide sea area with many peninsulas, lagoons and deep bays that are sheltered from the wind, projecting the international maritime route between the Indian Ocean and the Pacific Ocean. Being well aware of the importance of sea and islands and marine economic development, over the years, the Party and State have issued many resolutions, directives, strategies for planning, construction and development of habour, such as: Decision No. 202/QD-TTg dated October 12, 1999 of the Prime Minister on the master plan on development of Vietnam's habour up to 2010; Decision No. 1037/QD-TTg dated June 24, 2014 of the Prime Minister on Approval to adjust the master plan on development of Vietnam's habour system up to 2020, orientation to 2030, etc, and implement synchronously solutions to build and develop the seaport system in the context of international integration.

Practical theoretical research on fire prevention and fighting in general has been researched by many scientists and managers through published products in the form of textbooks, scientific topics at all levels, articles. Scientific articles

published in journals inside and outside the police force. In general, scientific research works have achieved certain achievements, the theory of fire prevention and fighting has been increasingly supplemented, perfected and developed, contributing to creating a solid foundation to help management agencies effectively perform the assigned functions and tasks. On the basis of general theories, research, analyze and clarify in a logical, scientific and systematic manner the management theory of fire prevention and fighting for seaports, especially the content of fire prevention and fighting management for seaports. seaports according to the functions of the Fire and Rescue Police force. From there, creating a solid scientific basis so that the Fire and Rescue Police force can effectively organize the implementation of the assigned functions, tasks and powers.

2. Research results and discussion

2.1. Seaports and requirements, safety conditions on fire prevention and fighting for seaports

a) Seaports

According to the Vietnam Maritime Code 2015 specifically in Clause 10, Article 4 and QCVN: 2021/BGTVT, the concept of a seaport is unified in a sense that: "A port is an area including land and areas. water belonging to a seaport, wharfs, warehouses, yards, factories, offices, service facilities, transportation systems, communication systems, electricity, water, water areas in front of the wharfs and navigational channels may be built. and other ancillary works. A port facility has one or more berths". Wharf is a fixed structure or floating structure in a harbour, used for ships to anchor, load and unload goods, pick up and drop off passengers and perform other services. This seaport concept shows that a seaport is a major part of a seaport. Thus, the con-

cept of a seaport clearly shows the general characteristics, structure and functions of a seaport when it is formed and put into operation and use. These contents have important significance in state management activities in general and state management of fire prevention and fighting for seaports in particular.

Regarding the role of seaports in the development of logistics activities, studying the experience of countries around the world shows that, for comprehensive development and high economic growth, most governments need to accept clearly the role of seaports. With more than 80% of the world's import and export goods transported by sea through seaports, seaports are an important focal point in goods circulation, playing a very important role in the development process. national economic development as well as regional and international economic integration. Seaports form the basis for service activities, for seaports themselves and for a range of other industries. When seaport services (logistics) develop, seaports will attract many ships, many goods imported and exported, temporarily imported for re-export, transited, from which economic and trade relations of a country, is also developed in all aspects. These activities bring significant benefits to coastal countries, especially attracting a large amount of foreign currency annually to the country. Therefore, the development of the seaport system, reducing transportation costs and logistics services will contribute to increasing competitiveness, creating an attractive investment and business environment for each country.

For Vietnam, in the process of renewal, opening up, regional and international economic integration, seaports play an even more important role. Seaports are the lifeblood of maritime traffic between our country and Europe, America, the Mid-

dle East and Asia; It is the focal point of forwarding and distribution of goods for all socio-economic activities of the country and a gateway for international economic exchanges, effectively serving the development of the country's marine economy.

The development of the seaport's material and technical facilities will meet the needs of trade in goods within the region as well as around the world, promote import and export activities, and accelerate the process of economic integration., strengthen the country's position in the international arena. The practice of developing logistics activities in countries around the world shows that logistics can only develop on a solid infrastructure foundation, especially seaport infrastructure. In other words, seaports play a very important role, deciding the development of the logistics industry.

For countries with a developed seaport system, especially in the locality where the port is located, it is considered as a comparative advantage for the formation and development of economic zones, industrial parks, and mining industries, shipbuilding industry, allowing to create many jobs for the local economy.

b) Fire prevention and fighting safety requirements and conditions for seaports

Research shows that the law on fire prevention and fighting does not have specific and clear regulations on requirements and safety conditions for fire prevention and fighting for seaports. However, based on the provisions of the law on fire prevention and fighting such as the Law on fire prevention and fighting in 2001 (amended and supplemented in 2013), Decree No.136/2020/ND-CP dated November 24, 2020 of the Government stipulating expenses detailing a number of articles and measures to implement the Law on Fire Protection and the Law amending and supplementing a number of articles of the Law on Fire Prevention

and Fighting (Decree No.136/2020/ND-CP) and guiding documents, showing that: According to Clause 3 Article 3 of the Law on Fire Prevention and Fighting 2001 (amended and supplemented in 2013), establishments are places of production and business, public works, working offices, apartment buildings and other independent works according to the list prescribed by law. Government regulations. Pursuant to Appendix I of the list of establishments subject to fire prevention and fighting management (issued together with Decree No. 136/2020/ND-CP), seaports are subject to fire prevention and fighting management, according to Appendix II issued together with this Decree. This Decree also stipulates that seaports are on the list of facilities at risk of fire and explosion and according to Appendix V, also stipulates that seaports are on the list of projects and works subject to design review and approval for fire prevention and fighting. In addition, according to these appendices, relevant facilities in the seaport area, if they are on the list, must comply with the provisions of the law on fire prevention and fighting. Thus, for seaports and facilities in seaports, collectively referred to as facilities and comply with Article 20 of the Law on Fire Prevention and Fighting 2001 (amended and supplemented in 2013) stipulating fire prevention requirements for basis. Concretizing Article 20 of the Law on Fire Prevention and Fighting 2001 (amended and supplemented in 2013), in Clause 1, Article 5 of Decree No.136/2020/ND-CP, clearly defined safety conditions on fire prevention and fighting for establishments.

2.2. Concept, characteristics, legal basis and responsibilities of entities managing fire prevention and fighting for seaports

a) Concepts

The management of fire prevention and fighting for seaports is an organized and adjusted

influence by the power of the State on the basis of the law on fire prevention and fighting and other relevant legal documents for the seaport. with fire prevention and fighting activities in the seaport area of the competent authorities, in order to minimize the occurrence of fires and the damage caused by fire, contributing to the protection of life, protection properties of the State, organizations and individuals, protect the environment, ensure security and social order and safety.

b) Characteristics

– Regarding the subjects of management of fire prevention and fighting for seaports:

Objects of management of fire prevention and fighting for seaports are fire prevention and fighting activities of enterprises, organizations and individuals investing in the construction and trading of technical infrastructure of seaports and exploitation and trading establishments. business, transportation… in the seaport area.

– The entity directly assigned to perform the state management of fire prevention and fighting for seaports and operating in seaports is the Fire Protection and Rescue Police force, which is specifically facilities led by the Police Department. Fire Prevention and Control Department and Provincial Police Department under the management.

– Management tools: Legal system on fire prevention and fighting and other laws related to seaports, standards and technical regulations on fire prevention and fighting for seaports…

– Management methods of fire prevention and fighting are ways and measures affecting the activities of subjects under management in the field of fire prevention and fighting.

– The objective of the management of fire prevention and fighting for seaports is to minimize the occurrence of fires and damage caused by fires at seaports, contributing to the protection of human life and health. protect properties of the State, organizations and individuals, protect the environment, ensure security and social order and safety; bring the aspects of fire prevention and fighting work step by step to meet the requirements of socio-economic development, effectively serving the cause of industrialization and modernization of the country.

c) Responsibilities of the subjects

The Ministry of Public Security, whose core is the Fire Prevention and Fighting Police force and the Central High Command in performing the task of state management of fire prevention and fighting in general, including seaports, is specified in Article 51 of Decree No.136/2020/ND – CP on 24/11/2020.

The Ministry of Transport is the governing and superior ministry in charge of the Vietnam Maritime Administration. Within the scope of its tasks and powers, the Ministry of Transport shall coordinate with the Ministry of Public Security in organizing the implementation of regulations on fire prevention and fighting; at the same time, organize the implementation of the provisions of Clause 1, Article 50 of Decree No.136/2020/ND-CP dated November 24, 2020 stipulating the responsibilities of ministries, ministerial-level agencies and agencies under Government.

People's Committees at all levels in the state management of fire prevention and fighting in general, including seaports are defined in Article 52 of Decree No. 136/2020/ND-CP dated November 24, 2020.

The Maritime Administration is an agency directly under the Vietnam Maritime Administration, performing the task of state management of navigation at seaports and assigned management areas. The port authority has legal status, has its

own head office, uses its own seal, and is allowed to open an account at the State Treasury. The maritime port authority has a transaction name written in English as Maritime Administration of… (proper name of the Maritime Administration).

3. Experience in organizing management of fire prevention and fighting for seaports in Vietnam

3.1. Formulate and direct the implementation of strategies, master plans and plans on fire prevention and fighting for seaports

Like other management fields, the management of fire prevention and fighting for seaports is first and foremost a management on a macro level, reflected in the formulation and direction of the implementation of strategies, master plans and plans on operations. Fire protection action for seaports. One of the basic characteristics of the management of fire prevention and fighting for seaports is that the management must have programs, plans, short-term goals and long-term goals. Building and directing fire prevention and fighting activities at seaports on the basis of strategic orientations with synchronous planning and plans is an indispensable requirement in management.

On that basis, proactively develop projects to improve the working capacity of the Fire Protection and Rescue Police forces, build a network of professional fire fighting teams; build grassroots and specialized fire prevention and fighting forces at seaports to meet the requirements of on-site fire prevention and fighting work; projects on traffic assurance and fire fighting water sources at seaports; step by step modernize the means of fire prevention and fighting; develop a plan for training and fostering human resources for fire prevention and fighting… in order to meet the requirements of fire prevention and fighting

work for seaports in the period of industrialization and modernization of the country.

3.2. Promulgate, guide and organize the implementation of legal documents on fire prevention and fighting related to seaports

The legal system on fire prevention and fighting related to seaports includes legal documents on the management of seaports and a system of relevant national technical standards and regulations on fire prevention and fighting. by competent state agencies in accordance with the Law on Promulgation of Legal Documents. In the legal system on fire prevention and fighting, the Law on fire prevention and fighting has the highest legal value.

3.3. Propagating, educating and disseminating knowledge about fire prevention and fighting; building a movement for all people to participate in fire prevention and fighting for seaports

Propagating and disseminating the law and knowledge on fire prevention and fighting is the content and the most important measure in the work of fire prevention and fighting. The main purpose of this work is to make all people, all officers, employees and heads of agencies and organizations understand and voluntarily implement the State's regulations on fire prevention and fighting in general and for wharf. seaport in particular.

State management activities in this field are the determination of responsibilities of state agencies, economic and social organizations in the work of propagating and educating knowledge and laws on fire prevention and fighting (responsibility of the information and propaganda agencies at the central and local levels; responsibilities in the organization and implementation of the Vietnam Maritime Administration, the Maritime Port Authority, the provincial departments, and of the Fire and Rescue Police force).

3.4. Organize and direct fire prevention and fighting activities for seaports

Measures to prevent fire and explosion at seaports must be strictly implemented, such as: Strict management and safe use of combustible substances, fire sources, heat sources, fire-generating equipment and tools., heat generation; regularly ensure the fire prevention and fighting safety conditions and organize the safety inspection on fire prevention and fighting in order to promptly detect loopholes and shortcomings, propose timely remedial measures. The State management agency in charge of fire prevention and fighting, which is directly the Fire Protection and Firefighting Police force, is responsible for guiding the port authorities to implement technical design solutions, ensuring fire safety right from the moment the construction works. new work items are only planning design drawings or technical designs; guide the Port Authority, investors operating at seaports to comply with fire prevention requirements for seaports and facilities operating at seaports.

In addition, the organization and direction of fire fighting activities must thoroughly grasp the principle: "Must be prepared with forces, means, plans and other conditions so that when a fire occurs, the fire can be extinguished promptly. effective time" in performing the task of standing ready for fire fighting of the professional firefighting and rescue police forces as well as for specialized fire protection forces and facilities at seaports.

3.5. Organize training, build forces, equip and manage fire prevention and fighting means for seaports

Organizing training is an important content in ensuring human resources for fire prevention and fighting. In addition to the source of staff trained from abroad, the staff of fire prevention and fighting activities are mainly trained from within the country (at the University of Fire Prevention and Control).

Building the fire prevention and fighting force, equipping and managing fire prevention and fighting equipment falls within the scope of the 2001 Law on Fire Protection (amended and supplemented in 2013). Therefore, this is an important content in the state management of fire protection for seaports. Therefore, it is the responsibility of the Maritime Port Authority to ensure: The grassroots fire prevention and fighting force must be organized in all facilities, being the core force in fire prevention and fighting work at each facility in the seaport; The port authority must establish specialized fire fighting teams of the seaports under their management.

For the Fire Protection and Rescue Police force, the 2001 Law on Fire Prevention and Fighting (amended and supplemented in 2013) stipulates that it must be built in a regular, elite, step-by-step modern manner to be worthy of being the core force. in the state management of fire prevention and fighting.

3.6. Ensuring budget for fire prevention and fighting activities; organize fire and explosion insurance associated with fire prevention and fighting activities at seaports

To ensure the financial source for fire prevention and fighting activities, not only rely on the state budget but also have to collect from fire and explosion insurance; from voluntary contributions of domestic and foreign agencies, organizations and individuals. The state budget only covers the necessary expenditures for fire prevention and fighting activities, but mainly for the fire prevention and fighting police forces, the administrative and non-business units, the armed forces and other units to enjoy the state budget.

country. The State has policies to encourage domestic agencies, organizations and individuals, overseas Vietnamese, foreign organizations and individuals, and international organizations to invest in and sponsor fire prevention and fighting activities.

For the compulsory fire and explosion insurance regime, the contents of state management are shown on the basis of the provisions of the Government's Decree No.23/2018/ND-CP dated February 23, 2018 on insurance. compulsory fire and explosion hazard. Accordingly, the Decree clearly stipulates who must buy compulsory fire and explosion insurance, insurance contracts, liability of insurance buyers and sellers, insurance premiums and principles of using 1% revenue from revenue. annual compulsory fire and explosion insurance in fire prevention and fighting activities.

3.7. Appraisal and approval of projects, design and acceptance of construction works on fire prevention and fighting; technical inspection, inspection and certification of conformity to vehicles, equipment, substances and goods subject to strict requirements on fire prevention and fighting for seaports

For seaport projects and works on the list of design appraisal and approval for fire prevention and fighting as prescribed in Appendix V issued together with Decree No. 136/2020/ND-CP dated November 24, 2020 of the Government Decree No. 136/2020/ND-CP of the Government stipulating the contents, order, procedures, time limit for design appraisal and approval, order and procedures for acceptance of works on fire prevention and fighting. At the same time, it stipulates the responsibilities of the investor, the design agency, the construction contractor, the project approval agency, the construction licensing agency and the

fire protection police agency in the construction investment in general and at seaports in particular.

Fire prevention and fighting means and equipment, substances, dangerous goods, fire and explosion, with strict requirements on fire prevention and fighting must be inspected, tested and certified in accordance with the law. Decree No.136/2020/ND-CP stipulates the list of fire prevention and fighting equipment subject to inspection in Appendix VII issued together with this Decree and strictly complies with Article 38. In addition, related Regarding goods at risk of fire and explosion, Decree No.136/2020/ND-CP has also specified in Article 9.

3.8. Organizing research, application and dissemination of scientific and technological advances in fire prevention and fighting for seaports

Organizing research, application and dissemination of scientific and technological advances in fire prevention and fighting is currently an issue that needs attention, stemming from the practice of fire prevention and fighting and the requirements of the 4.0 revolution that are affecting to. Therefore, the study of scientific – technological and organizational solutions in management, new fire prevention and fighting problems arising at seaports is very necessary in the current context. meet the requirements of sustainable development at seaports.

Research and apply advanced scientific and technological achievements in fire prevention and fighting in the world, research and manufacture in the country a number of means, tools and chemicals for fire prevention and fighting. Renovating the content and methods of training fire fighting forces.

Research and development of science and technology for fire prevention and fighting for seaports should closely follow the guidelines,

guidelines and policies of the Party and State on science and technology.

3.9. Inspect, examine, handle violations, settle complaints and denunciations about fire prevention and fighting; fire investigation

Inspection, examination, handling of violations and investigation of fires are activities according to the functions of the subjects of state management of fire prevention and fighting. At seaports, too, the specialized inspection on fire prevention and fighting for seaports is carried out by competent entities.

Fire safety inspection is the responsibility of the state management agencies in charge of fire prevention and fighting and the responsibility of the Port Authority, the heads of facilities operating in the seaport area as prescribed by law. on inspection contents, inspection regime, inspection responsibilities, inspection procedures on fire prevention and fighting.

Fire investigation activities to clarify the cause of the fire and the fire. The legal basis of the investigation of the fire is carried out in accordance with the provisions of the criminal law, the criminal procedure law, the Law on Organization of the Criminal Investigation Agency, Circular No.55/2020/TT-BCA …

3.10. Organization of state statistics on fire prevention and fighting for seaports

In order to ensure the leadership and direction of all levels and serve the advisory and planning of policies and measures on fire prevention and fighting, statistics and reports on fire prevention and fighting are mandatory requirements in management activities. State management of fire prevention and fighting in general and seaports in particular.

Accordingly, the law on fire prevention and fighting stipulates that the heads of agencies and organizations are responsible for making statistics and periodical reports on the situation of fire prevention and fighting work to the fire protection police agency, specifically here is the port authority. . Accordingly, the contents of state statistics on fire prevention and fighting for seaports include: Statistics on forces, means and fire protection systems at seaports; statistics on fire and explosion situation; causes of fire and explosion; damage caused by fire and explosion at seaports; … as well as conditions to ensure the organization and implementation of the provisions of law in the state management of fire prevention and fighting for seaports.

3.11. International cooperation on fire prevention and fighting

International cooperation on fire prevention and fighting is an inevitable trend in the current integration period. Through international cooperation, the fire prevention and fighting police force and the Central High Command have the conditions to improve their professional, scientific and technical skills, step by step to keep pace with the level of fire prevention and fighting of countries in the region and the world.

The content of international cooperation on fire prevention and fighting is carried out in many fields: Cooperation in the development of legal documents, regulations and standards on fire prevention and fighting; Cooperation in the field of experience exchange, professional training and retraining and participation in competition of fire prevention and fighting skills; Cooperation in the field of training experts in the field of fire protection for Vietnam; Cooperation in the field, research and application of scientific and technological advances in the field of fire prevention and fighting; Cooperation in the field of investment for fire prevention and fighting activities; Inter-

national cooperation in fire fighting, rescue and rescue in cases of disasters and natural disasters.

4. Conclusion

As discussed above, the fire prevention and fighting work for seaports in Vietnam is not a new issue, however, this is always a topical issue, because, ensuring safety of fire prevention and fighting, aiming at Sustainable economic development, international economic integration, related to investment, technology transfer… should always be of special interest to all levels and sectors in Vietnam. With the research results, the author wishes to exchange the initial results and orientations for future research.

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Section 3. Chemistry

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PHOSPHORUS-SULFUR AND NITROGEN-PHOSPHORUS-SULFUR COMPLEXES BY ACTIVATING PHOSPHORITES WITH SULFURIC AND NITRIC ACIDS IN THE PRESENCE OF SULFUR

Abtract. It was studied that it is possible to obtain complex phosphorus-sulfur and nitrogen-phosphorus-sulfur fertilizers with insecticidal properties necessary for agriculture by reprocessing low-grade Kyzylkum phosphorites in the presence of sulfur with incomplete standards of sulfuric and nitric acid. 30–40% of acid consumption is saved by replacing the amount of sulfur in the sulfuric acid used in the decomposition process with elemental sulfur. The received fertilizers contain phosphate minerals in mono- and dicalcium phosphate form, and sulfur in SO_4^{2-} ion and elemental form. It was found that the sulfur in the fertilizer is in a completely hydrophilic form.

Keywords: low-grade phosphorite, nitrogen-phosphorus-sulfur fertilizer, insecticide, technological scheme.

Introduction

Among the insecticides, sulfur containing drugs are not harmful to humans and livestock. Lime: sulfur (2:1) decoction (ISO), sulfur talc, colloidal sulfur are used as sulfur insecticides: However, the process of obtaining these insecticides is complex and requires a lot of energy and finance.

Scientists around the world, including in Uzbekistan are looking for low-cost and resource-efficient ways to obtain phosphate fertilizers from unenriched and low-quality phosphorites. In this regard, promising scientific research shows that a new type of complex fertilizers has been developed by activating phosphorites on the basis of chemical, mechanical, mechanochemical, thermal and bacterial means [1–2].

Therefore, one of the most pressing issues today is the development and implementation of specific resource-saving technologies for the production of phosphorus-sulfur and nitrogen-phosphorus-sulfur complex fertilizers containing insecticides that fight disease-causing insects, along with phosphorus feed. The application of these phosphorus-sulfur fertilizers simultaneously provides the plants with nutrients and protects them from various diseases.

The material significance of phosphate minerals in the Central Kyzylkum basin began to be studied by scientists by 1960 s. Phosphate minerals in the Kyzylkum basin cover an area of 65.000 km². Only 10% of granular phosphorites with a total volume of 10 billion tons can be mined opencast. The Geroy, Sardara, Tashqura, Qaraqat, and Jetimtog deposits in the Kyzylkum basin have been studied almost completely. The Jeroy-Sardara phosphorite deposit, one of the largest deposits, has reserves of 2.9–3.0 billion tons. (550 million tons P_2O_5). Of this, phosphate mineral reserves with an average content of 19.42 % P_2O_5 estimated to 223.9 mln. tons (43.5 million tons P_2O_5). This phosphorite reserve can be the basis for the supply of phosphate fertilizers to agriculture of the republic for 62 years. The Kyzylkum phosphorite complex was also built around this deposit.

Phosphorite reserves of Tashkura deposit are estimated at 1.1 billion tons. (200–250 million tons P_2O_5). The reserves of the Karakat field are estimated at 600–650 million tons. P_2O_5 (3.0––3.5 billion tons ore). Of this, 55–60 mln. tons P_2O_5 (320 million tons of ore) is located at a depth of 60 m.

Two top layers of phosphorite 1–1.3 m in width across the horizon are of industrial importance. They are separated from each other by weak phosphated marl layers of 8–12 m. The amount of P_2O_5 in the phosphorite is 16–19% in the first layer and 21–23% in the second layer. The results of chemical and physicochemical analysis revealed that the composition of Kyzylkum phosphate raw materials consists mainly of the minerals fluorocarbonatapatite and calcite.

Petrographic data show that Sardara area phosphorites are composed of granular organogenic-koolithic residues. In the surface part of the Paleocene and Eocene Cretaceous mixed deposits, types of phosphorites such as granular (Africa), shell (Chilisoy) and sandstone (Florida) have been identified.

Ore phosphated grains and coolite phosphates, which are organic residues, are composed of cement carbonates with about 70% and small amounts of clay additives. The results of mineralogical studies have shown that the composition of granular phosphorite ores is similar to each other. It is composed of 10% to 90% phosphate minerals, the rest being calcite, montmorillonite, hydromica, polygorskite, hydrogenite, quartz, gypsum, glauconite, feldspar and halite minerals [3–10].

Non-phosphated minerals include calcite (20–50%), montimorillonite, hydromica and polygorskite, hydrogemit (0.1–15%), gypsum (5–10%), quartz (0.1–70%), glauconite (residues). feldspar (0.1–0.3%) and halites. Iron residues in minerals occur in the form of yellow sulfide, hydroxide up to 12%. Clay carbonated phosphates have higher iron content and higher carbonate phosphorites have lower iron content. The main part of magnesium is in montmorillonite, and a small amount is in dolomite.

Average mineralogical composition of ore deposits (heavy fraction%); francolite-56.0, calcite-26.5, quartz-7.5–8.0, hydraulic minerals and feldspar 4–5, gypsum-3–5, getite-1, zeolite 1.0, and organic components are about 0.5.

The phosphate mineral in donor phosphorite corresponds to carbonatophthorapatite, known in the literature as "kurskit". The average chemical composition of the phosphate mineral (%) is P_2O_5–32.10; CaO-48.37; CO_2–5.0; F-3.19; MgO-0.04; Al_2O_3–0.2; Fe_2O_3; Na_2O-0.10; K_2O-0.05; SO_3–0.08; SiO_2 is 0.05.

Currently, scientists are proposing to produce a variety of phosphate fertilizers that are

chemically activated by phosphorites and have a gradual effect. Activation of phosphorites with high carbonate content increases the contact surface of phosphate particles due to their decarbonization. As a result, phosphorite is converted into a plant-assimilating form. There is a growing need to implement an accelerated technology for the production of low-cost, highly agrochemically efficient fertilizers through chemical activation of low-quality and unenriched phosphorites. At the same time, the urgency of obtaining complex fertilizers using various mineral acids, mineral salts used in agriculture, i.e. mineral fertilizers, etc., increases.

Scientific studies of the processing of Kyzylkum phosphorites have shown that it has a high ability to undergo chemical reactions. This requires the need to obtain high-efficiency complex fertilizers with intensive technology without spending large activation energy to convert phosphate raw materials into plant-assimilating form.

Experimental

In order to develop a scientific basis for the production of new varieties of insecticidal phosphorus-sulfur fertilizers from local raw materials, the process of decomposition of enriched phosphorite flour and low-quality phosphorite samples with incomplete norms of sulfuric acid in the presence of sulfur was studied. In order to determine the optimal conditions for the decomposition process, a mixture of phosphorite and sulfur with a ratio of 1: 0.001–0.2 was studied using 75, 80 and 93% solutions of sulfuric acid and at a rate of 60–90%. The amount of sulfuric acid consumed was calculated relative to the formation of calcium dihydrogen phosphate and calcium sulfate by breaking down the phosphate and calcite minerals in the phosphorite samples. Laboratory experiments were performed as fol-

lows. Samples of phosphorite and sulfur mixtures are mixed with a solution of sulfuric acid simultaneously for 15–20 minutes. Since the interaction reaction of the components is exothermic, it was observed that the temperature is 70–120 °C and higher depending on the acid norm. The heat released is used to evaporate excess water in the system, leading to an improvement in the commercial properties of phosphorus-sulfur fertilizers. After the finished product was cooled and classified, its components were chemically analyzed using certain standard methods. In order to develop a scientific basis for the production of complex phosphorus-sulfur fertilizers, the process of processing phosphate raw materials in the presence of a suspension of sulfuric acid was studied.

75%, 80% and 93% solutions of sulfuric acid were used in the study. Sulfur suspensions of these concentrated acids were prepared under laboratory conditions. Increasing the acid concentration has a positive effect on the hydrophilization of sulfur. This is because the non-polar molecules of sulfur tend to form a hydrophilic form only in non-polar solvents. A decrease in the acid concentration leads to an increase in the mass fraction of water in the solution. Water is a polar molecule.

Under the action of sulfuric acid molecules, it oxidizes to form a suspension of sulfuric acid. Phosphorite samples were processed through this suspension.

Initially, on the basis of intensive technology, the process of decomposition of unenriched phosphorite flour with different standards of suspension containing 93% sulfuric acid solution with 3.5 and 7.5% sulfur was studied. Sulfuric acid was the norm in stoichiometry, which was used to break down phosphate and carbon-

ate minerals in phosphorite to form calcium dihydrogen phosphate and calcium sulfate. The process of processing phosphorite flour with sulfuric acid was carried out as follows. In the reactor, 0.1–0.3 kg of raw phosphorite was mixed continuously with the sulfuric acid suspension for 20–30 min. After cooling and classification of the obtained product, the various forms of P_2O_5 and total CaO, CO_3, moisture content were analyzed using certain standard methods.

Results and discussion

The results of the analysis showed that the activation of phosphorite, ie the decomposition coefficient, increases with increasing sulfur content in the processing of phosphate raw materials. For example, with a 1: 0.001 ratio of phosphorite and sulfur, 59.66% of the total P_2O_5 in the processed product with 93% sulfuric acid is converted into a plant-assimilating form, and 48.76% into a water-soluble form. Also, the 1: 0.01, 1: 0.05, and 1: 0.15 ratios of phosphorite and sulfur were compared to the 1: 0.001 ratio, respectively, while the plant-absorbing part was 1.02, 2.21, and 1.46 times, respectively, while the water-soluble form was 1.01, 1.03, and 1.12 times. This bond is maintained in both 70 and 80% solutions of sulfuric acid. However, the rate of decomposition of phosphorite flour with sulfuric acid in the presence of sulfur varies depending on the acid concentration, i.e., a decrease in the acid concentration leads to a decrease in its decomposition coefficient. For example, when a mixture of phosphorite and sulfur in a ratio of 1:0.01, 1:0.05 and 1:0.15 is processed at a rate of 60% of an 80% solution of sulfuric acid, the plant absorption fraction is 1, respectively, compared to a 93% solution of acid. 06, 1.12 and 1.19, while the water-soluble form decreased by 1.38, 1.35 and 1.39 times, respectively. In a 75% solution of

the acid, the plant assimilation form decreases by 1.08, 1.15 and 1.25 times, and the water-soluble part by 1.50, 1.46 and 1.48 times.

When phosphate raw materials are processed with sulfuric acid in the presence of sulfur, we see that the decomposition coefficient is 1.2––1.3 times higher when compared with the sulfuric acid.

The process of processing a sulfur mixture of low-quality phosphorites with sulfuric acid is practically no different from that of unenriched phosphorite flour, i.e. the above mechanism is preserved. For example, when a 1:0.05 ratio of phosphorite and sulfur is processed in a 93% sulfuric acid solution at 60, 70, and 80%, the decomposition rate of the raw material is 62.42%, 73.20%, and 77.84%, respectively 36.92%, 39.98% and 43.83% in aqueous solution. This enriched phosphorite showed that the absorbent P_2O_5 fraction was 1.07, 1.09, and 1.17 times lower, and the water-soluble form 1.36, 1.35, and 1.32 times lower, respectively. This is because the content of low-quality phosphorite is slightly higher than that of carbonates and the grain content varies.

At incomplete rates of sulfuric acid, a certain proportion of phosphate minerals remain undigested. Under the influence of acid molecules, the crystal lattices of phosphate minerals in the raw material undergo changes. Phosphates that do not decompose due to defects in the crystal lattice nodes of minerals are converted into plant-absorbing phosphates as a result of oxidation of sulfur to form a weakly acidic environment.

The obtained fertilizers contain phosphorus in the form of mono- and dicalcium phosphates, and sulfur in the form of SO_4^{2-} ions and elemental sulfur. These results are also confirmed by X-rays and dervatograms of the fertilizer obtained.

Under the influence of sulfuric sulfuric acid, the phosphate raw material decomposes quickly (in 5–10 minutes) and easily. The carbon dioxide and fluorine compounds released during decomposition accelerate the diffusion of phosphate particles with the hydrogen ions of the acid. Since the decomposition reaction is exothermic, it was observed that the temperature was 70–120 °C and higher depending on the sulfuric acid norm. The heat released is used to dry the sulfur superphosphate.

The results of the study are presented in Table 1. The results showed that the rate of decomposition of phosphorite minerals also increases as the rate of sulfuric acid used for phosphorite processing increases. For example, in the processing of unenriched phosphorite, the stoichiometric rate of acid changes from 60% to 100%, the plant absorption of total phosphorus in the product increases by 1.46 times, and the water-soluble part increases by 1.40 times.

Decomposition of unenriched phosphorite flour in different proportions of sulfuric acid suspension differs by the fact that the amount of sulfuric acid used in traditional classical methods is economical and has insecticidal properties as free sulfur in the composition of the resulting fertilizer. The product formed by the reaction of phosphorite with sulfuric sulfuric acid is always broken down into fine particles during the mixing process and is exposed to the phosphate raw material that is not involved in the reaction. At the same time, phosphate raw materials continue to be activated due to sulfur in the system.

The process of decomposition of phosphorite continues even after the fertilizer is applied directly to the soil, as a result of oxidation of sulfur in the soil under the influence of oxidizing microorganisms. Simultaneously with the phosphate mineral, the calcite in the raw material is also broken down. As the acid norm increases, so does its rate of decomposition. The sulfur in the product has a positive effect on the decomposition rate of phosphorite. During the interaction of the components, part of the sulfur is oxidized to acid and it actively participates in the decomposition of minerals. The sulfur in the new fertilizer becomes hydrophilic.

As a result of exposure of phosphorite to a 3.5% sulfuric acid suspension at a rate of 60%, 14.52% of the total P_2O_5 is converted to a plant-assimilated form. Also, at the 70 and 90% norms, the plant-assimilating P_2O_5 fraction increases 1.17 and 1.42 times, respectively, compared to the 60% norm. The product obtained from the decomposition of unenriched phosphorite flour in the presence of a suspension of 7.5% sulfuric acid, compared with a suspension of 3.5% sulfuric acid, the plant assimilation form of phosphorus in the raw phosphate averaged 1.02 times, and on average 1.25 times in the unused sample. showed that it is high.

The amount of water in the sulfuric acid used in the decomposition of phosphorite flour affects the granularity of phosphate fertilizers. The high amount of water in the suspension, ie the low acid concentration, complicates the process and the product is obtained with unsatisfactory brand properties. When enriched phosphorite is processed at 60–80% of sulfuric acid stoichiometry, a powdery product is obtained. Its content of grains with a size of 1–3 mm is 30–40%. Under the influence of 80–100% of sulfuric acid, a new phosphorus fertilizer with a size of –3 – + 2mm and –2 – + 1mm, with an average grain size of 70–90% is obtained.

Table 1.– Decomposition of unenriched phosphorite flour with a suspension of sulfuric acid

H_2SO_4 norm,%	Quantitative composition of P_2O_5,%			CO_2,%	$S_{total.,\%}$	$S_{el.,\%}$	$\dfrac{P_2O_5\ used.}{P_2O_5\ total}$	$\dfrac{P_2O_5\ used.}{P_2O_5\ total}$	H_2O,%	$K_{dekarb.}$,%
	general	assimilation	watery							
				3.5% sulfuric acid						
60	14.42	9.74	7.71	4.51	10.86	1.08	67.54	53.47	0.46	70.04
70	13.87	10.91	7.98	3.01	12.17	1.22	78.65	57.53	0.61	80.26
80	13.26	11.93	8.96	1.22	13.30	1.33	89.97	67.57	0.78	92.00
90	12.68	12.13	9.12	0.82	14.38	1.43	95.66	71.92	0.90	94.62
100	12.22	12.09	9.17	0.28	15.30	1.53	98.94	75.04	1.04	98.16
				7.5% sulfuric acid						
60	14.29	9.76	7.72	4.40	12.07	2.40	68.30	54.02	0.40	71.15
70	13.61	10.81	7.91	2.84	13.43	2.67	79.43	58.15	0.47	81.38
80	13.00	11.70	8.87	1.17	14.65	2.91	90.00	68.23	0.71	92.33
90	12.44	11.97	9.01	0.51	15.77	3.14	96.22	72.43	0.81	96.65
100	11.98	11.87	9.10	0.19	16.88	3.37	99.08	75.96	1.03	98.75

Table 2. – Physical and mechanical properties of phosphorus-sulfur fertilizer grains

$S_{el.}$,%	H_2O,%	Volumetric weight, g/sm³	Strength, MPa/sm²	Flowability, %	Natural angle of slope, °	Fluidity, s	Hygroscopic point,%
			3.5% sulfuric acid				
1.08	1.25	0.81	1.61	100	39	18.71	77
1.22	1.19	0.81	1.67	100	40	17.98	76
1.33	1.12	0.83	1.73	100	41	16.89	75
1.43	1.04	0.88	1.78	100	42	15.98	73
1.53	0.98	0.96	1.86	100	42	15.07	73
			7.5% sulfuric acid				
2.40	1.23	0.82	1.66	100	40	18.52	76
2.67	1.16	0.82	1.72	100	41	17.02	74
2.91	1.09	0.83	1.78	100	42	16.72	73
3.14	1.02	0.90	1.84	100	42	15.77	73
3.37	0.95	0.97	191	100	42	15.05	72

In order to further improve the physical-mechanical and commodity properties of sulfur-phosphate fertilizers, the process of granulation of them in the presence of a 40% solution of ammonium sulfate was studied. The new fertilizer obtained in a plate granulator was dried 2–3 mm grains and their properties were studied. Physico-mechanical properties of granulated phosphorus-sulfur fertilizers are given in (Table 2).

The possibility of intensive processing of new multifunctional complex fertilizer by processing enriched phosphorite flour with a suspension of sulfuric acid, the properties of the fertilizer fully meet the requirements for use in agriculture.

In subsequent studies, phosphorite samples were processed with a suspension of sulfur in acid at different rates in order to reduce the amount of sulfuric acid consumption. The consumption of sulfuric acid required for the decomposition of phosphorite was reduced from 100% to 60% of the norm. It was calculated that the bound sulfur in the sulfuric acid content was replaced by the corresponding elemental sulfur to cover the reduced acidity. A sulfuric acid suspension was prepared by mixing the sulfur calculated in the stoichiometric norm with concentrated sulfuric acid.

The chemical composition of the new variety of fertilizer, which was processed phosphorite with a suspension of sulfuric acid (H_2SO_4 + + S), was analyzed by analyzing the chemical composition, ie the amount of P_2O_5 in different states. Hydrophilicity of sulfur, degree of decarbonization of phosphorite and CaO were also determined. Incomplete decomposition of unenriched phosphorite flour with sulfuric acid has been shown to have no adverse effect on product quality when elemental sulfur is used instead of acid-bound sulfur. For example, when decomposed in the presence of sulfuric acid, 98.24% of the total P_2O_5 in the fertilizer content of 11.38% is converted into plant-assimilating and 72.95% into water-soluble P_2O_5

When 5%, 20% and 40% of the sulfuric acid bound sulfur is replaced by elemental sulfur, the amount of plant-absorbing P_2O_5 in the new variety of fertilizer is 1.01, 1.04 and 1.19 times, respectively, and the solubility in aqueous solution is 1.02, 1., Decreased by 10 and 1.39 times, respectively. This indicates that the decomposition coefficient values of the phosphate mineral have not changed dramatically. The sulfur in the resulting fertilizer is 100% hydrophilic.

In the process of obtaining low-quality phosphorite fertilizer processed with sulfuric acid, the bonds observed in the unenriched phosphorite flour are preserved. When the sulfuric acid content is reduced to 40%, 81.12% of the total P_2O_5 content of 11.12% is plant-assimilating and 47.87% is water-soluble.

The acid consumption is saved by 30–40% when the sulfur sulfate we propose is decomposed under the influence of an acid suspension. As a result of the addition of sulfur to the composition of complex phosphate fertilizers, the amount of nutrients increases and has an insecticidal effect.

Different rates of nitric acid and their decomposition process in the presence of sulfur were studied to obtain insecticidal complex fertilizers containing NPSCa nutrients from low-grade unenriched phosphorites [29–30].

The stoichiometric 20–60% content of 57% nitric acid for the decomposition of phosphorite samples was calculated relative to the formation of monocalcium phosphate and calcium nitrate salts from the decomposition of carbonate and phosphate minerals in the raw material.

In order to study the effect of sulfur on the decomposition of phosphorite samples in the

presence of nitric acid, phosphorite containing 10% sulfur was decomposed with nitric acid.

During the decomposition of phosphorite, the temperature varies in the range of 30–45 °C depending on the acid norm. The resulting complex fertilizer was dried at a temperature of 100––105 °C.

The results of the chemical analysis of the composition of the formed fertilizers show that the decomposition rate of low-grade phosphorites varies depending on the acid norm. For example: enriched phosphorite is broken down under the influence of 20–60% of nitric acid, 9.03–12.03% of the total P_2O_5 in NPSCa complex fertilizer is 28.44–77.19% in the form of plant assimilation. The decarbonization rate rises from 30.76% to 81.89%, respectively. When the obtained fertilizers are analyzed after drying, 10.78–12.92% of the total P_2O_5 is 29.80–80.06% in plant assimilation form. It also contains 2.67–– 6.90% nitrogen, 30.06–35.58% calcium oxide, 6.43–8.10% elemental sulfur, 1.34–2.11% water.

Also, the conversion of sulfuric acid to sulfuric acid in NPSSa complex fertilizer decomposed into a sample containing 10% sulfur of unenriched phosphorite flour with a range of 20% to 60% of nitric acid increases with increasing acidity. For example: 10.15% of the total 8.94% of total sulfur is converted to sulfuric acid at a rate of 20%. When the nitric acid norm is 30 and 50%, the rate of conversion of sulfur to sulfuric acid is 1.24 and 1.32 times higher than the 20% norm, respectively. The sulfur remaining in the elemental state in the fertilizer is in a completely hydrophilic form.

The decomposition process of low-quality phosphorites in the presence of sulfur with nitric acid is practically no different from that of non-enriched phosphorites. The decomposition coef-

ficient of low-quality phosphorite is 1.33 times lower than that of unenriched phosphorite.

This difference can be explained by the fact that the granular composition of low-quality phosphorite is different.

Nitric acid is not only a source of chemical energy for the decomposition of phosphate minerals in the raw material, but also participates in the process of mutual oxidation-reduction of components in the system (phosphorite, sulfur, nitric acid, moisture, etc.). Under these conditions, elemental sulfur is oxidized from S^0 to S^{+4} (S^{+6}) and converted to sulfite and sulfuric acid in the system. When phosphorites are processed with nitric acid in the presence of sulfur, the decomposition coefficient is 1.45 times higher than that of nitric acid. The change in this indicator can be expressed as follows.

During processing, the undigested part of the phosphorites continues to be activated by the weak acidic environment formed in the crystal lattice system. The product contains salts of calcium hydrophosphate and calcium sulfate. Additional SO_4^{2-} ions in the reaction products begin to form in the form of gypsum.

Commodity properties of products obtained from more than 40% of acid standards do not meet agricultural requirements.

Unenriched phosphorite flour is 19.118% of the total P_2O_5 in the complex fertilizer composition processed under the influence of 20% norm of 57% nitric acid in the form of plant assimilator P_2O_5. The decarbonization rate of phosphorite flour is 22.62%.

The process of processing sulfur phosphorite with nitric acid also occurs rapidly. Scientific studies have shown that as the amount of sulfur in phosphorite increases, so does the rate of decomposition of the raw material. For example,

the decomposition rate of phosphorite containing 1% sulfur is 1.04 times that of a sample treated with 20% nitric acid, and the degree of decarbonization is We observe an increase of 1.06 times. During the decomposition of phosphorite flour, an increase in sulfur content of 5, 10 and 30% was observed to increase the nutrient value of assimilated phosphorus in NPSCa fertilizers by 1.25, 1.39 and 1.54 times, respectively.

When the content of sulfur in the content of unenriched phosphorite flour is from 1% to 30%, when processed at the rate of 30% of nitric acid, 9.34–12.04% of the total P_2O_5 is 37.69–60.17% in the form of plant assimilation. When 40% of nitric acid is used in this process, 8.70–11.08% of the total P_2O_5 is in the plant-assimilated form of 47.36–65.40%.

After the product dries, these values increase 1.12–1.30 times due to water loss. The increase in the decomposition rate of unenriched phos-

phorite flour in the presence of sulfur can be explained by an increase in the value of SO_3 in the obtained fertilizers (Fig. 1). For example, when a phosphorite sample is processed at 30% nitric acid without sulfur, it contains 1.65% SO_3, and when treated with 5 and 10% sulfur, its value is 3.85 and 5.32%, respectively.

Based on the results of the study, it was proved that it is possible to process enriched phosphorite flour in the presence of sulfur in an incomplete amount of nitric acid using an intensive method to obtain complex fertilizers containing multifunctional NPSCa.

A number of physical and mechanical properties of phosphorus-sulfur fertilizers were studied, including hygroscopicity, granular composition, grain strength, natural slope angle, bulk density, salinity and moisture content. Because these properties are associated with the efficiency of their storage, transportation, use in agriculture.
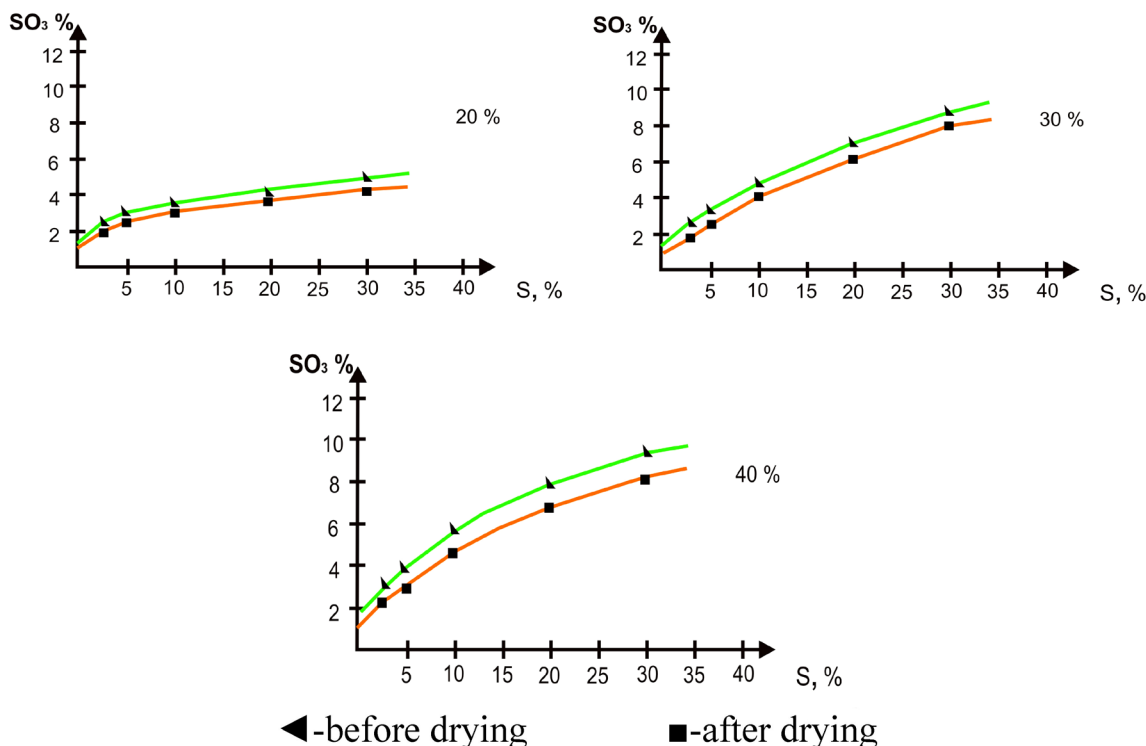
Figure 1. Formation of SO_3 in the decomposition of nitric acid in the presence of sulfur in enriched phosphorite flour with norms of 20, 30 and 40%

After the product dries, these values increase 1.12–1.30 times due to water loss. The increase in the decomposition rate of unenriched phosphorite flour in the presence of sulfur can be explained by an increase in the value of SO_3 in the obtained fertilizers (Fig. 1). For example, when a phosphorite sample is processed at 30% nitric acid without sulfur, it contains 1.65% SO_3, and when treated with 5 and 10% sulfur, its value is 3.85 and 5.32%, respectively.

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To determine the viscosity of phosphorus-sulfur and nitrogen-phosphorus-sulfur fertilizers, specific mass fertilizer samples are placed in special cylinders and stored under loaded mass for twenty-four hours. The product is slowly pushed out of the cylinder and inspected under the force required to spray it. Studies have shown that under the conditions studied, not all fertilizer samples are sticky, i.e., friable.

It is important that the product is sufficiently crumbly and granular to achieve full utilization of the necessary nutrient components of the plant. The granularity of fertilizers leads to an increase in the agrochemical efficiency of agricultural crops.

The granular composition of the obtained insecticidal phosphorus-sulfur fertilizers was determined. The data obtained are presented in Table 3. The results show that the small-sized fractions in the fertilizer samples do not exceed 15%.

Table 3. – Granular composition of fertilizer samples

Fertilizer samples	Amount of fractions mm, weight%				
	−5 +3	−3 +2	−2 +1	−1 +0.5	0.5 >
1	*2*	*3*	*4*	*5*	*6*
Unriched phosphorite flour					
PS fertilizer $P_2O_{5tot.}$ – 16.32%, $S_{tot.}$ – 10%	4.07	22.10	24.31	38.45	11.07
PS fertilizer $P_2O_{5tot.}$ – 13.27%, $S_{el.}$ – 2.60%	15.12	18.42	31.25	29.18	6.03
PS fertilizer $P_2O_{5tot.}$ – 12.54%, $S_{el.}$ – 2.68%	13.11	30.02	27.03	24.53	5.31
NPS fertilizer N – 4.19%, $P_2O_{5tot.}$ – 13.04%, $S_{el.}$ – 3.73%	14.86	19.23	38.61	24.95	2.35
Low quality phosphorites					
PS fertilizer $P_2O_{5 tot.}$ – 14.22%, $S_{tot.}$ – 10%	5.18	20.44	23.00	38.75	12.63
PS fertilizer $P_2O_{5 tot.}$ – 10.60%, $S_{el.}$ – 2.79%	16.27	17.26	28.19	30.98	7.93

1	2	3	4	5	6
PS fertilizer $P_{2}O_{5\,tot.}$ – 11.12%, $S_{el.}$ – 2.82%	15.42	26.31	26.01	25.15	7.11
NPS fertilizer N – 3.67%, $P_{2}O_{5\,tot.}$ – 12.14%, $S_{el.}$ – 4.41%	16.17	18.92	37.77	22.54	4.96

The moisture absorption rate of fertilizers and their hygroscopicity were determined under conditions of relative humidity of 50, 85 and 100% in desiccators. The moisture absorption kinetics curves of fertilizers obtained in the presence of sulfuric acid and sulfur are practically the same. The process of moisture absorption of the product takes place on average 1–1.5 days and its value is 1.5–2.5%.

Fertilizers obtained in the presence of nitric acid and sulfur, the equilibrium in the relative humidity of the studied air takes place in an average of 10–12 days, and their value is 20–25%. PS fertilizers obtained in the presence of sulfuric acid and sulfur are not hygroscopic. Even if they are stored for a long time in different seasonal conditions, they do not lose their brand properties. The complex fertilizer with PSN obtained in the presence of nitric acid and sulfur attracts more moisture due to the formation of calcium nitrate, ie it is hygroscopic. It is therefore recommended to store them in special inner polyethylene-lined bags.

Based on the research, the composition of phosphorite samples was calculated from the basic salts in complex fertilizers with insecticidal properties, processed in the presence of sulfuric, nitric acids and sulfur. These values, calculated on the basis of chemical analyzes, are given in Tables 4–6.

Table 4. – Amount of salts in phosphorus-sulfur fertilizers obtained using incomplete norms of sulfuric and sulfuric acids,%

Salts	Total	Components			
		$P_{2}O_{5}$	CaO	SO_{3}	CO_{2}
$Ca_{5}(PO_{4})_{3}F$	6.88	3.54	3.72	–	–
$Ca(H_{2}PO_{4})_{2}$	11.09	6.73	2.66	–	–
$CaHPO_{4}$	4.77	2.49	1.79	–	–
$CaCO_{3}$	10.05	–	5.63	–	4.42
$CaSO_{4}$	48.27	–	19.88	28.39	–
S	5.55	–	–	–	–
Additional substances	13.19	–	–	–	–
Total	100	12.76	33.86	28.39	4.42

Table 5. – Amount of salts in phosphorus-sulfur fertilizers obtained by suspension of sulfuric acid,%

Salts	Total	Components			
		$P_{2}O_{5}$	CaO	SO_{3}	CO_{2}
1	2	3	4	5	6
$Ca_{5}(PO_{4})_{3}F$	4.30	2.21	2.33	–	–
$Ca(H_{2}PO_{4})_{2}$	10.85	5.58	2.60	–	–

1	2	3	4	5	6
CaHPO$_4$	7.12	3.74	2.93	–	–
CaCO$_3$	6.05	–	2.39	–	2.66
CaSO$_4$	46.43	–	19.12	27.31	–
S	4.08	–	–	–	–
Additional substances	21.17	–	–	–	–
Total	100	12.54	30.37	27.31	2.66

Table 6. – Amount of salts in NPS fertilizers obtained using incomplete norms of sulfuric and nitric acid, %

Salts	Total	Components				
		P$_2$O$_5$	N	CaO	SO$_3$	CO$_2$
Ca$_5$(PO$_4$)$_3$F	12.48	6.42	–	6.67	–	–
Ca(H$_2$PO$_4$)$_2$	–	–	–	–	–	–
CaHPO$_4$	10.06	6.10	–	4.15	–	–
CaCO$_3$	12.68	–	–	10.10	–	5.58
CaSO$_4$	8.54	–	–	3.52	5.02	–
Ca(NO$_3$)$_2$	23.55	–	4.02	8.04		–
S	7.58	–	–	–	–	–
Additional substances	25.41	–	–	–	–	–
Total	100	12.52	4.02	37.20	5.02	5.58

Calculations showed that the main part of the fertilizer consists of calcium dihydrogen phosphate, calcium hydrophosphate and sulfur, which is not fully involved in the reaction, as well as phosphate minerals that have been activated.

Unprocessed phosphorite flour was processed with incomplete sulfuric or nitric acid in the presence of sulfur, and a technological system for the production of new insecticidal phosphorus-sulfur and nitrogen-phosphorus-sulfur complex fertilizers was developed.

These technological processes consist of the following stages:

- Department of reception, storage and transfer of phosphorite and sulfur raw materials;
- Department of reception, storage and transmission of mineral acids (sulfur, nitrate);
- Phosphorite decomposition, granulation and drying department;
- Department of preparation of binder solutions for granulation of the finished product;
- Department of dust and gaseous waste storage and treatment;
- Department of transportation, storage and packaging of finished products.

The main components of the new sulfur phosphorus fertilizer are mono- and dicalcium phosphates, various hydrated calcium sulfates and undigested active phosphorite.

The peaks in the distances between the planes are calcium sulphates in the d, Å 2.48, 2.18, 1.51, 2.06 CaSO$_4$, CaSO$_4 \cdot$ 0.5H$_2$O states, d, Å 1.97, 1.87, 1.85, 1.81, 1.79 CaHPO$_4 \cdot$ 2H$_2$O, d, Å 2.25, 1.65. containing dicalcium phosphates and d, va 1.76, 1.59, 1.51 Ca(H$_2$PO$_4$)$_2$, d, Å 3.38, 3.01, 2.74, 2.58, 1.58 Ca(H$_2$PO$_4$)$_2 \cdot$ H$_2$O were found to be suitable for monocalcium phosphates. Other diffraction lines in the product represent unaffected active phosphorite particles.

The above-mentioned correlations remain even when the product samples are analyzed after drying. During the drying period, we observe that the decomposition rate of phosphorite increased by 1.02–1.06 times. The resulting fertilizer contains 3–4% N in the form of calcium nitrate, 10–13% P_2O_5 – calcium hydrophosphate and activated phosphorite, 1–24% elemental C, 25–35% Ca O.
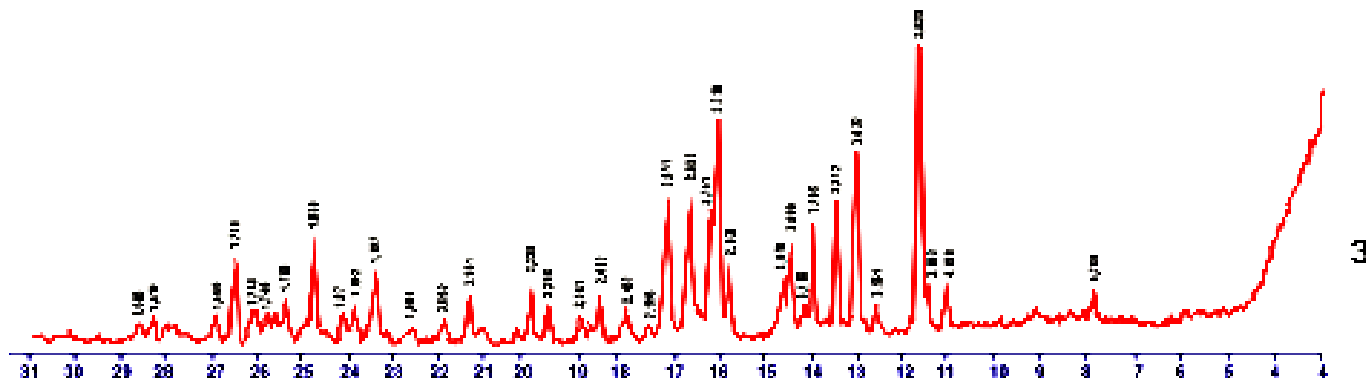

Figure 2. Powder X-ray diffraction pattern of complex NPSCa fertilizer

Conclusions

It was studied that low-grade Kyzylkum phosphorites can be processed in a short time with incomplete norms of sulfuric and nitric acids in the presence of sulfur to obtain complex phosphorus-sulfur and nitrogen-phosphorus-sulfur fertilizers with insecticidal properties necessary for agriculture.

Processing of phosphorite in the presence of sulfur with incomplete norms of sulfuric acid solution was carried out in a short time, for 15––25 minutes. Since the decomposition reaction is exothermic, it was observed that the temperature was 110–120 °C and higher depending on the sulfuric acid norm. The amount of heat released is used to evaporate excess water in the system, leading to an improvement in the commercial properties of phosphorus-sulfur fertilizers.

Sulfur is normally in the form of a ring with a stable S_8 content. At room temperature, as well as as a result of interaction with phosphate minerals, it forms relatively active forms containing S_2, S_3, S_4, S_5 and participates in the decomposition of phosphorite.

The amount of sulfuric acid used in the decomposition process is saved by 30–40% by replacing the amount of sulfur in elemental sulfur. An increase in the plant assimilation form of phosphorus in phosphorite samples was observed with increasing sulfur content. The obtained fertilizers contain phosphate minerals in the form of mono- and dicalcium phosphate, and sulfur in the form of SO_4^{2-} -ions and elements. The sulfur in the fertilizer was found to be in a completely hydrophilic form. These data were also confirmed by X-ray and dervatogram analyzes of the new variety of fertilizer. It was found that the decomposition coefficient of phosphorite samples when treated with sulfuric acid in the presence of sulfur is 1.2–1.3 times higher than the decomposition coefficient without the presence of sulfur (with sulfuric acid itself).

The decomposition process was also carried out in the presence of a suspension of sulfuric acid. The preparation of the suspension was carried out in the presence of 75, 80 and 93% solutions of sulfuric acid. As the acid concentration decreases, it becomes more difficult for the sulfur

to form a suspension. This is because non-polar molecules of sulfur tend to soak only in non-polar solvents. A decrease in the acid concentration leads to an increase in the mass fraction of water in the solution. Water is a polar molecule.

When the amount of sulfur required for the decomposition of phosphorite is the same, it is practically indistinguishable from the process of decomposition of phosphorite with sulfuric acid suspension, in the presence of phosphorite and sulfuric acid.

Different rates of nitric acid and their decomposition process in the presence of sulfur were studied to obtain insecticidal complex fertilizers containing NPSCa nutrients from low-grade unenriched phosphorites. When phosphorites are processed with nitric acid in the presence of sulfur, the decomposition coefficient is 1.45 times higher than that of a product decomposed without the presence of sulfur.

The change in this indicator can be expressed as follows: the degree of decomposition of unenriched phosphorite flour can be explained by an increase in the amount of SO_3 in the fertilizer obtained in the presence of sulfur. For example, when a phosphorite sample is processed at 30% nitric acid without sulfur, it contains 1.65% SO_3. When phosphorite is treated with nitric acid by adding 5 and 10% of sulfur, its content is 3.85 and 5.32%, respectively. Nitric acid is not only a source of chemical energy for the decomposition of phosphate minerals in the raw material, but also participates in the process of mutual oxidation-reduction of components in the system (phosphorite, sulfur, nitric acid, moisture, etc.). Under these conditions, the elemental sulfur S^0 is oxidized from the oxidation state to S^{+4} (S^{+6}) and converted into sulfite and sulfuric acid in the system.

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CONSTRUCTION OF A KINETIC MODEL FOR THE OXIDATION OF C$_3$-C$_4$-ALDEHYDES ON HETEROPOLY COMPOUNDS

Abstract. The kinetic regularities of oxidation of unsaturated aldehydes acrolein and methacrolein into corresponding acids have been studied on modified phosphormolybdenum heteropoly acid catalysts. It was found that methacrylic acid is formed according to the sequential scheme, and deep oxidation products according to the parallel-sequential scheme. The analysis of experimental data shows that the acetic acid yield on heteropolyacetic acid catalysts is high enough and can reach 30%. Therefore, it is incorrect to neglect the route of acetic acid formation when assessing the kinetics of the process. Differential equations were made to process the experimental data on the kinetics of aldehyde oxidation. The developed kinetic model can be used to model the reaction apparatus.

Keywords: kinetics, heteropolyacids, acrolein, methacrolein, acrylic, and methacrylic acid.

There are almost no data in the literature on the kinetics of acrolein or methacrolein oxidation on hetero compounds. For example, [1] provides only brutto-equations for the rate of formation of methacrylic acid (MAA) and the rate of consumption of methacrolein (MACR).
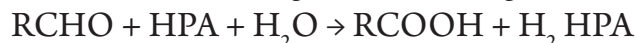
$$-\frac{d[MA]}{dt} = K_1 P_{MACR}^{0,6-1} \times P_{O_2}^{0-0,2} P_{H_2O}^{0} \quad P_{O_2}^{0-0,2} P_{H_2O}^{0}$$

$$\frac{d[MAK]}{d\tau} = K_2 P_{MACR}^{0,5-1} \times P_{O_2}^{0,1-0,2} P_{H_2O}^{0'}$$

In [2], it is pointing out that the reaction proceeds by the redox mechanism through the following stages:

$$RCHO + HPA + H_2O \rightarrow RCOOH + H_2 HPA$$
$$H_2 HPA + \tfrac{1}{2} O_2 \rightarrow HPA + H_2O$$

where HPA – heteropoly acid.
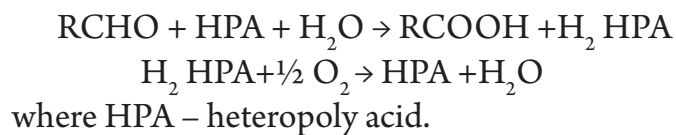
It follows from the following kinetic equations that the next stage is the limiting one:

$$RCHO + HPA + H_2O \rightarrow RCOOH + H_2 HPA$$

As can be seen from the equations, the rate of methacrylic acid formation and methacrolein consumption weakly depend on oxygen concentration, the order of methacrolein changes from 1 to 0,5, and this agrees with our experimental data.

In [3], some kinetic regularities of the oxidation of methacrolein into methacrylic acid on a modified phosphoromolybdenum catalyst are

also given. The research work shows that the conversion of methacrolein increases markedly with increasing temperature and does not depend on the initial concentration of methacrolein in the contact time interval studied, and this is also following the results of our studies.

An analysis of the literature data showed different points of view on the mechanism of acetic acid formation. In [4], it is shown that the afterburning of methacrylic acid leads to the formation of the same products as in the case of heteropoly acid catalyst. However, this conclusion is based on kinetic data, but there are no experiments on the direct attainment of methacrylic acid in this work.

To determine the mechanism of acetic acid formation during the oxidation of methacrolein into methacrylic acid, the authors of [2] performed a qualitative experiment on a modified phosphoromolybdenum heteropoly acid catalyst to transform methacrolein in an empty reactor.

It turned out that methacrolein is pre-oxidized in the presence of air at $t = 330$ °C into acetic acid, acrylic acid, and carbon oxides. The same products are formed during the pre-oxidation of methacrylic acid.

Thus, according to the authors [2], sequential products of deep oxidation form methacrylic acid by a parallel-sequential scheme. The yield of acetic acid formed during the oxidation of methacrolein in the desired temperature range was < 5%. Therefore, specially staged schemes of acetic acid formation in work [3] are not reflected.

Based on the data on the oxidation of methylacrolein and afterburning of methacrylic acid, as well as on the dependence of the selectivity of methacrylic acid formation on the degree of aldehyde transformation, the general scheme of the methacrolein oxidation process appears as follows:

$$MACR \rightarrow MAA \ AAC$$
$$MACR \rightarrow CO_1 CO_2, \ AAC$$
$$MAA \rightarrow CO_1 \ CO_2, \ AAC$$
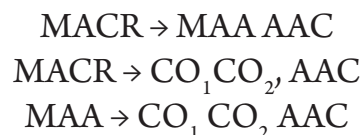
Analysis of the kinetic data allows us to show that the following equations describe the process rates for routes 1–3:

$$R_1 = \frac{K_1 P_{MACR} \ P_{O_2}}{\left(1 + \alpha \ P_{O_2}\right)}$$

$$R_2 = \frac{K_2 P_{MACR} \ P_{O_2}}{\left(1 + \alpha \ P_{O_2}\right)}$$

$$R_3 = \frac{K_3 P_{MACR} \ P_{O_2}}{\left(1 + \alpha \ P_{O_2}\right)}$$

Expressions for the rate of consumption of methacrolein (W_{MACR}), the rate of formation of methacrylic acid (W_{MAA}), and the rate of formation of deep oxidation products (W_{PDO}) in excess oxygen are as follows:
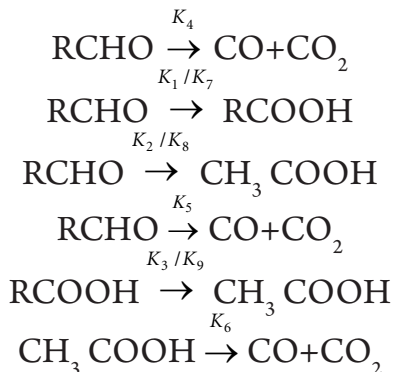
$$W_{MACR} = \left(K_1 + K_2\right) P_{MACR}$$
$$W_{MAA} = K_1 \ P_{MACR} - K_3 \ P_{MAA}$$
$$W_{PDO} = K_2 \ P_{MACR} + K_3 \ P_{MAA}$$

The values of constants $K_1 - K_2$ were determined from experimental data as the angular coefficients of the corresponding linear anamorphoses W_{MAA} from P_{MACR} and W_{MACR} from P_{MAA} at different temperatures. The values of the constants (C^{-1}), also determined by the experiment, were equal:

$$K_1 = 5.8 \cdot 10^7 \ EXP \ (-22000/RT)$$
$$K_2 = 1.4 \cdot 10^5 \ EXP \ (-18000/RT)$$
$$K_3 = 8.0 \cdot 10^{13} \ EXP \ (-40000/RT)$$

Analysis of experimental data [4] shows that the yield of acetic acid on heteropoly acid catalysts is high enough and can be up to 30%. Therefore, it is incorrect to neglect the route of acetic acid formation when assessing the kinetics of the process. In this connection, it becomes evident that a parallel-sequential scheme can describe the set of reactions occurring during the oxida-

tion of methacrolein on modified heteropolyacid catalysts.

$$RCHO \xrightarrow{K_4} CO + CO_2$$

$$RCHO \xrightarrow{K_1/K_7} RCOOH$$

$$RCHO \xrightarrow{K_2/K_8} CH_3COOH$$

$$RCHO \xrightarrow{K_5} CO + CO_2$$

$$RCOOH \xrightarrow{K_3/K_9} CH_3COOH$$

$$CH_3COOH \xrightarrow{K_6} CO + CO_2$$

Based on the above, the following differential equations were made to process the experimental data on the kinetics of aldehyde oxidation:

$$\frac{dP_{AAD}}{d\tau} = -\frac{K_1P_{AAD}}{1+K_7P_{acid}} - \frac{K_2P_{AAD}}{1+K_8P_{AAc}} - K_4P_{AAD}.$$

$$\frac{dP_{acid}}{d\tau} = \frac{K_1P_{AAD}}{1+K_7P_{acid}} - \frac{K_3P_{acid}}{1+K_9P_{AAc}} - K_5P_{acid}.$$

$$\frac{dP_{AAC}}{d\tau} = \frac{K_2P_{AAD}}{1+K_8P_{AAC}} + \frac{K_3P_{acid}}{1+K_9P_{AAC}} - K_6P_{AAC}.$$

Initial conditions:

With $\tau = 0$ $P_{AAD}(0) = P^0_{AAD}$, $P_{acid}(0) = P^0_{acid}$ и $P_{AAC}(0) = P^0_{AAC}$

An optimization criterion of the species was formulated to determine the kinetic parameters of $K_1 - K_9$:

$$F = \sum_{i=1}^{M} \cdot \sum_{j=1}^{N} \left(\frac{P^E_{ij} - P^C_{ij}}{P^E_{ij}} \right)^2$$

where E – experimental, C – calculated and constraints on the kinetic parameters in the form of $K_{oi} > 0$

$$a_i \le E_i \le C_i$$

where K_i – the rate constant of chemical reactions, $i = 1.9$,

E_i – activation energy,

K_{oi} – pre-exponential factor,

a_i and c_i – respectively lower and upper limits of changes in the activation energies,

P^E_{ij} – experimental process data,

P^C_{ij} – accounting data,

M and N – number of temperatures and experimental points.

The system and initial conditions together constitute the Cauchy problem for the first order ordinary differential equations. The problem was solved by the Runge-Kutta-Merson method with automatic selection of the integration step. The optimization criterion $a_i \le F_i \le C_i$ is an additive function that depends on the input and output variables of the states and the kinetic parameters of the process.

To determine the kinetic parameters $K_1 - K_9$, the following problem of optimization conditions was set: it is required to find such equations K_{oi}, $F_i (i = \overline{1,9})$, that satisfy the constraints $a_i \le F_i \le C_i$, at which the target function F takes a minimum value.

We used the sliding acceptance and Powell methods to determine the kinetic parameters. These methods are optimization methods based on a direct comparison of function values at neighboring points.

Calculated isotherms, compared with experimental data, showed that there is a good correspondence between them.

Based on the above, the following conclusions can be made: the developed kinetic model can be the basis for modeling the reaction apparatus.

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HYBRID DISTRIBUTED ENERGY GENERATION SYSTEM

Abstract. The paper considers the issue related to the uninterrupted supply of electric energy generated by a hybrid energy wind turbine (HEWT) of the consumer. At the same time, a solution to the problem arising during the operation of the HEWT is proposed. One of such problems is the dependence of the functioning of the HEWT on weather conditions. The paper indicates that gas turbine engines (GTE) can be used very effectively to solve this problem. It is assumed that in this way it is possible to continuously provide, regardless of weather conditions, consumers of hard-to-reach regions, not only with electric energy, but also with thermal energy. Biogas obtained from agricultural, crop and livestock waste is offered as fuel for the operation of the gas turbine engine.

The efficiency of the proposed power system is particularly emphasized, not only in the production of heat and electricity, but also its usefulness for land farms, especially for greenhouses. Since the resulting biohumus soil, which is a waste obtained by burning agricultural, crop and livestock waste, has the property of increasing yields.

Keywords: Hybrid power system, gas turbine engine, renewable energy sources, system operation, thermal energy, electric energy, remote regions, biohumus soil.

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ГИБРИДНАЯ СИСТЕМА РАСПРЕДЕЛЕННОЙ ГЕНЕРАЦИИ ЭНЕРГИИ

Аннотация. В работе рассматривается вопрос связанный с бесперебойным обеспечением электрической энергией, вырабатывающийся гибридной энергетической ветроустановкой (ГВЭУ) потребителя. При этом предлагается решение проблемы возникающей при эксплуатации ГВЭУ. Одна из таких проблем: зависимость функционирования ГВЭУ от погодных условий. В работе указывается, что для решения этой проблемы очень эффективно можно использовать газотурбинные двигатели (ГТД). Предполагается, что тем самым можно бесперебойно обеспечить, вне зависимости от погодных условий, потребителей труднодоступных регионов, не только электрической энергией, но и тепловой энергией. Топливом для работы ГТД предлагается биогаз, получаемой из сельскохозяйственных, растениеводческих и животноводческих отходов.

Особенно подчеркивается эффективность работы предлагаемой энергосистемы не только при выработке тепловой и электрической энергии, но и полезность для земельных хозяйств, особенно для тепличного хозяйства. Так как получаемый биогумусный грунт, являющийся отходом, получаемый при сжигания сельскохозяйственных, растениеводческих и животноводческих отходов, имеет свойство повышать урожайность.

Ключевые слова: Гибридная энергосистема, газотурбинный двигатель, возобновляемые источники энергии, эксплуатация системы, тепловая энергия, электрическая энергия, отдаленные регионы, биогумусный грунт.

Введение. В последнее время системы гибридного энергоснабжения потребителей становятся весьма популярным. Они предусматривают использования различных возобновляемых источников энергии (ВИЭ). Электрическая энергия генерируемая с использованием солнечных фотоэлектрических панелей, ветряных турбин и генерирование тепловой энергии для систем отопления, горячего водоснабжения и технологических процессов осуществляемые с использованием солнечных коллекторов (плоских и фрактальных), геотермальных систем, а также других преобразователей тепловой энергии сильно зависит от погодных условий. Для устранения такой уязвимости устройств работающих на базе

ВИЭ в работе [1; 2] предлагается концепция по созданию гибридных энергосистем, не зависящих от погодных условий. Суть этой концепции заключатся в следующем: *конъюгация различных устройств работающих на базе ВИЭ.* Это не только наличие таких элементов, как солнечные коллекторы, фотоэлектрические панели, ветровые турбины, но и использование единой системы управления для обеспечения эффективной совместной работы этих элементов, что составляет основу более стабильной гибридной системы энергоснабжения.

В последние годы темпы развития высоких технологий значительно повысились. Возобновляемые источники энергии (ВИЭ) стали центром внимания энергетиков, физиков, ученых и политиков. В связи с этим начались усиленные разработки технологии использования ВИЭ для генерации различных типов энергии. Для покрытия энергетических нужд географически отдаленных регионов, от больших городов требует широкомасштабное внедрение в эту сферу устройств работающих на базе альтернативных источников энергии. Так как, на эти регионы нецелесообразно, а иногда невозможно, провести различные типы линии энергопередач, то оптимальным видом для обеспечения энергоснабжения этих регионов, является использование для этой цели гибридных энергосистем использующих энергию солнца, ветер и биотопливо. Но здесь появляются трудности в технологии использования этих ВИЭ. Эти трудности связаны с погодными условиями. Если погода пасмурная, неэффективно использовать солнечные панели, а если не ветренная погода, то не эффективно использовать ветрогенераторы и т.д. Такая ситуация наводит на мысль создания модульно гибридной энергосистемы, дающее

одновременно электрические и другие виды энергии, независимо от погодных условий. Проектировании таких систем на сегодняшний день является очень актуальна.

Методика эксперимента

Цель данная работы является разработка конструкции и принципы работы гибридной энергосистемы, работающие на базе альтернативных источников независящей от погодных условий.

Метод решение системы распределенной генерации энергии (СРГЭ) это гибридная система энергоснабжения, объеденённая из различных источников энергии, которые построены непосредственно в близости от потребителей и в максимально возможной степени учитывают их индивидуальные особенности с точки зрения мощности и профиля. Рост доли распределенной генерации в энергосистемах не только имеет положительные стороны, но и создают определенные технические проблемы, связанные с изменениями свойств систем, их возможности непрерывной работы при нормальных и аварийных условиях.

Основной отличительной чертой предлагаемой СРГЭ является стохастический характер параметров источника первичной энергии, поэтому энергия, генерируемая из этих источников, создает новые проблемы у потребителей. Задачей современных энергетических систем является бесперебойное обеспечения электрической и тепловой энергией потребителя. Большинство автономных энергетических систем, работающих на базе ВИЭ, обеспечивают возможности расширения их функциональности и наращивания потенциала путем новых источников генерации. Это ситуация объясняется главным образом, тем, что параметры получаемой энергии, гене-

рируемые источником возобновляемой энергии, существенно различаются по основным техническим показателям, таким как тип тока, частота, и величина выходного напряжения и сильно зависят от погодных условий.

В работе предлагается один из таких СРГЭ работающий в конъюгации с газотурбинным двигателем (ГТД) и гибридной ветро энергетической установкой (ГВЭУ), работающие на базе альтернативных источников энергии. Такая энергосистема бесперебойно обеспечивает электрической и тепловой энергией потребителя вне зависимости от погодных условий. Ниже опишем эту систему, состоящую из двух частей.

Первая часть. Как мы знаем, что принцип работы ГТД основан на сжигании топлива в виде смеси газа и воздуха. В следующих работах подробно описаны принцип работы ГТД [3–5].

Газотурбинный двигатель (ГТД) – тепловой двигатель, в котором газ сжимается и нагревается, а затем энергия сжатого и нагретого газа преобразуется в механическую работу на валу газовой турбины. В результате в камере сгорания рождаются силы, создающие крутящей момент для вала, расположенного в камере сгорания, и выбрасывается огромное количество тепловой энергии.

На базе этой конструкции можно построить гибридную энергосистему, которая бы вырабатывала электрическую и тепловую энергии.

В отличие от поршневого двигателя, в ГТД процессы происходят в потоке движущегося газа. Сжатый атмосферный воздух из компрессора поступает в камеру сгорания, куда также подаётся топливо (биогаз), которое, сгорая, образует большое количество газообразных продуктов сгорания под высоким давлением. Затем в газовой турбине энергия давления продуктов сгорания преобразуется в механическую работу за счёт вращения лопаток, часть которой расходуется на сжатие воздуха в компрессоре. Остальная часть работы передаётся на приводимый агрегат. Работа, потребляемая энергия этим агрегатом, и считается полезной работой двигателя [6]. Здесь возникает задача связанная обеспечением ГТД биогазом, играющий роль топливы.

Технология получения биогаза осуществляется следующим образом.

Извлечение из биомассы энергоносителей, как биогаз получают из отходов растениеводства или животноводства. Одна из возможной установки получения биогаза показан на (рис. 1).
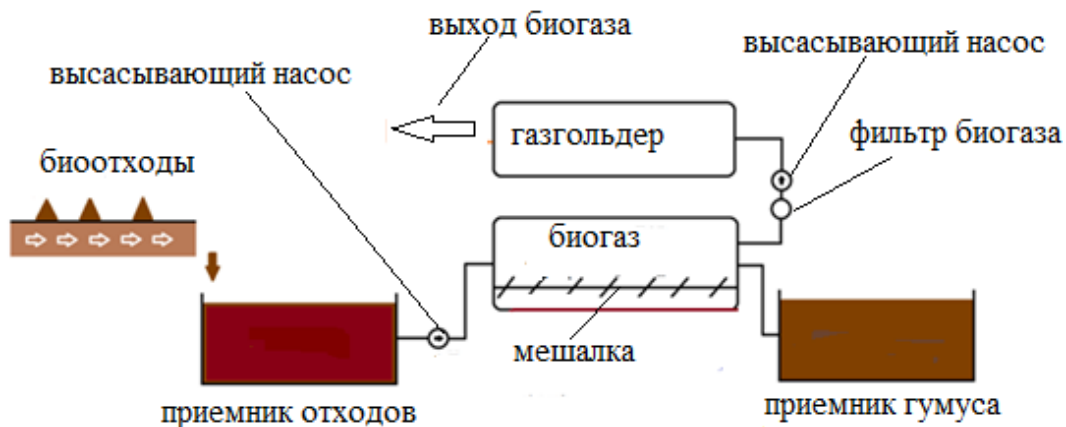

Рисунок 1. Принципиальная схема устройство получения биогаза

Эта установка работает следующим образом [6]. Получаем биологический газ, получаемый из биоотходов (навоз, опилки и т.п.). Биоотходы через приемник отходов всасываются в биореактор для получения биогаза с помощью брызжения. Полученный биогаз с помощью мешалки доводится до нужной кондиции, и газ проходя фильтрацию через высасывающий насос, отправляется в газгольдер. Остаток, называемый органическим гумусом передается в приемник гумуса. Гумус, находящийся в приемнике, является незаменимым земельным продуктом для тепличных хозяйств.

На базе этих двух устройств можно конструировать гибридную энергостанцию вырабатывающую электрическую и тепловую энергию с помощью ГТД работающей на биогазе (рис. 2) [7; 8].
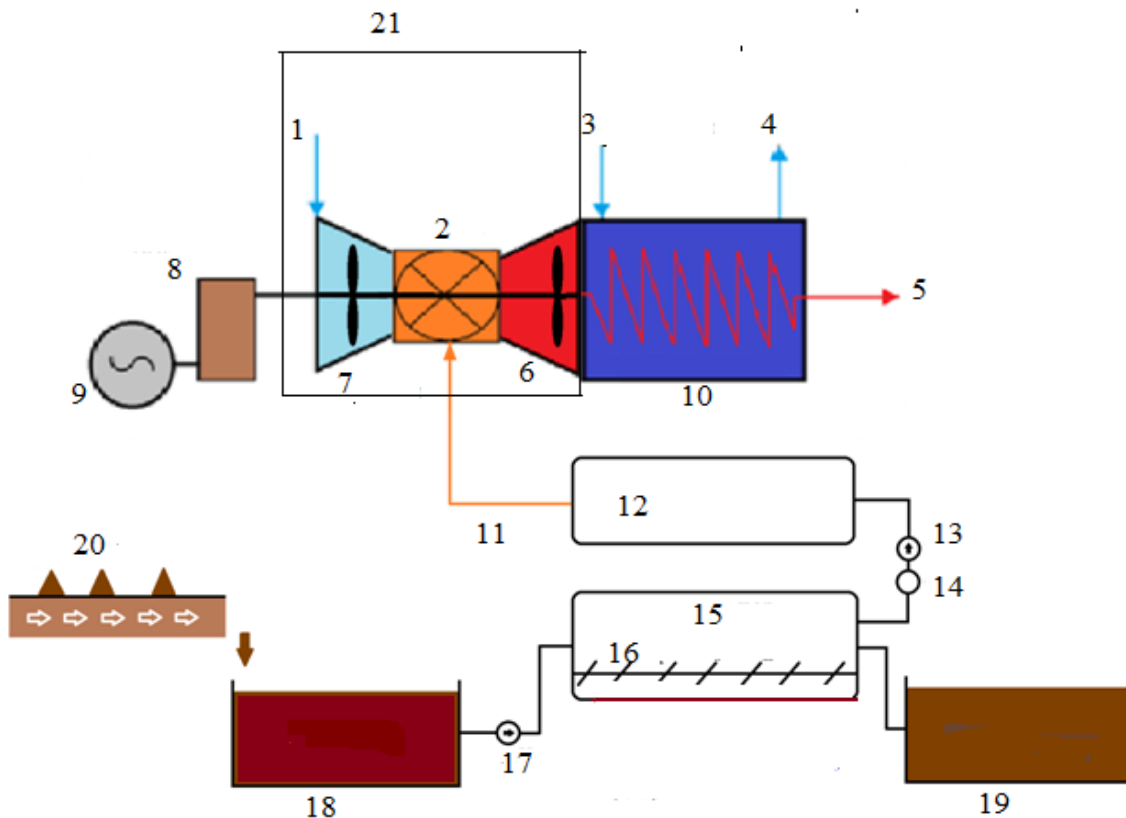
Рисунок 2. Принципиальная схема Гибридная станция теплоэнергетической энергии работающая на базе ГТД

Гибридная станция теплоэнергетической энергии состоит из ГТД (21), в котором газ сжимается и нагревается, а затем энергия сжатого и нагретого газа преобразуется в механическую работу на валу газовой турбины и выхлопные газы, выбрасывается через аккумулятора тепла (10).

В ГТД (21) процессы происходят в потоке движущегося газа. Сжатый атмосферный воздух из компрессора (1) поступает в камеру сгорания (2), куда также подаётся биогаз (11), который, сгорая, образует большое количество газообразных продуктов сгорания под высоким давлением. Затем в газовой турбине энергия давления продуктов сгорания преобразуется в механическую работу за счёт вращения лопаток, часть которой расходуется на сжатие воздуха в компрессоре (7). Остальная

часть работы передаётся через привод (8) на (9) для выработки электрической энергии. Выхлопной газ через турбины(6) подается на аккумулятор тепла (10). Далее, выхлопной газ нагревая холодную воду поступающую из трубы (3) выбрасывается через трубу (5). Горячая вода в виде тепловой энергии снимается из трубы (4). В качестве топлива используется биологический газ поступающий из газгольдера (12). Биологические отходы поступают в биореактор (15) всасыванием (17) из приемника биоотходов (18), подготовленных в отстойнике (20). Полученный биогаз с помощью мешалки (16) доводится до нужной кондиции, и биогаз через фильтр (14) высасывается (13) в газгольдер. Остаток в биореакторе (15), называемый биологиче-

ский гумус, отправляется в приемник (19). Биологический гумус, находящийся в приемнике (19) является ценным земельным продуктом, называемый биогумус, для тепличных хозяйств.

Вторая часть.

Гибридная ветроустановка (рис. 3), вырабатывающая постоянную и переменную электрическую энергию состоит из мачты 1, солнечны панелей 2, магнитных лопастей 3, асинхронного двигателя 4, индукционной катушки 5, выпрямителя 9, 15 шины постоянного тока, инвертора 10 с переключателем 11, потребителя тока 220/380 13, потребителя тока 6 или 10 Квт 16, блок накопителя энергии(БНЭ) 14 и аккумуляторы 12, точки подключения следующих гибридных ветроустановок 17.
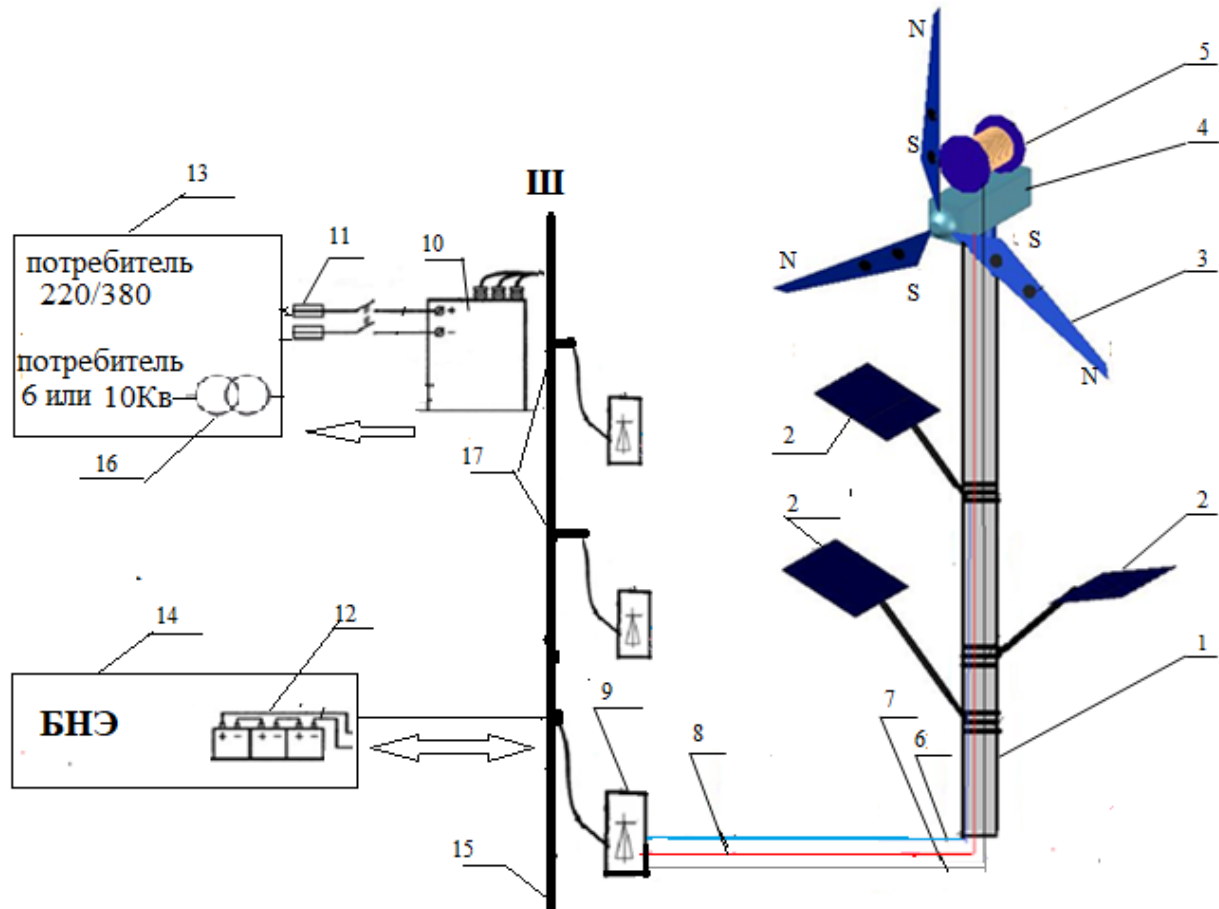

Рисунок 3. Гибридная ветроэнергетическая установка (ГВЭУ)

Гибридная ветроустановка работает следующим образом (Фиг. 3). Под действием ветра магнитные лопасти 3, вырабатывает переменный электрический ток 7 с помощью асинхронного двигателя 4, и вокруг себя создает магнитное поле, которое пересекая обмотки индукционной катушки, вырабатывает переменный индукционный ток 8. Постоянный ток, выработанный, на солнечных панелях 2, через контроллер 9 передается на шину постоянного тока 15. Из шины ток подается инвертору 10, и переменный ток 220/380, или 6–10 Квт подается потребителям 13 или 16. Избыточная электрическая энергия накапливается в блок БНЭ, имеющая двухстороннюю направленность. К 17 подключаются дополнительные гибридные ВЭУ.

Конъюгируя вышеописанных устройств можно конструировать СРГЭ, работающий на базе возобновляемых источников энергии и не зависящий от погодных условий. Что интересно такая конструкция способна бесперебойно обеспечивать электрической и тепловой энергией потребителей находящиеся в отдаленных регионах.

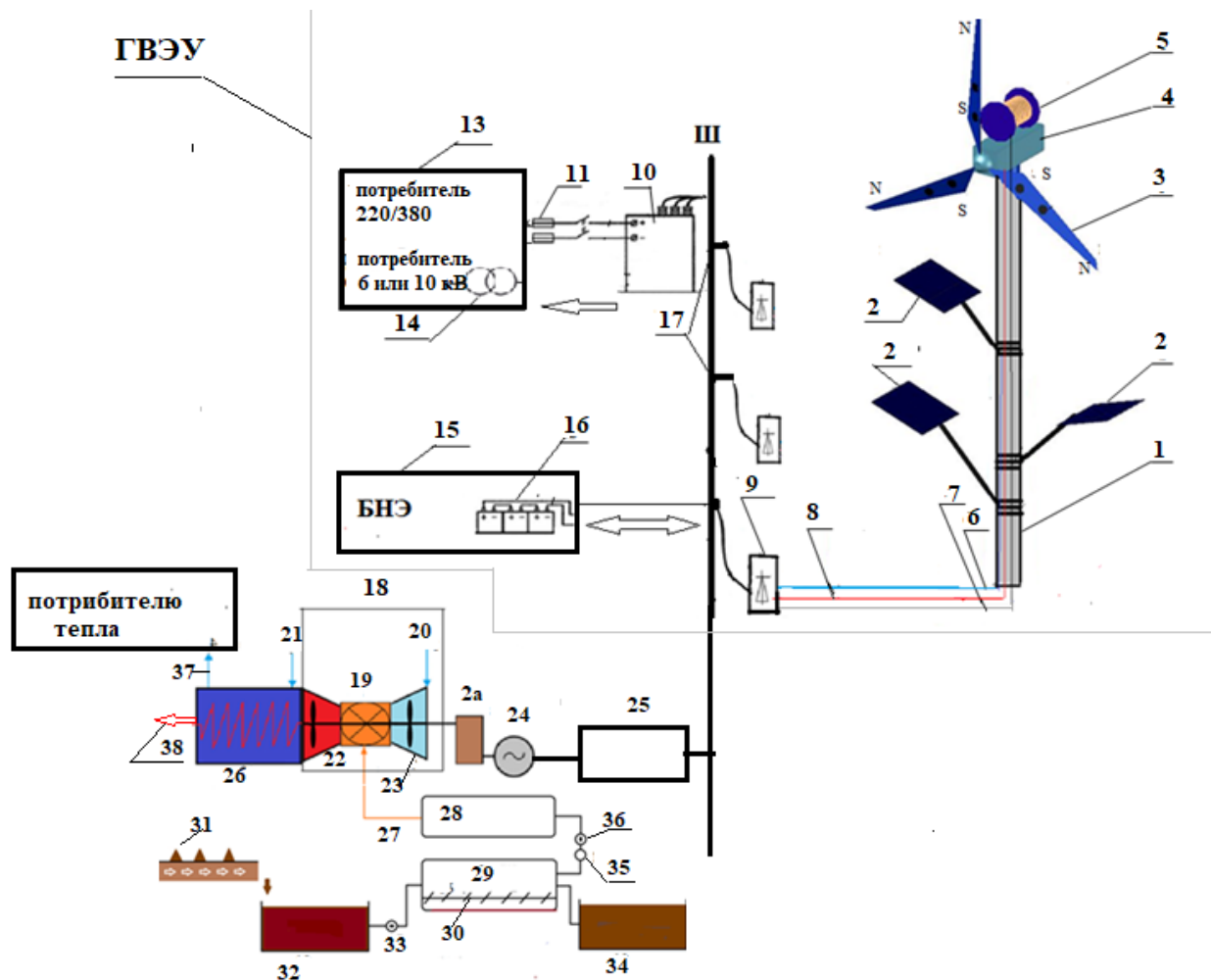Применение гибридной энергосистемы основанной на ГТД работающей на биогазе.

Рисунок 4. Гибридная система распределенной генерации энергии

Предложенная гибридная энергостанция состоит из ГВЭУ (рис. 4), вырабатываюшую постоянную и переменную электрическую энергию состоит из мачты 1, солнечных пане-

лей 2, магнитных лопастей 3, асинхронного двигателя 4, индукционной катушки 5, выпрямителя 9, 15 шины постоянного тока, инвертор. 10 с переключателем 11, потребителя тока 220/380 13, потребителя тока 6 или 10 Квт 16, блок накопителя энергии (БНЭ) 14 и аккумуляторы 12, точки подключения следующих гибридных ветроустановок 17. ГВЭУ работает следующим образом (рис. 4).

Под действием ветра магнитные лопасти 3, вырабатывая переменный электрический ток 7 с помощью асинхронного двигателя 4, и вокруг себя создает магнитное поле, которое пересекая обмотки индукционной катушки, вырабатывает переменный индукционный ток 8. Постоянный ток, выработанный, на солнечных панелях 2 через контроллер 9 передается, на шину переменного тока **Ш.** Из шины ток подается инвертору 10, и переменный ток 220/380, или 6–10 кВт подается потребителям 13 или 16. Избыточная электрическая энергия накапливается в блок БНЭ, имеющий двухстороннюю направленность. К 17 подключаются дополнительные ГВЭУ. С помощью ГТД (18), в котором газ сжимается и нагревается, а затем энергия сжатого и нагретого газа преобразуется в механическую работу на валу газовой турбины и выхлопные газы выбрасываются через аккумулятор тепла (26), вырабатывается тепловая и электрическая энергия. В ГТД (18) процессы происходят в потоке движущегося газа. Сжатый атмосферный воздух из компрессора (20) поступает в камеру сгорания(19), куда также подаётся биогаз (27), который, сгорая, образует большое количество газообразных продуктов сгорания под высоким давлением. Затем в газовой турбине энергия давления продуктов сгорания преобразуется в механическую работу за счёт вращения лопаток, часть, которой рас-

ходуется на сжатие воздуха в компрессоре (23). Остальная часть работы передаётся через (2 а) на приводимый агрегат (24). Агрегатом (24) Выработанная электрическая энергия с помощью преобразователя (25), передается на шину переменного тока Ш. Выхлопной газ через турбины (22) подается на аккумулятор тепла (26). Далее, выхлопной газ, нагревая холодную воду поступающую из трубы (21) выбрасывается через трубу (38). Горячая вода в виде тепловой энергии снимается с трубы (37) и подается потребителю тепла. В качестве топлива в ГТД используется биологический газ, получаемый из биогумусных отходов из газгольдера (28). Биогаз полученной в беореакторе (29), проходя фильтр (35) высасывается (36) в газгольдер (28). Биологические отходы поступают в беореактор через всасывание (33) из приемника отходов (32), находившиеся в приемнике (31). Полученный биогаз с помощью мешалки (30) доводится до нужной кондиции, и газ отправляется в газгольдер. Остаток, называемый органический гумус передается в приемник (34). Гумус, находящийся в приемнике (34), является незаменимым земельным продуктом для тепличных хозяйств. При отсутствие солнечной радиации и ветра, ГТД вырабатывает электрическую и тепловую энергию, и тем самым обеспечивается бесперебойное вырабатывание тепловой и электрической энергии вне зависимости от погоды.

Выводы. Наличие большого запаса сельскохозяйственных, животноводческих и растениеводческих отходов и большого запасов ветровой и Солнечной энергии в РК побудило нас использовать ВИЭ для получения тепловой и электрической энергии для трудно доступных регионов. За основу для конструирования СРГЭ состоящая из двух модулей

и вырабатывающая тепловой и электрической энергии использован ГТД и ГВЭУ. При этом впервые в качестве топливо для работы ГТД использован биогаз получаемой из сельскохозяйственных, животноводческих и растениеводческих отходов. Тем самым решили следующие задачи дающий практический выход. Первое, появился возможность использовать биоотходов для получения тепловой и электрической энергии низкой по себестоимости. Второе, доказан возможность использования биогаза получаемое из биоотходов в качестве топливо для ГТД. Третье, на практике показан преумущества предложенной СРГЭ для бесперебойного снабжения тепло и электро энергией потребителя. При этом выяснилось еще одно приемущество конструриванной СРГЭ. Отходы получаемое при получении биогаза в виде гумус грунта является основой получения хорошого урожая в тепличном хозяйстве.

Данная работа, даёт лишь некоторые рекомендации на предмет того, как можно наладить производство гибридных энергосистем работающих на базе ВИЭ не зависящих от погодных условий.

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