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Section 1. Biology

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THE MATERIAL AND SPIRITUAL FACTORS OF CREATION PROSPEROUS LIFE IN VILLAGES OF UZBEKISTAN

Abstract. The scientific article outlines the main directions of the reforms being implemented in Uzbekistan for the existing villages, the living standards of the population involved in agricultural production, the quantitative and qualitative changes in it, the material and spiritual factors for the creation of a prosperous life.

Keywords: agriculture, population, living standards, prosperity, material and spiritual factors, reform, material and spiritual wealth.

More than three and a half billion people in the world live in rural areas, mainly engaged in foodstuffs for the people of the world, and light and food industry needs for raw materials. Hence, the residence of the rural population is one of the main attributes of the socio-economic life of any country. Therefore, in the context of globalization, the rural population is a specific social space where people live and, thus, determining their future prospects are among the most pressing issues of the day.

More than one billion economically active population of the world's population is engaged in agriculture. It is well-known that the prospect of agriculture has always been dependent on the proper and degraded lands and the way they are used. Today, the area of land suitable for rural areas is 4 billion 480 thousand hectares, and the useless land is 4 billion 400 thousand hectares.

Most of the rural lands are annually withdrawn from rural areas for expansion of urban areas, industrial construction, construction of transport routes and other purposes. This, in turn, leads to a decline in rural and urban discrepancies, deterioration of the ecological situation, and a decline in human health.

As a result, 124 million people in the world suffer from hunger [4, 34].

Thus, it is one of the topical issues that have been raised to the level of vital necessity to find a scientifically-practical solution to this problem. The number of permanent residents of the Republic of Uzbekistan is 33,254.1 thousand. People, of which 16805.0 thousand. People live in urban areas (50.5% of the total population), and the rural population is 16449.1 thousand. People (49.5%).

At the same time, 30.3% of the total population of the Republic has reached the working age, 59.5% of able-bodied age and 10.2% of the adult population (as of January 1, 2019). The population density is 74.1 people in the country, including 713.2 in Andijan region, 544.8 in Ferghana region, 370.0 in Namangan region, and 8.8 in Navoi region. and 11.2 in the Republic of Karakalpakstan [5, 78].

Today, there are about 10.000 to 11.000 rural settlements in Uzbekistan, with about 16 million inhabitants [3]. So the prosperity of the villages, the prosperity of the people living there, the happiness of the entire population of our country. Farmers living in the countryside are the main drivers of farming. In this regard, the President of the Republic of Uzbekistan Sh. M. Mirziyoev said: "When we say a farmer, we have a lot of fields, gardens, a variety of festive meals, wedding parties, cheerful days and all our lives.

In this sense, the farmer is not an exaggeration if we say that life is a strong pillar and a solid supporter of life [2, 123].

That is, the rural population, the peasants who are its main driving force, have the right to live a comfortable life. Therefore, it is crucial to deeply analyze the results of the ongoing reforms to ensure the well-being of the rural population, and to identify the most important measures for the harmonization of the material and spiritual factors of the welfare of the rural population on the basis of the received scientific and practical conclusions.

Building a prosperous life in the village begins with improving the lives of the rural population. The greater the standard of living depends on their real earnings, which they earn because of their skilled work in this area. Real income is a source of prosperity for the rural population. The greater or less of it depends on the proportion of material and spiritual factors existing in the village.

So, what is the question of the village itself? Village is a place where people are engaged in agricultural work, their place of residence and place of residence. Scientists primarily divide agriculture into a consumer-oriented, second-generation, commercially-based group based on extensive activity.

Villages in Uzbekistan were subjected to "cotton alone" during the Soviet era. Various poisonous chemicals were sown in the rural population as a result of the overwhelming harvest of cotton. As a result, the water and the land were in danger of exposure to toxic chemicals. The villagers began to play a massive "yellow patient." The women had anemia. Children's death rose.

The genealogy of the rural population began to fail. All this has created serious socio-economic, ecological, spiritual-cultural problems.

After the independence of Uzbekistan, the issue of solving the problem of ensuring the well-being of the rural population on the basis of consistent harmonization of the new production and mental and spiritual environment that satisfies the material and spiritual needs of the population in rural areas has become a historical necessity.

To solve this problem, villagers were given land for private farming, farms were established, cotton fields were reduced, crops of grain, vegetables, melons and gourds were created, gardens were created, people's livestock horses increased, attention was drawn to family business in the village As the agricultural sector progresses, the people living in rural areas have a strong hope for a prosperous life.

Today, the following sources of material wealth for rural livelihoods are: "expanding the production of environmentally-friendly products, significantly enhancing the export potential of the agrarian sector; further optimization of sown areas through new intensive orchards and placement of vineyards: development of multistage farming enterprises dealing with the processing, procurement, storage, sale, construction and rendering of agricultural products; construction of new processing plants equipped with state-of-the-art hi-tech equipment for the production of semi-finished and ready-made foodstuffs and packaging products, storage, transportation and sale of agricultural products, agrochemical, financial and other expanding the infrastructure of market services; introduction of modern agricultural and water saving technologies; It is among the strategic tasks to address the global climate change and the adoption of structural measures to mitigate the adverse impact of the Aral Sea on agricultural development and the adverse effects on the lives of the population".

These tasks have begun to give positive results. As a result, the volume of agricultural production in the past two years (2017–2018) amounted to

101.9%, including agricultural products – 100.7% and livestock products – 104.2%. 63.6% of agricultural output was made up by dekhkan (personal subsidiary) farms, 34.7% by private farms and 1.7% by agricultural activities [5, 65].

This creates a solid foundation for the well-being of the rural population.

First of all, the natural factors – the improvement of the soil structure through the means of human inventions, the selection in the field of agriculture, the development of genetics in livestock, and second, the social factors – strengthening the physical, psychological, intellectual abilities of the rural population, forming; thirdly, organizational and economic factors – the acceleration of agricultural production organization, specialization, advanced experience, new management systems and methods; Fourthly, the technological and technical factors are the following: technical assistance in the agricultural sector, automation, introduction of science in production, development of agricultural products processing nanotechnologies; Fifthly, the economic factors – the prospects of agricultural development, development of road maps, analysis of their implementation, introduction of modern methods of payment; Sixth, ethical-spiritual-ideological factors – to nourish as the primary source of the production of bread, to cultivate ecologically clean products, to look at soil and water as valuable, to grow traditional products inherited from the ancestors (apricot, almond, walnut, melon, watermelon and so on), look at the dehkans and livestock as labor creatures, and strengthen their admiration and enhance their praise.

The combination of the material and spiritual factors of a well-being in the village is as follows: a) simple, traditional – spiritually worn out; b) intensive – high productivity; c) high intensity – the use of technologies that provide competitiveness.

In harmonizing the material and spiritual factors of a well-being in the village, the following is required:

1) to develop non-extensive, but not intentionally rural development;

2) specializing in comprehensive production of agricultural products (including seasonality);

3) wide opportunities for independent development of production of dekhkan, farmer and private farms;

4) putting a number of agricultural activities into the sphere of public services;

5) the development of public methods of state support and response in different ownership conditions;

6) full coverage of agricultural production with highly qualified personnel;

7) Complete programming of agricultural infrastructure at the fastest pace of development of information and communication technologies;

8) the achievement of its ultimate goal, if the development of agriculture is accomplished through the establishment of an alliance with the upbringing of a great moral and spiritual character [8; 9].

References:

1. The Decree of the President of the Republic of Uzbekistan. On the Strategy for the Further Development of the Republic of Uzbekistan.– T.: “Justice”, 2017.– P. 18–19.
2. Mirziyoev Sh. M. Our main task is to glorify the work of the agriculturally livelihoods of the creator, and to elevate the development of the industry to a new level. It is ours. The consent of our people is the highest gem in our work.– Tashkent: NMIU, Uzbekistan, 2018.– 42 p.
3. Kurtsev I. V. Основные настрификации развития инновационных систем APK Sibiri: method. rekom.– Novosibirsk, 2008.– 61 p.
4. Stat. uz. Official site of the State Committee of the Republic of Uzbekistan on Statistics. URL:http://day.news.uz/news/2018/03/24/bmt-duneda-city-customers-worldly-conducted-for

5. Stat. uz. Official site of the State Committee of the Republic of Uzbekistan on Statistics. URL:https://kun.uz/55381466
6. Stat. uz. Official site of the State Committee of the Republic of Uzbekistan on Statistics. URL:http://uztag.info/uz/news/zbekistonda-ar-t-rtinchi-ishlo-a-olisi-soni-1–001dan-2-ming-teng-teng

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CREATION OF STABLE SIMPLICIAL COMPLEXES OF THE P. II

Abstract. Using the definitions considered in work [2, 11–14] it is proved theorems: the prototype of the simplicial sets associated with functors $\forall a \in G_N(A)$ is general linear group $GL(k,A)$, about simplicial an investment: $\tilde{W} : V_{k,n}(A) \otimes \gamma^3 \to V_{k,n+k}(A)$.

Keywords: simplex, investment, flag, algebra, homotopy, *K*-functor.

Remark. Let the module Q in flags $F \in D_k^*$ be fixed, then the flag F_{inf} is, the single minimum flag for a set D_k^* [1, 17–20].

In work [3, 20–22] the theorem was formulated that the prototype of the simplicial sets associated with functors $\forall a \in G_N(A)$ is general linear group $GL(k,A)$, we will provide its proof.

Theorem 1. Let $p : V_{N,K}(A) \to G_N(A)$, then for any top $a \in G_N(A)$ we have $p^{-1}(a) = GL(k,A)$.

Proof

Let $a \in G_N(A)$ a zero-dimensional (top) simplex in $G_N(A)$, then we will define a set $p^{-1}(a)$ – a top preimage a in $V_{N,K}(A)$.

As homomorphisms $\varphi_i = \psi_i = 0$ for a zero-dimensional simplex $a = (P,Q), P \oplus Q = A^n$ in this case, the flag $F = \{A^n \geq 0\}$ will be conditionally minimum flag for top *a*.

Let tops $b_0, b_1, ..., b_n$ define a simplex in a complex $V_{N,K}(A)$, where

$$b_i \in p^{-1}(a), b_i = (u_1^i, ..., u_k^i, Q), \{u_1^i, ..., u_k^i\}, i = 0,1,...,n.$$

As homomorphisms $\varphi_i = \psi_i = 0, G_i \neq 0, i = 1,...,n$ in this case, display of basis vectors $u_1^0, ..., u_k^0$ of the module $P = \{u_1^i, ..., u_k^i\}$ are carried out by operators $1 + G_i, i = 1,...,n$, i.e. we have transformations of bases in the same module P.

As the second Q module in tops $b_0, b_1, ..., b_n$ remains at the same time to the fixed, then owing to **a remark:** for K – admissible flags at tops $b_0, b_1, ..., b_n$ there is the single minimum flag.

This reasoning shows that a module matrix P in bases $\{u_1^0, ..., u_k^0\}, ..., \{u_1^n, ..., u_k^n\}$ form a simplex in group $GL(k,A)$, where k – dimension of the module P, i.e. $p^{-1}(a) = GL(k,A)$. The theorem 1 is proved.

Let's use definitions $G(A), V(A), GL(A)$, provided in work [2, 11–14] and we will consider the display $p : V(A) \to G(A)$ which is display of topological spaces.

We need to construct a simplicial investment of a simplicial complex $V_{k,n}(A)\oplus\gamma^3$ in a complex $V_{k,n+k}(A)$, where simplicial complexes $\gamma^3, V_{k,n}(A)\oplus\gamma^3$ are defined as follows.

Let there $\sigma_V^l=(b_0,b_1,\dots,b_L,F^n)$ is a l-dimensional simplexinacomplex $V_{k,n}(A)$, where $b_0=(b_1,\dots,b_L,Q_0)$, $b_i=((1+\varphi_i+G_i)e_1,\dots,\ (1+\varphi_i+G_i)e_k,Q_i), i=1,\dots,l$ – simplex tops σ_V^l, φ_i,ψ_i,G_i – operators of transition from top b_0 to top b_i, $F^m=\{A^N=P_0\oplus Q_0\supseteq\supseteq P_1\oplus Q_1\supseteq\dots\supseteq P_m\oplus Q_m\supseteq 0\}$ – length flag m.

Let's present a flag F^m as the direct sum of submodules of the module A^N: $F^m=P^1\oplus Q^1\oplus\dots\oplus P^m\oplus Q^m$, where $P_0=P^1\oplus P_1$, $P_1=P^2\oplus P_2,\dots,P_{m-1}=P^m\oplus P_m$, $Q_0=Q^1\oplus Q_1$, $Q_1=Q^2\oplus Q_2,\dots,Q_{m-1}=Q^m\oplus Q_m$.

Let's describe $\tilde{W}$ a simplicial investment of a simplicial complex $V_{k,n}(A)\otimes\gamma^3$ in a simplicial complex $V_{k,n+k}(A)$, where γ^3 – simplicial the complex consisting of four tops $\{c_0,c_1,c_2,c_3\}$, of pair of tops (c_i,c_{i+1}) in this list is set by one-dimensional simplexes, i.e. $V_{k,n}(A)\otimes\gamma^3$ in a complex there are three simplicial subcomplexes of a look $V_{k,n}(A)\otimes\sigma$.

Let's consider in a complex $V_{k,n}(A)\otimes\gamma^3$ a subcomplex $\sigma_V^l\otimes\gamma^3$, in which there are three subcomplexes of a look $\sigma_V^l\otimes\sigma^1$. Will designate through $f_i, i=1,2,3$ three investments: $f_i: V_{k,n}(A)\otimes\sigma^1\to\to V_{k,n}(A)\otimes\gamma^3$ i.e. investments according to three subcomplexes $V_{k,n}(A)\otimes(c_i,c_{i+1}), i=0,1,2,$ and through $g_i, i=0,1,2,3$ we will designate compositions of investments: $\sigma_V^l\to\sigma_V^l\otimes c_i\to\sigma_V^l\otimes\gamma^3, i=0,1,2,3.$

If $\sigma_V^l=(b_0,b_1,\dots,b_l,F^m)$ in $V_{k,n}(A)$, that we designate a simplex through $\tilde{\sigma}_V^l,\sigma_V^l$ the following simplexes: $\tilde{\sigma}_V^l=(\tilde{b}_0,\tilde{b}_1,\dots,\tilde{b}_L,\tilde{F}^m), \sigma_V^l=\left(b_0,b_1,\dots,b_L,F^m\right)$, where $\tilde{\sigma}_V^l,\sigma_V^l$ – simplexes from $V_{k,n+k}(A)$, and tops their following:

$\tilde{b}_0=(e_1,\dots,e_k,Q_0\oplus A^k), \tilde{b}_i=((1+\varphi_i+G_i)e_1,\dots,$
$\dots,(1+\varphi_i+G_i)e_k,Q_i\oplus A^k),$

$b_0=(u_1,\dots,u_k,Q_0\oplus P_0), b_i=(u_1,\dots,u_k,Q_i\oplus P_i),$
$P_0=\{e_1,\dots,e_k\},$
$P_0=\{(1+\varphi_i+G_i)e_1,\dots,(1+\varphi_i+G_i)e_k\}, A^k=\{u_1,\dots,u_k\},$
i.e. $u_1,\dots,u_k$ is the basis in the free module $A^k, i=1,\dots,l$ and the flags of these simplexes are as follows: $\tilde{F}^m=P^1\oplus Q^1\oplus\dots\oplus P^m\oplus Q^m\oplus A^k, F^m=\{A^{n+k}\supseteq 0\},$
$P_0\oplus Q_0=A^n, P_i\oplus Q_i=A^n, P_0\oplus Q_0\oplus A^k=A^{n+k}.$

Theorem 2. There is a simplicial investment: $\tilde{W}: V_{k,n}(A)\otimes\gamma^3\to V_{k,n+k}(A)$, it that
$\tilde{W}(b_0\otimes\gamma^3)=\tilde{W}(1)(\tilde{b}_0)=b_0,$
$\tilde{W}(b_i\otimes\gamma^3)=\tilde{W}(1)(\tilde{b}_i)=b_i, i=1,\dots,l,$ where $\tilde{W}(1)$ designates the path consisting of composition of three one-dimensional simplexes $\tilde{W}_1\cdot\tilde{W}_2\cdot\tilde{W}_3$:

$$\begin{pmatrix} 1_k & 1_k & 0 \\ 0 & 1_k & 0 \\ 0 & 0 & 1_{n-k} \end{pmatrix}\begin{pmatrix} 1_k & 1_k & 0 \\ -1_k & 1_k & 0 \\ 0 & 0 & 1_{n-k} \end{pmatrix}\begin{pmatrix} 1_k & 1_k & 0 \\ 0 & 1_k & 0 \\ 0 & 0 & 1_{n-k} \end{pmatrix},\text{where}$$

1_k designates a unit matrix of dimension k, and this path begins from top $\tilde{b}_0$, and action of a matrix product $\tilde{W}_1\cdot\tilde{W}_2\cdot\tilde{W}_3=\tilde{W}(1)$ on top $\tilde{b}_0$, is understood as action of this work on the following vector from modules: $\{e_1,\dots,e_k\}\oplus\{u_1,\dots,u_k\}\oplus\{e_{k+1},\dots,e_n\}=A^{n+k}$, where $e_1,\dots,e_k$ – basis of the module P_0, $e_{k+1},\dots,e_n$ – basis of the module Q_0, $u_1,\dots,u_k$ – basis of the free module $A^k, \tilde{W}\cdot g_0(b_0)=\tilde{b}_0$, $\tilde{W}\cdot g_0(b_i)=\tilde{b}_i$, $i=1,\dots,$
$\tilde{W}\cdot g_0(\sigma_V^l)=\tilde{\sigma}_V^l$, $\tilde{W}\cdot g_3(b_0)=b_0$, $\tilde{W}\cdot g_3(b_i)=b_i$,
$\tilde{W}\cdot g_3(\sigma_V^l)=\sigma_V^l.$

Proof

Step 1.

Let's construct a simplicial investment $\tilde{W}\cdot f_1: V_{k,n}(A)\otimes\sigma^1\to V_{k,n+k}(A).$

Let a simplex σ_V^l from $V_{k,n}(A)$, we will construct a simplicial investment $\tilde{W}\cdot f_1:\sigma_V^l\otimes\sigma^1\to V_{k,n+k}(A).$

Let's define investments $\tilde{W}\cdot g_0,\tilde{W}\cdot g_1$ both at tops $b_0,b_1,\dots,b_l$ and on a simplex σ_V^l flag F^m so:
$\tilde{W}\cdot g_0(b_0)=\tilde{b}_0$, $\tilde{W}\cdot g_0(b_i)=\tilde{b}_i, i=1,\dots,l$, $\tilde{W}\cdot g_0(F^m)=\tilde{F}^m$,
$\tilde{W}\cdot g_1(b_0)=(e_1+u_1,\dots,e_k+u_k,Q_0\oplus A^k),$
$\tilde{W}\cdot g_1(b_i)=((1+\varphi_i+G_i)e_1+u_1,\dots,$

$(1+\varphi_i+G_i)e_k+u_k, Q_i\oplus A^k)$, $\quad \tilde{W}\cdot g_1(F^m)=\tilde{F}^m$, $\tilde{F}^m=P^1\oplus Q^1\oplus\ldots\oplus P^m\oplus Q^m\oplus A^k, A^k=\{u_1,\ldots,u_k\}$, $i=1,\ldots,l.$

As operators of projection φ_i,ψ_i,G_i of top b_0 on tops $b_i, i=1,\ldots,l$ at the same time of an investment are left without change, i.e. we don't change K – nilpotent algebra $NA_k(\varphi_i,\psi_i,G_i)$, and K – the minimum flag $F^m=P^1\oplus Q^1\oplus\ldots\oplus P^m\oplus Q^m$ of a simplex σ_V^l changes trivially: to it the free module A^k increases, as well as to modules $Q_0,Q_1,\ldots,Q_l$ in tops $\tilde{b}_0,\tilde{b}_1,\ldots,\tilde{b}_l$, at this investment the module A^k is in a core of operators $\varphi_i,\psi_i,G_i, i=1,\ldots,l$, then apparently that the investment $\tilde{W}\cdot g_0:\sigma_V^l\to\tilde{\sigma}_V^l$ is simplicial.

At an investment $\tilde{W}\cdot g_1$ operators of projection of top $\tilde{W}\cdot g_1(b_0)$ on tops $\tilde{W}\cdot g_1(b_i), i=1,\ldots,l$, as it is easy to see, will be the following:

$$\varphi_i,\ G_i,\ \psi_i'=\begin{pmatrix}0&0&0\\0&0&0\\-\psi_i&0&0\end{pmatrix}\cdot\begin{pmatrix}1_k&1_k&0\\0&1_k&0\\0&0&1_{n-k}\end{pmatrix}=\begin{pmatrix}0&0&0\\0&0&0\\-\psi_i&-\psi_i&0\end{pmatrix},$$

where operators ψ_i' affect the following sum of modules $P_0\oplus A^k\oplus Q_0$, at the same time the module A^k is, apparently, in a core of the operator ψ_i'.

It is easy to see that K – the flag will be the minimum flag $\tilde{F}^m$ for a simplex $\tilde{W}\cdot g_1(\sigma_V^l)$. So, images of a simplex σ_V^l at investments: $\tilde{W}\cdot g_0$ and $\tilde{W}\cdot g_1$, i.e. $\tilde{W}\cdot g_0(\sigma_V^l), \tilde{W}\cdot g_1(\sigma_V^l)$, are simplexes in a complex $V_{k,n+k}(A)$.

Simplexes $\tilde{W}\cdot g_0(\sigma_V^l)$, $\tilde{W}\cdot g_1(\sigma_V^l)$, $\tilde{W}_1=\begin{pmatrix}1_k&1_k&0\\0&1_k&0\\0&0&1_{n-k}\end{pmatrix}$ have, apparently, the following common K – a minimum flag: $\tilde{F}^m=P^1\oplus Q^1\oplus\ldots\oplus P^m\oplus Q^m\oplus A^k$.

So, it is shown that simplicial investments $\tilde{W}\cdot g_0$, $\tilde{W}\cdot g_1$ proceed to a simplicial investment: $\tilde{W}\cdot f_1:\sigma_V^l\otimes\sigma^1\to V_{k,n+k}(A)$,

i.e. $\tilde{W}\cdot f_1: V_{k,n}(A)\otimes\sigma^1\to V_{k,n+k}(A)$.

Step 2. Creation of a simplicial investment $\tilde{W}\cdot f_2$.

Let's define an investment $\tilde{W}\cdot g_2$ at tops $\tilde{b}_0,\tilde{b}_1,\ldots,\tilde{b}_l$ and on a flag F^m as follows: $\tilde{W}\cdot g_2(b_0)=(e_1+u_1,\ldots,e_k+u_k,Q_0\oplus P_0)$, $Q_0\oplus P_0=A^n$, $Q_i\oplus P_i=A^n$, $\quad \tilde{W}\cdot g_2(b_i)=((1+\varphi_i+G_i)e_1+u_1,\ldots,(1+\varphi_i+G_i)e_k+u_k,Q_i\oplus P_i), i=1,\ldots,l$, $\tilde{W}\cdot g_2(F^m)=P^1\oplus\ldots\oplus P^m\oplus Q_0\oplus A^k$, $P^1\oplus\ldots\oplus P^m=P_0$, $Q^1\oplus\ldots\oplus Q^m=Q_0$.

The investment $\tilde{W}\cdot g_2$ is simplicial as at display $\tilde{W}\cdot g_2$ operators of projection of top $\tilde{W}\cdot g_2(b_0)$ on tops $\tilde{W}\cdot g_2(b_i), i=1,\ldots,l$, apparently, the following G_i,φ_i,ψ_i, and K – a minimum flag for K – nilpotent algebra $NA_k(\varphi_i,G_i,\psi_i)$, it will be apparent K – a flag $\tilde{W}\cdot g_2(F^m)=P^1\oplus\ldots\oplus P^m\oplus Q_0\oplus A^k$.

We receive that $\tilde{W}\cdot g_2(\sigma_V^l)$ is a simplex in a complex $V_{k,n+k}(A)$.

It is easy to show that simplexes $\tilde{W}\cdot g_1(\sigma_V^l), \tilde{W}\cdot g_2(\sigma_V^l), \tilde{W}_2=\begin{pmatrix}1_k&0&0\\-1_k&1_k&0\\0&0&1_{n-k}\end{pmatrix}$ have the following common K – a minimum flag: $\tilde{W}\cdot f_2(F^m)=A^1\oplus P^1\oplus Q^1\oplus\ldots\oplus A^m\oplus P^m\oplus Q^m$, where dimensions of modules A^i,P^i in the direct sum $A^i\oplus P^i\oplus Q^i$ for everyone $i=1,\ldots,m$ coincide, and enter modules A^i,P^i, which are generated respectively by vectors e_j,u_j only a vector with identical indexes j, i.e. $A^i=\{e_{j_1},\ldots,e_{j_s}\}, P^i=\{u_{j_1},\ldots,u_{j_s}\}$, where

$P^1\oplus\ldots\oplus P^m=P_0$, $\quad Q^1\oplus\ldots\oplus Q^m=Q_0$,

$A^1\oplus\ldots\oplus A^m=A^k$.

So, it is shown that simplicial investments $\tilde{W}\cdot g_1,\tilde{W}\cdot g_2$ proceed to a simplicial investment: $\tilde{W}\cdot f_2:\sigma_V^l\otimes\sigma^1\to V_{k,n+k}(A)$,

i.e. $\tilde{W}\cdot f_2: V_{k,n}(A)\otimes\sigma^1\to V_{k,n+k}(A)$.

Step 3. Creation of a simplicial investment $\tilde{W}\cdot f_3$.

Let's define an investment $\tilde{W}\cdot g_3$: $\tilde{W}\cdot g_3(b_0)=b_0, \tilde{W}\cdot g_3(b_i)=b_i$, $\tilde{W}\cdot g_3(F^m)=\{A^{n+k}\supseteq 0\}=F^m, i=1,\ldots,l$, $A^{n+k}=P_0\oplus Q_0\oplus A^k$.

The investment $\tilde{W} \cdot g_3$ is simplicial as operators of projection of top b_0 on tops $b_i, i = 1,...,l,$ will be the following: $\varphi_i = G_i = \psi_i = 0$ and K – a minimum flag [1, 17–20] in this case, apparently, following: $F^m = \{A^{n+k} \supseteq 0\}$, i.e. $\tilde{W} \cdot g_3\left(F^m\right) = F^m$.

We receive that the image $\tilde{W} \cdot g_3\left(\sigma_V^l\right)$ of a simplex σ_V^l at an investment $\tilde{W} \cdot g_3$ is a simplex in a complex $V_{k,n+k}\left(A\right)$.

It is easy to show that simplexes $\tilde{W} \cdot g_2\left(\sigma_V^l\right), \tilde{W} \cdot g_3\left(\sigma_V^l\right), \tilde{W}_3 = \begin{pmatrix} 1_k & 1_k & 0 \\ 0 & 1_k & 0 \\ 0 & 0 & 1_{n-k} \end{pmatrix}$ have the following common K – a minimum flag: $\tilde{W} \cdot f_3\left(F^m\right) = P^1 \oplus A^1 \oplus Q^1 \oplus ... \oplus P^m \oplus A^m \oplus Q_0$, where the same modules A^i, P^i, as in a flag $\tilde{W} \cdot f_2\left(F^m\right)$ a step 2 and the module $Q_0 = Q^1 \oplus ... \oplus Q^m$.

It follows from the fact that K – the nilpotent subalgebra is generated in this case by the following operators: $\varphi_i, G_i, \begin{pmatrix} 0 & 1_k & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, i = 1,...,l.$ Thus, it is shown that simplicial investments $\tilde{W} \cdot g_2, \tilde{W} \cdot g_3$ proceed to a simplicial investment: $\tilde{W} \cdot f_3 : \sigma_V^l \otimes \sigma^1 \to V_{k,n+k}\left(A\right)$,

i.e. $\tilde{W} \cdot f_3 : V_{k,n}\left(A\right) \otimes \sigma^1 \to V_{k,n+k}\left(A\right)$.

The set of the constructed simplicial investments $\tilde{W} \cdot f_1, \tilde{W} \cdot f_2, \tilde{W} \cdot f_3$ sets a simplicial investment $\tilde{W} : V_{k,n}\left(A\right) \otimes \gamma^3 \to V_{k,n+k}\left(A\right)$, at which simplex σ_V^l tops $b_0, b_i, i = 1,...,l$ in a complex $V_{k,n}\left(A\right)$ pass respectively into tops $b_0, b_i, i = 1,...,l$:

$$\tilde{W}\left(b_0 \otimes \gamma^3\right) = \tilde{W}\left(1\right)\left(\tilde{b}_0\right) = \tilde{W}_1 \cdot \tilde{W}_2 \cdot \tilde{W}_3\left(\tilde{b}_0\right) =$$

$$= \begin{pmatrix} 0 & 1_k & 0 \\ -1_k & 0 & 0 \\ 0 & 0 & 1_{n-k} \end{pmatrix} \cdot \begin{pmatrix} P_0 \\ A^k \\ Q_0 \end{pmatrix} = \begin{pmatrix} A^k \\ P_0 \\ Q_0 \end{pmatrix} = \tilde{b}_0 = \left(A^k, P_0 \oplus Q_0\right) =$$

$$= \left(A^k, A^n\right), A^k = \{u_1, ..., u_k\},$$

then all tops $b_0, b_i, i = 1,...,l,$ of a simplex σ_V^l from $V_{k,n}\left(A\right)$ are transferred by a homotopy $\tilde{W}$ to the single top $\left(u_1, ..., u_k, A^n\right)$ of complex $V_{k,n+k}\left(A\right)$. Theorem 2 is proved.

References:

1. Dergachev V., Lelyavin S. Creation of the infinite algebraic K – functors of the p. II. Austrian Journal of Technical and Natural Sciences, – No. 3–4. 2018. (March-April).– P. 17–20.
2. Dergachev V. Lelyavin S. Creation of stable simplicial complexes of the p. I Austrian Journal of Technical and Natural Sciences, –No. 7–8. 2018. (July-August).– P. 11–14.
3. Dergachev V., Lelyavin S. Design to algebraic *K*-functors. Austrian Journal of Technical and Natural Sciences, – No. 3–4. 2015. (March-April).– P. 20–22.

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INVESTIGATION OF THERMOPHYSICAL PROPERTIES AND CHARACTERISTICS OF DISPERSED MATERIALS BASED ON EXPERIMENT PLANNING METHODS

Abstract. Thermal physical characteristics of dispersed materials are studied on the basis of experiment planning methods, their thermal conductivity, thermal diffusivity, heat capacity, thermal absorption, which are thermal characteristics and mass transfer characteristics: moisture conductivity, thermal conductivity, mass capacity, etc., have been determined. Thermal processes of materials as well as the structure of the material as a quasi-homogeneous body have been studied.

Keywords: heatphysical characteristic, disperse materials, thermal process, experiment, planning of an experiment.

Thermophysical characteristics are usually of great interest. They represent a set of parameters that characterize simultaneously the reaction of the material to the processes of heat and mass transfer. The latter includes, first of all, thermal characteristics:

- coefficient of thermal conductivity λ,
- coefficient of thermal diffusivity k,
- volumetric heat capacity C,
- heat absorption $b=\sqrt{\lambda C}$, as well

As mass transfer characteristics:

- coefficient of moisture permeability K,
- coefficient of thermal and moisture permeability δ_T,
- coefficient of mass intensity δ_M, etc.

In this work, the main emphasis is placed on a comprehensive study of only the complex of thermal characteristics of λ, k, C and b.

The research was motivated by the following assumptions. On the one hand, the authors had studied, in addition to typical dispersed materials, also complex solid non-metallic structures. In such objects, as a rule, there is no mass transfer. On the other hand, dispersed systems are characterized by the simultaneous flow of organically interrelated processes of heat and moisture exchange.

The study of thermal processes in such materials is carried out in two key directions.

1. Based on data gathering, solving and analyzing a unified system of equations of heat and mass transfer. It is necessary to know the thermal and mass transfer characteristics of the material. This alternative finds more and more applications; however, its practical implementation at present is associated with considerable difficulties: the need to take into account a large number of characteristics that vary widely depending on the structure of the material and the conditions of experience.

Currently, rather complex nature of these dependencies is far from being fully understood. Otherwise, when precise quantitative relationships are established between the complex of thermal characteristics and the properties and structure of the material, complications arise in solving non-linear heat conduction problems. As a rule, to bring the solution to a productive end, it is necessary to take the thermal characteristics of the substance within certain limits constant.

2. Based on the representation of the structure of the material as a quasi-homogeneous body. In this case, the task of finding the temperature field is reduced to solving one heat conduction equation, complicated by the action of internal sources and, first of all, by the presence of variable thermal characteristics. With this approach, it is necessary to take into account only the thermal characteristics of the material such as λ, k, b and C.

In this case, the characteristics are not taken as constant ones: they reflect mutual impact of all possible processes in the material, in addition to thermal conductivity, such as convection, radiation and, above all, mass transfer. Therefore, it is rather unjustified to call them thermal characteristics and the term thermophysical characteristics is proper to describe them. We emphasize that such a narrowing of the problems solved on the basis of the second principle as compared with the first one is undoubtedly a disadvantage, since it is not possible to simultaneously find the humidity and temperature fields.

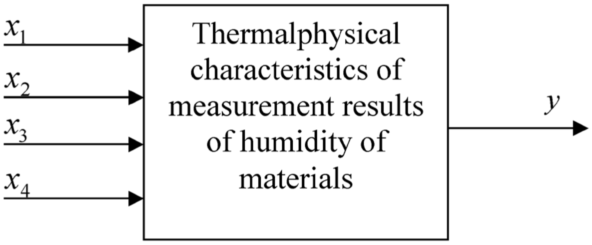
However, other obvious advantages of the second principle: its relative simplicity, a significantly smaller number of necessary parameters, the ability to bring solutions up to the operational view – all of the above allow recommending it in a significant number of engineering-type tasks.

This technique is especially effective when it is necessary to jointly evaluate heat and mass transfer, if boundariers are set within which it ends and the boundaries of the temperature and humidity under study are precisely defined, as well asthe structural features of the material under study are noted.

Thus, we believe that in order to assess the thermal properties of dispersed materials and to understand the basic thermal processes occurring in them under the most different modes and conditions, it is necessary and sufficient knowledge of four parameters λ, k, b and C, and reflected as effective characteristics of the entire set of heat exchange and mass transfer processes occuring in the material. The choice of the first or second option is not an alternative. On the contrary, they should complement each other.

To facilitate the selection, we put forward a factor that distinguishes the extremum-type tasks. The task is extreme if its goal is to search for the extremum of a certain function. To establish which of the two problems is extreme, one must turn to their formulations and find out where the requirements of extremality are satisfied. In task 1, it is required to establish a relationship between the moisture content of the material and three factors. It is not determined here what thermal conductivity is optimal, and it is not required to optimize it.

In task 2, it is necessary to increase the reliability of the device. The very formulation of the problem indicates that the existing reliability does not satisfy the experimenter and requires the search for such conditions under which its values will increase. Tasks of type 1 will be called interpolational, and of type 2 – extremal.



x_1 - humidity; x_2 - gaseous phase; x_3 - solid phase; x_4 - temperature

Figere 1. “Black box” schematic

To describe the object of study, it is convenient to use the concept of a cybernetic system, which is schematically shown in Fig. 1. Sometimes such a system is called a “black box”. The arrows on the right depict the numerical characteristics of the research objectives. We denote them by the letter “y” and call them optimization parameters.

For experiments, one must be able to influence the behavior of the “black box”. All methods of such exposure, we denote by letter “x” and call them factors. In solving the problem, we will use mathematical models of the object, i.e. the equation relating the interrelation between optimization parameter and the factors. This equation in general form can be written as follows:

$$y = \phi(x_1, x_2, ..., x_k), \tag{1}$$

where (ϕ), means: “as a function of”.

Such a function is called *a response function*. Later we will look at how this function can be selected and built. Now we can comprehend how the conditions for conducting experiments are obtained in the experiment that we are going to conduct.

Each factor in the experience can take one of several values. Such values will be called levels. It may turn out that the factor is capable of taking infinitely many values (continuous series). However, in practice, the accuracy with which a certain value is established is not infinite.

Therefore, we can assume that every factor has a certain number of discrete levels. This assumption greatly facilitates the construction and analysis of the “black box” and experiment, and also simplifies the assessment of their complexity.

A fixed set of levels of factors determines one of the possible states of the “black box”. At the same time, this is the essence of the conditions for conducting one of the possible experiments. If we enumerate all possible sets of states, then we get a complete set of various experiments.

To find out the number of different states, the number of levels of factors (if it is the same for all factors) is enough to raise to the power of the number of factors k : p^k,: where p is the number of levels. In addition, it is obvious that the real objects that we encounter every day, have significant complexity. So, at first glance, a simple system with four factors on four levels is very complex.

In these conditions, it is necessary to abandon such experiments, which include all possible experiments: the search is too large. The question arises: how many and what kind of experiments should be included in the experiment to solve the problem? This is where experiment planning comes to the rescue.

However, it should be borne in mind that when planning an experiment, it does not matter what properties the object of a study has. We indicate two basic requirements that have to be considered.

First of all, it is important whether the experimental results are reproduced on the object. We will select some levels for all factors and in these conditions we will conduct an experiment. Then we repeat it several times at unequal intervals and compare the values of the optimization parameter.

The scatter of these values characterizes the reproducibility of the results. If it does not exceed a certain predetermined value (our requirements for the accuracy of the experiment), then the object satisfies the requirement of reproducible results, and if it exceeds, it does not satisfy this requirement. We will consider only those objects for which the requirement of reproducibility is satisfied.

Planning an experiment implies active intervention in the process and the possibility of choosing in each experience the levels of factors that are of interest. Therefore, this experiment is called active. The object on which an active experiment is possible is called a managed one. This is the second requirement for the object of study.

In practice, there are no absolutely controllable objects. A real object is usually affected by both controlled and unmanaged factors. Uncontrollable factors affect the reproducibility of the experiment and cause its violation. If the requirement of reproducibility is not met, one must turn to the active – passive experiment.

Perhaps poor reproducibility is explained by the action of a factor that is systematically changing (drifting) in time. Then you need to refer to a special method of planning. Experiment, finally, it is possible that all factors are uncontrollable. In this case, the problem arises of establishing a connection between the optimization parameter and the factors from the results of observations of the object's behavior, or, as they say, from the results of a passive experiment (7). We will not consider these cases. Our goal is to present the methods of planning an extreme experiment for reproducible controlled static objects.

Planning an extreme experiment is a method of choosing the quantity and conditions for conducting experiments that are minimally necessary for finding the optimal conditions, that is, for solving the problem posed.

Starting to get acquainted with the planning of an extreme experiment, one must keep in mind that when optimizing, the so-called deterministic approach is widespread, especially widely used in chemistry. In this case, it is proposed to build a physical model of the process based on a thorough study of the mechanism of the phenomena (for example, kinetics, hydrodynamics), which makes it possible to obtain a mathematical model of the object in the form of a system of differential equations.

Undoubtedly, the deterministic and static (associated with the planning of the experiment) approaches should reasonably complement each other, and not be contrasted.

The use of all possible experiments to obtain a model leads to absurdly large experiments. The task of choosing the experiments necessary for the experiment, methods of mathematical processing of their results and decision-making – this is the task of planning an experiment. A special case of this task is the planning of an extreme experiment, that is, an experiment designed to find the optimal conditions for the functioning of an object.

Using the principles of regression and correlation analysis in the processing of experimental data, it is possible to find a relationship between the variables and optimum conditions. In both cases, the mathematical model is the response function, which relates the optimization parameter characterizing the results of the experiment, with the variable parameters with which the experimenter varies during the experiments:

$$y = \phi(x_1, x_2, \dots, x_k). \qquad (2)$$

It is customary to call independent variables as $x_1,\ x_2,\ \dots,\ x_k$ factors, the coordinate space with the coordinates $x_1,\ x_2,\ \dots,\ x_k$ – the factor space, and the geometric image of the response function in the factor space – the response surface.

This surface can be represented as a contour diagram (Fig. 1), reflecting, for example, the dependence of the reaction yield (in%) on temperature and concentration. In this case, the optimal output is concentrated in a small area of the surface. If the experiments and their processing were carried out by the traditional method (when only one variable changes, and all the others are kept constant) there is a high probability of falling into a false optimum.

When using statistical methods, the mathematical model is represented as a polynomial – a segment of the Taylor series into which the unknown relation (2) decomposes:

$$\mathrm{y} = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + \sum_{u,j=1 u\neq 1}^{k} \beta_{uj} x_u x_j + \sum_{j=1}^{k} \beta_{jj} x_j^2 + \ldots, \quad (3)$$

where $\beta_j = \left.\frac{\partial \phi}{\partial x_j}\right|_{\vec{x}=0}$ $\beta_{uk} = \left.\frac{\partial^2 \phi}{\partial x_u \partial x_j}\right|_{\vec{x}=0}$ $\beta_{jj} = \left.\frac{\partial^2 \phi}{\partial x_j^2}\right|_{\vec{x}=0}$.

Due to the fact that in a real process there are always uncontrollable and uncontrollable variables, the change in magnitude is random. Therefore, when processing the experimental data, so-called sample regression coefficients b_0, b_j, b_{uj}, b_{jj} are obtained, which are estimates of theoretical coefficients $\beta_0, \beta_j, \beta_{uj}, \beta_{jj}$.

The regression equation derived from the experience will be written as follows:

$$y = b_0 + \sum_{j=1}^{k} b_j x_j + \sum_{u,j=1}^{k} b_{uj} x_u x_j + \sum_{j=1}^{k} b_{jj} x_j^2 + \ldots \quad (4)$$

The coefficient b_0 is called the free term of the regression equation; the coefficients b_j are linear effects; the coefficients b_{jj} are quadratic effects; coefficients b_{uj} – interaction effects.

The coefficients of equation (4) are determined by the least squares method from the condition:

$$\varphi = \sum_{i=1}^{N} (y_i - y_i)^2 = \min. \quad (5)$$

Here: N – the sample size from the entire set of values of the parameters studied. The difference between the sample size N and the number of links imposed on this sample *l* is called the number of degrees of freedom of the sample f:

$$f = N - l \quad (6)$$

When finding a regression equation, the number of links is equal to the number of coefficients to be determined.

When studying the dependence on one variable parameter, it is useful to determine the type of regression equation by constructing an empirical regression line. For this, the entire range of variation on the correlation field (Fig. 2) is divided into different intervals v. All points in this interval Δx_j belong to its middle x_j. To do this, calculate the private average for each interval $\overline{y}_j$:

$$\overline{y}_j = \frac{\sum_{i=1}^{n_j} x_{ji}}{n_j} \quad (7)$$

Here: n_j – number of points in interval Δx_j.

$$\sum_{j=1}^{k} n_j = N \quad (8)$$

where k – number of intervals of division; N – selection volume.

Then the points (x_j, $\overline{y}_j$) are connected in series with straight line segments. The resulting broken line is called an empirical regression line of *y* by *x*. By the form of the empirical regression line, you can choose a regression equation $y = f(x)$.

The task of determining the parameters of the regression equation is reduced practically to the determination of the minimum of the function of several variables. If a

$$y = f(x, b_0, b_1, b_2, \ldots) \quad (9)$$

there is a function that is differentiable and requires b_0, b_1, b_2, … to choose so that

$$\varphi = \sum_{i=1}^{N} [y_i - f(x_i, b_0, b_1, b_2, \ldots)]^2 = \min. \quad (10)$$

A necessary condition for the minimum $\varphi(b_0, b_1, b_2, \ldots)$ is the fulfillment of equations:

$$\frac{\partial \varphi}{\partial b_0} = 0,\ \frac{\partial \varphi}{\partial b_1} = 0,\ \frac{\partial \varphi}{\partial b_1} = 0\ \ldots \quad (11)$$

or

$$\left.\begin{array}{l} \sum_{i=1}^{N} 2[y_i - f(x_i, b_0, b_1, b_2, \ldots)]^2 \frac{\partial f(x_i)}{\partial b_0} = 0 \\ \sum_{i=1}^{N} 2[y_i - f(x_i, b_0, b_1, b_2, \ldots)] \frac{\partial f(x_i)}{\partial b_1} = 0 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \end{array}\right\}. \quad (12)$$

Thereafter we receive:

$$\left.\begin{array}{l}\sum_{i=1}^{N} y_i \frac{\partial f(x_i)}{\partial b_0} - \sum_{i=1}^{N} f(x_i, b_0, b_1, b_2, \ldots) \frac{\partial f(x_i)}{\partial b_0} = 0 \\ \sum_{i=1}^{N} y_i \frac{\partial f(x_i)}{\partial b_1} - \sum_{i=1}^{N} f(x_i, b_0, b_1, b_2, \ldots) \frac{\partial f(x_i)}{\partial b_1} = 0 \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \end{array}\right\}. \quad (13)$$

The system of equations (13) contains as many equations as the unknown coefficients b_0, b_1, b_2, … enters the regression equation and is called in mathematical statistics the system of normal equations.

The value $\Phi \geq 0$ for any b_0, b_1, b_2, …; therefore, it must necessarily have at least one minimum. Therefore, if the system of normal equations has a unique solution, then it is the minimum for the quantity Φ. It is impossible to solve the system (12) in general. To do this, you need to specify a specific form of the function *f*.

References:

1. Chudnovsky A. F. Thermophysical characteristics of dispersed materials. State publishing house of physical and mathematical literature.– M.: 1962.– 456 p.
2. Berliner M. A. Moisture measurement. Ed. 2nd, Pererab. And add.– M., "Energy", 1973.– 400 p.
3. Osipenko N. B. Experiment planning and experimental data processing: texts of lectures for students of mathematical specialties: texts of lectures for students of specialty 1–31 03 01–02 – "Mathematics (scientific and pedagogical activity" / NB Osipenko; Education of the Republic of Bashkortostan, F. Skaryna Gomel State University – Gomel: F. Skaryna State University, 2010.– 439 p.
4. Scott E. Maxwell, Harold D. Delane, Ken Kelley. Designing Experiments and Analyzing Data: A Model Comparison Perspective, Second Edition (Avec CD) 2nd Edition. Kluwer Academic Publishers, – Boston. 2010.
5. Bonamente Massimiliano. Statistics and Analysis of Scientific Data. Springer. 2013.

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DEVELOPMENT OF TECHNOLOGY FOR PRODUCING CEMENTITIOUS COMPOSITES BASED ON GYPSUM MINERALS IN KARAKALPAKSTAN

Abstract. The chemical, physico-mechanical properties of gypsum minerals of various deposits of Karakalpakstan are investigated. Studied the colloid-chemical basis for the production of binders. Based on gypsum minerals, gypsum binders such as building gypsum, high-strength gypsum and extreme gypsum, as well anhydrite cement.

Keywords: gypsum mineral, building gypsum, marl, Karakalpakstan, glauconite, bentonite, high-strength gypsum, binders.

Introduction. Research on the development of new gypsum binders was carried out taking into account the specific features in the chemical and mineralogical compositions of natural gypsum minerals in the deposits of Karakalpakstan, as well as their basic colloidal chemical characteristics.

Building gypsum is an airy binder. This type of gypsum binder can not be used for structures in contact with water, which is associated with the solubility in water of two-water gypsum formed during hardening of binders. When the gypsum is dried, its strength is restored again. As a result of the studies, the possibility of increasing water resistance by adding small amounts of some surfactants to gypsum, a mixture of finely ground lime or cement, and clay minerals was established. In the literature there is evidence of an increase in water resistance when organosilicon and other substances are added to gypsum [1, 464; 2, 27–36].

Study Subjects and Methods. The study subject in this work is the gypsum minerals of various deposits of Karakalpakstan and mineral fillers, which is unrivaled throughout Uzbekistan. In composition, it is close to high-grade, therefore, it can be used to obtain binders with high physico-mechanical properties.

Gypsum stone belongs to sedimentary rock; the content of calcium hydrogen sulfate in it varies from 68.4 to 93.8%. Three samples were taken for the study – from three different deposits of Karakalpakstan, respectively, and their full silicate analysis was carried out. The study of the physicochemical and mechanical properties of gypsum binders was carried out respectively with the requirements of GOST 23789–79 and 4013–82 [3; 4].

Discussion and study results. To obtain building gypsum from natural raw materials, the following operations were carried out: crushing, grinding and firing, depending on the performance of which the following technological schemes for the production of binders are possible: the first is the firing of previously crushed gypsum stone with subsequent grinding; the second – grinding previously purified from impurities of natural raw materials into a powder of the required dispersion with subsequent firing.

The study results showed that the use of the second method of obtaining gypsum binders is more profitable from an economic point of view, because this greatly reduces the time of firing gypsum stone, due to which a reduction in energy costs is achieved. It should also be noted differences in technological characteristics i.e. as a finished product. The technological characteristics of gypsum based on gypsum minerals of Karakalpakstan are given in (table 1).

Table 1. – Physico-mechanical properties of gypsum binders

No	Name of parameter	Urge No. 1	Raushan No. 2	Aybuyir No. 3	Kushanatau No. 4	Beltau No. 5	Khujakul No. 6
1.	Milling fineness, screening residue 0,2%	2	3	8	2	6	6.2
2.	Normal density W/G,%	52	52	57	57	51	46
3.	Setting time beginning, min end, min	4 10	6 15	7 16	6 12	7 19	9 16
4.	Ultimate compressive strength in 2 hours, kgf/cm^2	105	84	64	73	51	35
5.	Ultimate tensile strength under bending, kgf/cm^2	42	39	34	34	24	16
6.	Binder grade	G-10	G-8	G-6	G-7	G-5	G-3
7.	Metal impurities content, mg	2	3	4	3	4	8
8.	Volume dilatation	0.2	0.4	0.3	0.4	0.3	0.4
9.	Impurities, which are insoluble in the hydrochloric acid,%	0.5	0.8	0.9	0.8	0.9	2.8

As shown by the data given in (table1). binders based on the Urge and Raushan deposits possess higher technological properties. To increase the operational characteristics, as well as the water resistance of gypsum binders based on them, it is sufficient to use WSP additives (waste from soda production) in the amount of 5 and 8%, respectively. The use of sand dune, WSP, marl also improves the water resistance of gypsum based on other studied samples several times (table. 2).

Table 2. – Physico-mechanical properties of gypsum binders of the Urge deposit

No	Name of parameter	GB + d/sand	GB + marl	GB + limestone	GB + bentonit	GB + glauconite	GB+ WSP
1	**2**	***3***	***4***	***5***	***6***	*7*	***8***
1.	Milling fineness, screening residue 0,2%	5	3	2	3	6	2

1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
2.	Normal density W/G,%	52	58	52	47	49	59
3.	Setting time beginning, min end, min	5 17	2 12	2 16	3 19	6 21	2 15
4.	Ultimate compressive strength in 2 hours, kgf/cm^2	106	122	113	54	72	143
5.	Ultimate tensile strength under bending, kgf/cm^2	38	53	49	21	27	58
6.	Binder grade	G-10	G-12	G-11	G-5	G-7	G-14
7.	Metal impurities content, mg	8	7	5	7	9	6
8.	Volume dilatation	0.4	0.3	0.3	0.4	0.4	0.2
9.	Impurities, which are insoluble in the hydrochloric acid,%	1.7	1.1	0.9	1.3	1.9	2.0

The obtained experimental results make it possible to recommend gypsum minerals from the Urge and Raushan deposits for the production of gypsum, used mainly for the production of gypsum and gypsum concrete products for the interior of buildings, as well as for the production of gypsum-gypsum plaster mortars. On the basis of other gypsum minerals, it is also possible to obtain building gypsum with satisfactory technological characteristics [5, 117–122].

High-strength gypsum differs from gypsum in larger crystals of non-fibrous structure, as a result of which it has less water demand.

To obtain this type of binder, heat treatment of gypsum crushed stone was carried out in a self-steaming autoclave at temperatures of 120–125 °C for 3–5 hours. With this treatment, recrystallization of two-water gypsum into a coarse-crystalline semi-aquatic α-modification, consisting of long needle-like transparent crystals. After steaming, the crushed stone is unloaded from the autoclave and is dried, then milled. The high-strength gypsum obtained as a result of these operations has the following characteristics (Table 3).

Table 3. – High Strength Plaster Test Results

No	**Name of parameter**	**Indicators of gypsum binder from the Raushan field**	**Indicators of gypsum binder from the Raushan field+10% glauconite**
1.	Milling fineness, screening residue 0,2%	8	5
2.	Normal density W/G,%	58	52
3.	Setting time beginning, min end, min	5 14	6 17
4.	Ultimate compressive strength in 2 hours, kgf/cm^2	199.7	98.9
5.	Ultimate tensile strength under bending, kgf/cm^2	77	55
6.	Binder grade	G-23	G-19
7.	Metal impurities content, mg	2	2
8.	Volume dilatation	0.2	0.4

The experiments showed that based on the gypsum minerals of the Raushan deposit, it is possible to obtain high-strength gypsum binders by the above method without the additional cost of chemicals, setting stabilizers, etc. The use of marl or lime in the amount of 4–6 or 3–5%, respectively, of sample No. 3 in the grinding process contributes to obtaining a high-strength binder with relatively high technological parameters. Such results were also obtained for samples No. 3 and 4.

Anhydrite binders are obtained by firing at temperatures above 600 °C. Known methods for producing such binders also without firing method – grinding natural anhydride with hardening activators.

In studies, anhydrite cement was obtained by calcining gypsum at 650–700 °C and then grinding it finely together with additives. Soda waste, sodium hydrogen sulfate, and vitriol in various mass ratios were used as additives.

The main technological characteristics of anhydrite binders based on the studied samples are shown in (table 4).

Table 4.– Characterization of anhydrite binders based on test samples

No	Characteristic	Sample No. 1	Sample No. 2
1.	Specific surface of $CaSO_4$, cm^2/g	1030…1080	1010…1071
2.	Content of the main substance,%	95	97
3.	H_2O total content,%	1.2	0.94
4.	The content of residual sulfuric acid,%	0.03	0.005
5.	Sieve composition of anhydrite	100% < 60 μm	100% < 60 μm
6.	Specific surface area, cm^2/g	1600	1560
7.	H_2O total / H_2O crystal,%	0.7/0.7	1.2/1.2

The water requirement of anhydrite binders to obtain a test of normal density is 23–36%. Of these samples, high calcined gypsum based on samples No 4 and 5 are characterized by the slowest setting and hardening. The setting begins not earlier than 3 hours from the start of mixing. Anhydrite gypsum based on sample No 6 has more unsatisfactory properties.

High-fired gypsum based on samples No 1 and 3 have high technological characteristics and can be used to obtain mortars and concrete, for the manufacture of artificial marble and other construction needs.

Physico-mechanical and indicators of pilot batches of gypsum binders confirm that they correspond to the results of laboratory tests and satisfy the requirements for gypsum binders used in the construction of various structures [6, 19–2; 7, 56–62].

Conclusion. The study of the physico-chemical and physico-mechanical properties of gypsum binders derived from gypsum minerals in Karakalpakstan shows the possibility of using these minerals for the production of binders such as building, high strength and estrich gypsum, as well as anhydrite cement.

The introduction of the studied minerals is economically effective, since the binders are obtained with low-temperature firing and fine grinding of raw materials without waste and, accordingly, the cost of materials will be relatively low.

The influence of various microfillers and their concentrations on the technological properties of the resulting gypsum binders.

Developed gypsum compositions differing in technological properties.

Developed physical and colloidal-chemical bases for obtaining high-strength gypsum binder based on gypsum minerals Raushan, suitable as a binder for the construction industry.

References:

1. Volzhensky A. V. Mineral binders.–M.: Stroyizdat, 1986.– 464 p.
2. Dvorcin L. I., Dvorcin O. L. Mineral building binders.– M.: Infra-Engineering, 2011.– P. 27–36.

3. GOST 4013–82. Gypsum and gypsum-anhydrite stone for the production of binders. Technical conditions – M.: 07/01/1983.
4. GOST 23789–79. Cementing gypsum. Methods of eating.– M.: 07/01/1980.
5. Abylova A. Zh., Turemuratov Sh. N., Khamraev S. S. Obtaining a variety of gypsum binders based on gypsum minerals of the Republic of Karakalpakstan // Actual problems of modern science.– M., 2014.– No. 5.– P. 117–122.
6. Abylova A. Zh., Turemuratov Sh. N., Khamraev S. S. Obtaining binders based on gypsum minerals of the Ustyurt deposit // Chemistry technology and control control.– T., 2015.– No. 1.– P. 19–24.
7. Abylova A. Zh., Khamraev S. S. Cementing materials based on gypsum minerals of the Republic of Karakalpakstan // Chemical industry.– M., 2016.– No. 2.– P. 56–62.

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PRACTICAL RESULTS OF CREATING A MULTISERVICE INTELLIGENT SYSTEM OF AUTOMATED ACCESS TO SCIENTIFIC AND TECHNICAL INFORMATION

Abstract. The article is devoted to the practical results of creating a multifunctional intelligent system of automated access to scientific and technical information as an innovative technological trend, prospects for the development of a system based on open technologies. The security policy is confirmed by a Certificate. Management controllers and modules that make up the structure of the server part of the application are presented.

Keywords: digital integrated platforms, open technologies, multifunctional systems, security policy, controllers, server, application.

The development trends of the world community focus on the problem of digitalization of electronic resources in all the infrastructures of society. An intelligent system of automated access to scientific and technical information (https://library-test.guiaidn.ru) with the ability to provide modern information services was developed and introduced at the Institute of Artificial Intelligence. Using the capabilities of the Internet, the system provides remote access to the necessary electronic resources available in libraries of organizations, publishing houses connected to this system [1, p. 67].

Built distributed information and communication system, which is integrated with existing departmental systems. Modern computer technology allows you to visually present information about existing electronic resources of the DPR in the form of an interactive system. Integration technologies: technologies of a single service bus, event driven architecture; intelligence (machine learning, context sensitivity, metadata, semantics, intelligent shells, initiation and response, intelligent recommendations, automatic and intelligent detectability, dynamic linking, dynamic intelligent information packets, intelligent screen savers, semantic hints in the user interface, file system conversion, flexible user-driven analysis of information, flexible semantic queries, electronic documentation, etc.).

A single security policy and authentication system is provided with the services Fail 2 ban, Suricata, Certbot-auto (the security policy certificate is valid, host protection against unauthorized access, intrusion prevention system, multitasking and high-performance open system) [2, p. 70].

The possibility of full automation of electronic resources of institutions is implemented. Databases of library funds are converted and integrated with the project database [3, p. 181]. In addition, an effective automated multi-criteria resource search system has been developed and implemented.

The functions of the automated data preparation service, the automation of generating electronic documents for statistical reporting, the formation of consolidated reports, the generation and printing of summary reports on various indicators of the library fund and reporting forms were implemented.

The project was developed on the basis of modern technologies, freely distributed and open source: PostgreSQL, Node.js, Sequelize, Express.js, Angular.js, HTML 5, CSS3 and Git.

The results of the project are innovative. For the first time in the Republic, a digital platform of integrated electronic resources of the Donetsk People's Republic, Russia and the world has been created and implemented. A register of institutions subordinated to the Ministry of Education and Science of the DPR, enterprises and publishing houses was created. The introduction of the project carried out in 655 institutions, 16 publishing houses. The system works without fails hardware-software complex for 20 months.

The monitoring of the electronic resources of the Republic made it possible to realistically assess the material and technical support and library funds of the DPR, which is subject to WEB-analytics and WEB-statistics of resources. The function of automated data preparation service, automation of the formation of electronic documents for statistical reporting, the formation of consolidated reports has been implemented, printing of summary reports on various indicators of the library fund and reporting forms.

The automated workplaces "Interlibrary school subscription" has been developed. The functionality allows you to keep records, systematization and search in the database of textbooks in your personal On-line office. Automatic indexing, on the basis of which a quick search is implemented, allows it to be performed on any elements of the bibliographic description and their combinations.

General electronic catalog of publications of the Republic was created. The Catalog of school textbooks of the Republic has been created; it is designed to monitor school libraries and exchange textbooks between them.

As a result of the automation of accounting and control of electronic resources of educational and scientific institutions, a consolidated electronic catalog of scientific and technical information of the DPR library funds was formed on the basis of a digital platform.

The system's web server is a computing server, a database server, applications, communications. The server interprets queries, creates, reads, deletes, updates information and searches, generates results.

Interpretation of search requests, the creation of informational updates and the generation of query processing results is performed by the server. The structure of the server part of the application contains SERVER.JS (core server, the main part); Libdatabase.js (database description, database copy creation function DB); Server Comm Proc.js (common date / time functions, error logging function); SERVERD iss Auto.JS (functions with dissertations / abstracts (add, edit, delete, search); unctions with dissertations / abstracts (add, edit, delete, search); SERVERD igest.JS (work with journals, collections, scientific articles, periodicals); SERVERWord.JS (preparation of reports in Word format (according to the register of libraries, publications of the catalog)); SERVERE xcel.JS (preparing tables and charts in the format MS Excel); SERVER Regis.JS (add / edit library entries); SERVERP ub.JS (work with publishers: editing, adding data about the publisher, search, delete; add / delete, edit edition data); SERVERK at.JS (work with catalogs, search for data on books, monographs); SERVER Manual.JS (working with school textbooks: information about school classes, information about textbooks used in education, information about issuing books). Procedure library Node_modules c express (framework WEB – applications for Node.js), body-parser. Fs (client request parsing), cookie-parser (read and write cookie from/to user requests), officegen (use of Microsoft Office services).

Controllers provide the formation of the exchange between the pages and the database and the display of data on the pages: – modules for managing html – page: add Article Ctrl – Adding an article to the journal collection)); addcity Ctrl – add city to cities directory; addcityreg Ctrl – the addition of a district into the directory of urban areas; addmanual Ctrl– adding a textbook to the textbook directory; addmbook Ctrl – adding / editing publications in the catalog of publications; add Periodic Ctrl – adding / editing publications in the catalog of publications; baseController – create and restore databases; change Ctrl – change user password; city Ctrl – view directory of localities; Detail Ctrl – view library information; Doc 1 Ctrl – shaping 6-HK; dpl Ctrl – password recovery; exloginCtrl – login and password at login; List Ctrl – register of libraries and search in it; List Kat Ctrl – catalog of publications of the library and search in it; List Kat Comm Ctrl– general catalog of publications and search in it; List NII Ctrl – browse libraries by category; mainCtrl – home page controller; mbookclasses Ctrl – the distribution of the selected textbook in school classes; manual List Ctrl – textbook; mbook find Ctrl – search text book in libraries of other schools; mcarte Ctrl – Site Map; mclasses Ctrl – class list for school; personal Ctrl – Personal Area; phones Controller – filling in library information; Report Ctrl – report generation and structure charts of information resources and logistics in MS Excel.

The Unified Digital Platform – a successful practice of a national technology initiative, a roadmap; customer-oriented system that adapts to the customer and offers solutions that best solve his problems; a tool for strategic socio-economic development, Smart City Technologies, on the basis of which industrial and non-industrial cluster technological systems are successfully integrated, including agriculture, health care, international cooperation, etc., with the possibility of commercialization.

The integration of complex systems of clusters of the socio-economic development of the Republic will ensure effective cooperation in single information and trading space for manufacturers, suppliers, contractors and buyers in the domestic and global markets. The project will allow for the implementation of coordination, information, expert-analytical, organizational and technical support for activities in the implementation of complex systems with strong artificial intelligence.

References:

1. Innovative aspects of the introduction of automated access to scientific and technical information: development prospects / V. V. Bondarchuk, N. M. Kravchenko, T. D. Klyushanova // World science: problems and innovations: a collection of articles of the XXVI International Scientific and Practical Conference. In 2 parts. Part 1.– Penza: ICSC "Science and education". 2018.– P. 66–70.
2. Technology implementation of digital integrated platforms / V. V. Bondarchuk, N. M. Kravchenko, T. D. Klyushanova // Science and education: preserving the past, we create the future: a collection of articles of the XIX International Scientific and Practical Conference. In 2 parts. Part 1.– Penza: ICSC "Science and education". 2019.– P. 69–71.
3. Vectors of digitalization of the Republic on the example of a multiservice intelligent system of automated access to scientific and technical information: / V. V. Bondarchuk, S. B. Ivanova, N. M. Kravchenko, T. D. Klyushanova et al. // Innovation processes in science and education. Monograph / Under the general editorship of G. Yu. Gulyaev – Penza: ICSC "Science and education". 2019.– P. 178–185.

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OPTIMAL PROACTIVE MANAGEMENT OF CARGO FLOWS

Abstract. A mathematical model of optimal control of mine conveyor transport is proposed. The dynamics of the process described by a system of differential equations. The method of optimal proactive control of cargo flows for the technological scheme of the Assembly part of the mine conveyor line is applied.

Keywords: conveyor line, freight flow, management, bunker, mathematical model, differential equation.

Depending on the type of the task and the degree of complexity of the object or system under study, different types of modeling used: physical, mathematical, functional. For the analytical study of the process of technological schemes of conveyor lines in General, the most rational is the mathematical model. Modeling of the process is possible only if a clear formal description constructed for it, which takes into account the main regularities of the process and the existing factors. The mathematical model used to obtain General regularities or specific numerical characteristics associated with the process of modeling conveyor transportation as a control object.

The complexity of the technological schemes of conveyor lines serving several mines complicates the management of conveyor transport. Due to the overload of the main conveyors or the overflow of hopper devices, it is possible to stop a particular face. The irregularity of traffic is one of the reasons for empty runs of the conveyors and the incomplete utilization of their productivity. The efficiency of conveyor transport can be raised by such a management organization, in which, based on the analysis of the current situation, optimal modes of starting and stopping conveyors, loading and unloading hopper devices are provided. Therefore, the creation of a system of optimal control of mine conveyor transport is an urgent task. The analysis of the developed technological schemes of treatment and preparatory works, as well as the structures of conveyor lines of existing, newly built and designed mines allows all technological schemes of conveyor transport to be combined into several groups, for each of which a control algorithm has been developed.

The first group retained the conveyor line with no intermediate containers or intermediate hasenkam, loading into trucks or hopper.

The second group retained the conveyor line with intermediate through hopper, through which the entire flow of cargo, loading into trucks or hoppers.

The third group retained the conveyor line with intermediate the bypass hopper in which the cargo arrives in the waiver period the stock house line or during periods when each capacity of the stock house conveyor allows you to receive all cargo from lava.

The fourth group – distributed conveyor lines, which consist of trunk and parcel lines. The technological scheme of the district line can be attributed to one of the three unallocated lines.

Transport delay of the traffic flows at the site constrain the attainment of rational unloading bins when intensive traffic leads to frequent overflow of bunkers, over-collection conveyor and reusable emergency failure of the conveyor line, significantly reducing work efficiency. These factors can be overcome by managing the unloading of bunkers with the prevention of cargo flows that are brought to them.

Consider the plot of the conveyor line, which contains n bins, adjacent to the stock house line and the total precast stock house conveyor (Figure 1).

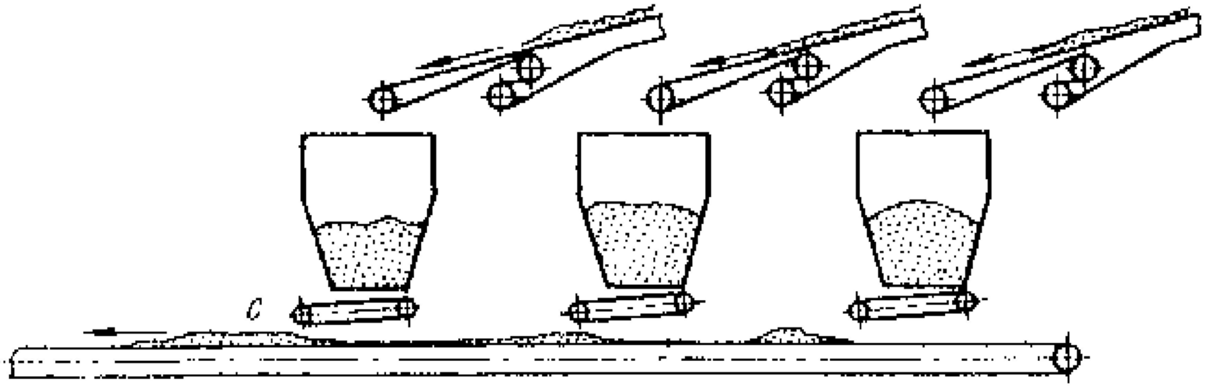

Figure 1. Technological scheme of the conveyor line

Cargo flows that are fed to the bunkers, passing through them, are fed to the assembly line. Full cargo flow will be created at point *C* of the assembly line connection. The state of the section and its interaction with other sections of the conveyor line are determined by the following variables. V – total volume of cargo on the assembly line, V_0 – the volume of cargo that is transported through this section, $V_1 \dots V_n$ – filling volumes 1,… *n – th* bins, Q – rate of traffic at the point $C, O_1, \dots, Q_n$ – traffic intensity. Denote by τ – the time of transportation of cargo from the first hopper to the place of discharge collection conveyor, then τ_i and T_i – is the time of transportation of cargo from *i-th* to the 1st tank and to the unloading place:

$$T_i = \tau_0 + \tau_i, i - 1, \dots, n. \qquad (1)$$

Dynamics described by a system of differential equations:

$$\frac{d}{dt} V_0(t) = q(t) \qquad (2)$$

$$\frac{d}{dt} V_1(t) = Q_i(t) - q_1(t) \qquad (3)$$

$$\frac{d}{dt} V(t) = \sum_{i=1}^{n} q_1(t) - q(t) \qquad (4)$$

$$Q(t) = \sum_{i=1}^{n} q(t - \tau_i) \qquad (5)$$

$$q(t) = Q(t - \tau_0),\ i = 1, \dots, n \qquad (6)$$

Neglecting the inertia of the device discharge feeders, hoppers believe that the desired productivity of bins is established immediately. Then, for the considered section of the line, as a control object, q_j variables play the role of control variables. Informally, the purpose of cargo management at the assembly section of the conveyor line can be expressed as an increase in efficiency, due to the prevention or reduction of downtime of conveyors caused by overflowing bins, overload or blockage of the assembly line, reducing the time of transportation of goods through the site.

The mathematical formulation of the control goal should cover both the normal operation of the site and its emergency modes, which are accompanied by stops of some conveyors. It is necessary to consider the following technological parameters: $V_{i\,max}$ – capacity of the *i-th* bin; $q_{i\max}$ – the marginal productivity of the feeder; Q_i – the productivity of the passport collection conveyor (depends on the power conveyor of the electric motor and limits the total load of the conveyor).

Let L be the length of the rod collection conveyor, V_i – passport rate, γ the average density of the cargo. Then the maximum allowable total volume of cargo on the assembly line is represented by the expression:

$$V_{\max} = \frac{Q_H L}{3600\gamma V_H}.$$

When planning a management strategy for the time T ahead, the management goal is as follows:

$$V_0(t+T) \to max \tag{7}$$

$$V_i(S) \le V_{imax},\ i = 1,\ \dots,\ n \tag{8}$$

$$V\ (S) \le V_{max} \tag{9}$$

$$Q(S) \le Q_{max} \tag{10}$$

These expressions are criteria reflect the desire to optimize the work of the site. The ability to adhere to the conditions of (8–10) is largely determined by the choice of time T. According to expression (5) the value productivity of the feeder of the *i-th* hopper $q_i(t)$ will affect the complete traffic Q after a time τ_i according to (1), (4–6) will be reflected at the load collection conveyor during the time interval $(t, t+T_n)$. So it will be possible to completely manage the state of the site only at $T \ge T_n$. Equations (2) – (6) are no longer sufficient to describe the dynamics of the site in emergency modes. In particular, the emergency shutdown of the *i-th* netbanking conveyor will stop his route and as a consequence to the change of traffic $Q_i(t)$. This effect is not described by the above equations. In addition, for emergency mode, the condition (7) – (10) must be extended to minimize the total downtime of the conveyors. Next, we will analyze only the normal operation of the site, assuming that with proper management of traffic conditions (8) – (10) can be met. For severe mathematical formulation of the problem of management, it is necessary to clarify that the flow information about cargo flows enters the management system, take into account information about the time and technological characteristics of cargo flows. If there are data of statistical analysis of cargo flows, it is necessary to set the problem of optimal stochastic control, in solving which the operation of taking the mathematical expectation is introduced to criterion (7). In case of absence of data of statistical survey of cargo flows it is possible to set the problem of optimal control.

The way to overcome this difficulty is to discretize the control of unloading bins. Suppose that the control effects of $q_i(t)$ are formed discretely in time with a sampling step $q_i(t)$ and during each cycle are fixed where τ_0 is the origin, θ is a discrete integer time.

$$\tau^* = \tau_0 + \theta\Delta\tau \tag{11}$$

$$q_i(t) = q_i(t^*),\ t^* \le t \le t^* + \Delta t, \tag{12}$$

We denote the time-discretized traffic flows $Q_i(\theta)$ and $q(\theta)$. We also denote dynamic variables $V(\theta)$, $V_i(\theta)$, $Q(\theta)$, $q(\theta)$ and $q_1(\theta)$ in accordance with the equation:

$$\xi(\theta) = \xi(\tau^*) \tag{13}$$

Next, you will need an integer delay V, V_1, ξ and ξ_1 that satisfy the inequalities:

$$T \le v\Delta t \le T + \Delta t \tag{14}$$

$$T \le v\Delta t \le T_1 + \Delta t \tag{15}$$

$$t_i \le \delta\ \Delta t \le \tau_i + \Delta t \tag{16}$$

$$\delta = \delta_n \tag{17}$$

Integrate equations (2) – (4) in the range from $t = t^*$ to $t = t^* + \Delta t$ substitute the argument (11) in equation (5) and calculate the integral taking into account the expressions (5) and (6).

Consider also the relationship between (1), (17), (18), (12), (13) and (15):

$$V_0(\Theta+1) = V_0(\Theta) + q(\Theta);$$

$$V_i(\Theta+1) = V_i(\Theta) + Q_i(\Theta) - \Delta t q_i(\Theta)$$

$$V(\theta+1) = V(\theta) + \sum_{i+1}^{n} \Delta t q_i(\theta) - q(\theta);$$

$$Q(\theta) = \sum_{i+1}^{n} q_i(\theta + \delta);$$

$$q(\theta) = \sum_{i+1}^{n} q_i \left[(T_i - (v_i - 1)^* (\theta - v_i) q_i \right] +$$
$$+ \left[(v_i \Delta t - T_i)(\theta - v_i + 1) q_i \right];$$

$$Q_i(\theta) = \int_{t^*}^{t^* + \Delta t} Q_i(t) dt,\ i = 1, \dots, n;$$

$$q(\theta) = \int_{t^*}^{t^*+\Delta t} q(t)dt$$

A significant difficulty in managing the unloading of a group of bunkers is caused by the difference in transport delays with which cargo flows from different bunkers come to a common point with *C*. An effective way to overcome this problem is to coordinate the unloading of bunkers by artificially introducing time delays into the control channels of feeders where $q_i[\theta], \quad i = 1, \ldots n$ is control signals coming to the delay unit:

$$(\delta - \delta_i)\Delta t;$$

$$q_i(\theta) = q_i[\theta - \delta - \delta_i],$$

When considering the technological scheme of the assembly part of the conveyor line of the mine “Mine Zasyadko” using the method of optimal proactive management of cargo flows, the following results were obtained.

Two mountain bunkers volume by *300 м*^{2} each, the average bunker removed from the extreme to a distance of 400 *m*, a collecting conveyor 2*LU*100*B* has a length of 1500 *m*, passport productivity – 1200 *t/h*, reception capacity *31м*^{3}*/min*, rated speed of 3.15 *m/s*.

Choosing the alert time *T* = 8 *min*, the quantum duration management $\Delta t = 15 \quad c$, the resulting integer problem $\nu = 32, \quad \delta = 17$.

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STUDY OF THE EFFECT OF SOME TECHNOLOGICAL PARAMETERS ON THE MECHANICAL PROPERTIES OF INDUSTRIAL WOOD

Abstract. The article presents the results of studying the effect of humidity on the mechanical properties of industrial wood. The mechanical property under study is the relative density of the wood. A mathematical model of dependence is constructed showing an analytical dependence between the studied values.

Keywords: moisture content, relative density of wood, mathematical model of the dependence between humidity and relative density of wood.

Industrial wood includes many types of wood used as, first of all, fuel, as well as a material for the manufacture of specialized tools and wooden structures, paper, furniture, homes, sleepers for railroad tracks and much more. For wood the main and most important are the following properties:

1. Mechanical strength, hardness, specific viscosity, elasticity;

2. Physical: appearance (texture, gloss, color), humidity (drying, warping, hygroscopicity, density), thermal conductivity, sound signals (acoustic impedance), electrical (dielectric properties);

3. Chemical properties. Wood is an anisotropic material, that is, a material with different properties in directions of fibers.

The mechanical properties of industrial wood are moisture content dependent. Moisture content of wood can be absolute and relative. The absolute moisture content of wood is the ratio of the weight of moisture contained in wood to the mass of absolutely dry wood, expressed as a percentage. The relative moisture content of wood is the ratio of moisture contained in wood to the weight of raw wood, expressed as a percentage. The moisture content of the wood is determined as follows: the sample mass of the wet material is measured, then the measured sample is dried in a dryer at a temperature of 100–105 °C, then re-weighing is done, but of a dry material. The difference between the mass of wet and dry material determines the amount of water contained in the sample. For practical purposes, the relative moisture of wood is most important, since it is this that shows the degree of suitability of wood for a particular technological operation. At the Kharkiv National Automobile and Highway University at the Department of Road-Building Materials under the guidance of Professor V. A. Zolotaryev studies of the relative density of wood versus moisture have been carried out [1].

The study results are presented in (table 1).

Table 1.

No.	X_i	Y_i	No.	X_i	Y_i	No.	X_i	Y_i
1.	5	0.98	7	11	0.997	13	17	1.01
2.	6	0.983	8	12	1	14	18	1.013
3.	7	0.986	9	13	1.002	15	19	1.014
4.	8	0.989	10	14	1.005	16	20	1.016
5.	9	0.992	11	15	1.007			

Where in the (table 1) X_i is the moisture content of wood, Y_i is the relative density of wood. The relative density is shown as the ratio of the density of wood at fixed moisture content to the density of wood at standard moisture content (12%). The density of wood (specific gravity) is the ratio of the mass of wood to the volume of wood. A certain theoretical and practical interest is a generalization of experimental data and a representation of the dependence between the studied values in an analytical form. In the article, we construct a function in the form of a linear dependence

$$y = ax + b$$

where $У$ is the relative density; X is the wood humidity, a and b are the coefficients of linear dependence. The coefficients are sought by the method of least squares. The idea of the least squares method is as follows [2]: we are looking for a function for which the sum of squared deviations between the theoretical function and the experimental values would be the smallest. According to the results of the calculations, the values of the coefficients were obtained: $a = 0.073$; $b = 0.01$. Where $Y = 0.073x + 0.01$. A functional dependence constructed in an analytical form allows one to control the technological process of using wood in production, to predict the influence of initial parameters on the quality of products.

References:

1. Золотарев В. А. Испытания дорожно-строительных материалов.– Харьков, ХНАДУ, 2006.
2. Пискунов Н. С. Дифференциальное и интегральное исчисление для втузов. Т. 1.– М.: Наука, 1970–1978.

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INFLUENCE OF THE CONTENT OF HARMFUL SUBSTANCES TO THE FOOD SAFETY OF POLYMER PACKAGES

Abstract. The quality of food products is largely dependent on their packaging. Packaging should protect food from external influences as much as possible and not negatively affect the quality of products. At the same time, more and more attention is being paid to the elements of plastic packaging, namely the content of substances harmful to health, such as monomers, harmful low molecular weight compounds, plasticizers, dyes, acids, etc., which are capable of transferring (migrating) from packaging to food products.

The purpose of the study: the aim of this work is to ensure food safety of polymer packaging by determining acetaldehyde by gas chromatography.

Keywords: polyethylene terephthalate, acetaldehyde, thermal degradation, PET bottles, concentration limits, gas chromatography.

Currently, the negative effects on the human body of food products in polymer packaging, in particular from PET, have been unequivocally proven. In developed countries, there is a tendency to replace PET bottles with disposable thin-walled glass containers.

However, in many countries, plastic packaging made from polymers, including PET, is still widely used for food packaging.

The migration of acetaldehyde from PET bottles, despite the potential carcinogenic effect of the substance, can hardly be hazardous to health, since the amount of acetaldehyde migrating from the package is several orders of magnitude less than what is already found in natural foods. However, in drinks that have the least taste of their own, even small proportions of acetaldehyde lead to tangible taste changes. Lowering the level of acetaldehyde migration to values below the threshold of perception is technically possible, however – apparently, for cost reasons – not all packaging manufacturers go for it. [eleven].

No less important for packaging materials are their barrier properties, in particular, sorption and desorption of acetaldehyde. This effect is associated with the production of containers, the consequence of which is the release of acetaldehyde at high temperatures and its subsequent sorption upon cooling.

Acetaldehyde is a substance released in small quantities during the processing of PET. Acetaldehyde is capable of diffusion from the walls of bottles and affects the taste of drinks, so it is necessary to control its release during the production and processing of PET and the production of preforms. Acetaldehyde is released during the polymerization of PET in the melt and passes into the structure of PET during cooling and granulation. Acetaldehyde is partially liberated during solid phase polymerization, and up to 1.5 ppm (millionths) of acetaldehyde can remain in the starting granules. The same amount of acetaldehyde is released during PET blowing, and more acetaldehyde is released during injection [2, 100]. The formation of acetaldehyde is not associated with any noticeable loss of internal viscosity, but is a consequence of the transition of acetaldehyde from a solid solution to a gaseous and / or liquid state at high temperatures. This means that the amount of acetaldehyde released can be reduced by choosing the optimal casting conditions, that is, minimizing the temperature, that is, choosing the optimal PET processing mode. Therefore, it is necessary to ensure:

- low cylinder temperature;
- minimize screw speed, back pressure, injection speed – all factors leading to additional dissipative heat generation;
- minimize the melting time (the shorter the time, the better), since the more PET is at elevated temperature, the more acetaldehyde is released [3, 31].

Thus, during thermal degradation, it is possible to release very harmful substances that migrate into the liquid poured into the bottle and poison the drinkers and working people living nearby in the production of preforms. Permissible concentrations of harmful substances released during the production and processing of PET are presented in (table 1).

Table 1. – Permissible concentrations of harmful substances released during the processing of polyethylene terephthalate [4]

Harmful substance according to GOST 12.3.030–83	Migration to model environments in finished products, mg/l	In the air of the working area, mg/m^3	In the atmospheric air of populated areas (maximum one-time), mg/m^3	In the atmospheric air of populated areas (daily average), mg/m^3
Acetaldehyde	0.2	5	0.01	0.01
Dimethyl terephthalate	0.5	0.1	0.05	0.01
Terephthalic acid	–	0.1	0.01	0.001
Acetic acid	–	5	0.2	0.06
Carbon oxide	–	20	5	3

Table 2. – Sanitary rules norms and hygienic standards of packaging and closures [5]

I. Polymer materials and plastics based on them **						
Name of material	**Controlled indicators**	**Allowable migration, mg/l**	**MPC, in water, mg/l**	**Hazard Class**	**MPC mg/m^3 in air**	**Hazard Class**
Terephthalic Acid-Based Polyethylene Terephthalate and Copolymers	Acetaldehyde	–	0.200	4	0.010	3
	Ethylene glycol	–	1.000	3	1.000	–
	Dimethyl terephthalate	–	1.500	4	0.010	–
	Formaldehyde	0.100	–	2	0.003	2
	Alcohols:					
	methyl	0.200	–	2	0.500	
	butyl	0.500	–	2	0.100	3
	isobutyl	0.500	–	2	0.100	4
	Acetone	0.100	–	3	0.350	4

The catalyst for thermal degradation of PET is water. It is proved that, in order to avoid thermal degradation, PET must be dried to a moisture content of less than 0.003–0.004 wt.%. Such a low moisture content is unattainable with conventional polymer drying techniques. For this, it is necessary to have special, expensive units and installations for the deep drying of PET granules.

It is known that the technology for the production of PET containers is associated with heating of PET granules and molds, while acetaldehyde is released from under-dried PET granules, which, when solidified, remains locked in microcracks and voids in the polymer. Over time, acetaldehyde is released into the environment and dissolved in food stored in this container. The consequence of this is an increase in the toxicity of the product. This necessitates periodic analytical monitoring of the acetaldehyde content in the PET container. It is no coincidence that GOST 51695 Polyethylene terephthalate. General specifications ", which sets out the method for gas chromatographic determination of acetaldehyde in polyethylene terephthalate (PET). The mass fraction of acetaldehyde in PET according to GOST should not exceed 2 ppm. [6].

However, a critical examination of the method reveals a number of inaccuracies, not specific, but general provisions that suggest multivariance and irreproducibility of the results of the analysis, there are no clear indications of the implementation of the definitions. In particular, according to the GOST methodology, sampling and injection is carried out using an automatic metering device or syringe. These two methods of sampling and introducing samples are put on an equal footing and, in all likelihood, assume the equality of results. However, knowing the principle of operation and the arrangement of both devices, the opposite can be assumed. According to the GOST method, sampling of sample vapors preheated to 80 °C is carried out. If the experimenter uses a syringe, then in this case condensation of sample vapors on the cold walls of the syringe is possible, which is not observed when using an equilibrium steam dispenser, since the pipelines along which the steam sample is moving are heated above the boiling point of acetaldehyde.

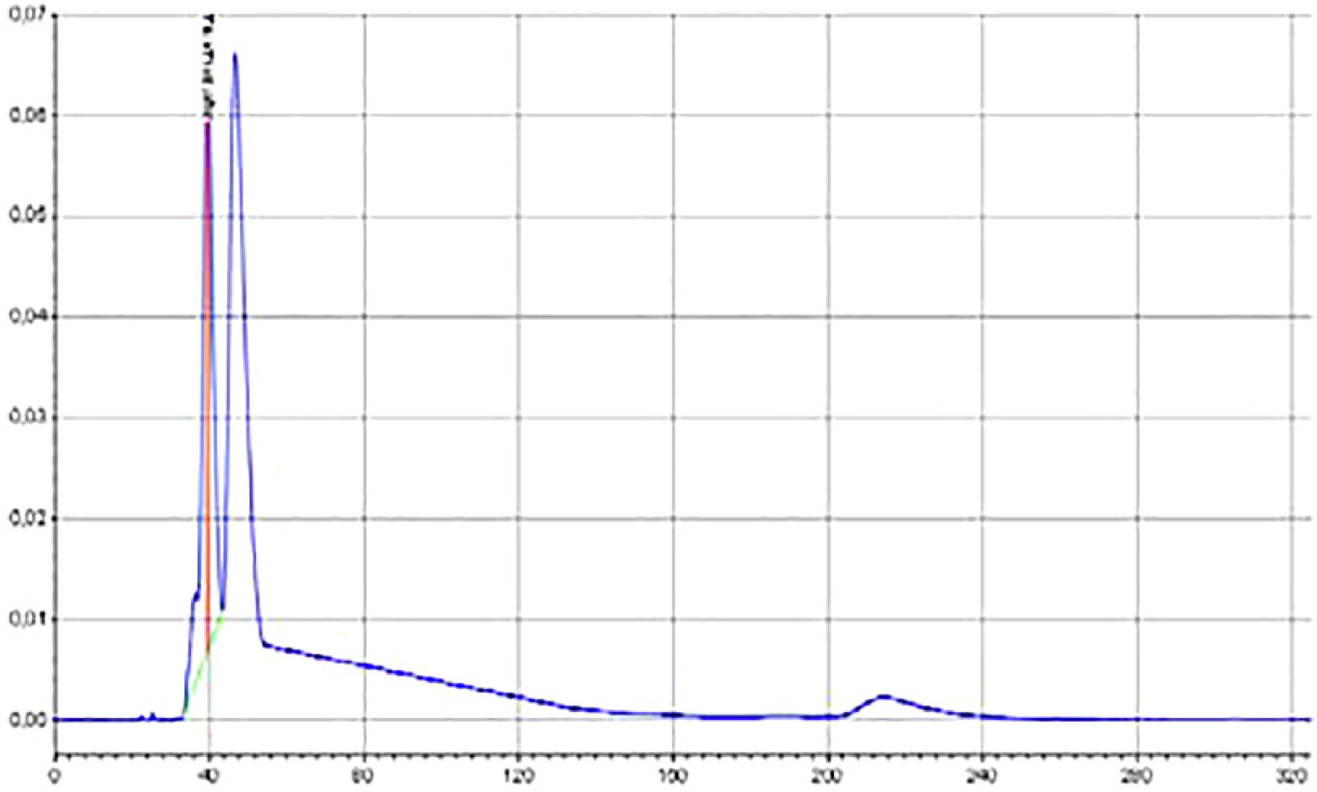

Figure 1. Chromatogram of acetaldehyde at 80 °C

Thus, the condition for the equality of such a parameter as temperature is not met, not to mention the fact that these are completely different methods of sampling and sampling, characterized by different errors, and equivalent results cannot be obtained.

The work was carried out in a gas chromatograph in accordance with the conditions of the methodology under consideration by GOST. Since the developers of the technique do not offer a specific metering device, in our experimental work we used an automatic dispenser of equilibrium acetaldehyde vapor.

Before comparing the results of analyzes with two variants of sample injection, we conducted an experiment to eliminate errors associated with the preparation and temperature control of the sample at 80 °C (Fig. 1.).

For the experiment, a solution of acetaldehyde was prepared so that its vapor concentration did not change over time. The chromatographic conditions in the experiment corresponded to the GOST methodology. Sampling and injection were carried out using a syringe, and without pre-heating the sample. The sample thus prepared was repeatedly analyzed. To determine the magnitude of the random error, the mean square deviations (S) were calculated from the retention time, height and peak area. S by retention time, which was 0.22%, by peak height – 2.35%, by peak area – 2.36%. Thus, in this experiment, we excluded errors associated with sample preparation and temperature control of samples, which are part of the total error. A random error consisted only of the error of the experimenter and the device. Next, we changed the experimental conditions and conducted it with preliminary heating of the sample at 80 °C. In this experiment, sampling and injection were carried out with a syringe: a) without heating, b) with preliminary heating of the syringe. According to the results of the experiment, the mean square deviation was calculated. When using a cold syringe, S was 5.37% in peak height and 5.35% in peak area. When using a heated syringe, S was 4.39% in peak height and 4.10% in peak area. On average, according to the results of the experiment, thermostating of the sample increased the value of the random error by 1.5 times. The greater scatter of the analysis results is associated, in our opinion, with the instability of the thermostat, as well as with the condensation of the sample on the colder walls of the vessel and the nodes of the syringe, which also leads to a change in the composition of the gaseous phase. Preheating the syringe leads to some improvement in the convergence of the analysis results, which, in our opinion, indicates a decrease in the contribution of the condensation factor of the sample on the walls of the syringe (the syringe was also thermostated at 80 °C). The magnitude of the random error consisted of the errors of the experimenter, instrument, and thermostating of the sample [7, 30–33].

In the next experiment, sampling and injection were carried out using an equilibrium steam dispenser. The root mean square deviation was calculated from the height and peak area. S by peak height, which amounted to 3.54%, by peak area – 3.53%. Comparing these data with the results obtained in the previous experiment, we can conclude that the random error decreased by an average of 1.5 times, which is very obvious if we take into account that when using an equilibrium steam meter, condensation of the sample does not occur on cold walls, since pipelines along which the steam sample is moving are warming up.

Thus, the results of the studies showed that these methods of sampling are unequal, and this, in our opinion, is one of the oversights of the GOST methodology. The methodology as amended by the aforementioned GOST cannot provide reliable analytical control over the content of acetaldehyde as a toxicant. In addition, the GOST methodology contains a number of other inaccurate and non-specific guidelines for analysis. So, in the technique two methods of sample preparation are equalized: “grinding the sample in a special mill or manually using any cutting tool.” At this stage, an error may occur, associated in particular with a different degree of grinding of the material. In addition, the use of the mill as a more "aggressive" way of influencing the sample can lead to various mechanochemical side processes caused by the action of shear deformations. This can also affect the results of gas chromatographic analysis, since according to GOST, mechanical and manual grinding of the samples are placed in one row, and it is understood that they are equivalent [8, 34–36].

In our opinion, the process of grinding the sample must be carried out in a liquid nitrogen environment, eliminating the evaporation of acetaldehyde.

The approach to the number of parallel measurements is unclear; according to the methodology, it is enough to draw two parallels. Based on such data, it is impossible to obtain the necessary metrological characteristics of the results and conduct competent statistical processing (to evaluate reproducibility and correctness).

The presence of such oversights made by the developers of the methodology reduces its practical value, and requires additional review and introduction of appropriate adjustments to the existing methodology.

References:

1. Elmar Schwartzr Mullerdi (VHC) Harald Brugger – Aspects of the impact of beverage packaging on health. Environmental Policy Information, – Vienna, AK Österreich. 2011.
2. Khamrakulov M., Negmatova M.– Research of the effect of different factors on the allocation of acetaldehyde from polyethylene polyethylene terephthalate. The 4th International youth conference "Perspectives of science and education" (December 10, 2018) SLOVO \ WORD, New York, USA. 2018.
3. Pogodina Elena – PET: subtleties of processing. Plastics Journal № 10 (104) 2011.
4. GOST 12.3.030–83. SSBT. Processing of plastics. Safety requirements.
5. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated July 7, 2017.– No. 476 On approval of the General Technical Regulation on the safety of packaging in contact with food.
6. GOST R51695–2000 – Polyethylene terephthalate: General specifications.
7. Sayfullaeva Z. S., Khamrakulov M. G., Khasanova D. Yu., Askarov I. R. Identification examination of polymer products.– Standart scientific and technical journal "Uzstandard" – No. 1. 2019.– P. 30–33.
8. Sayfullaeva Z. S., Khamrakulov M. G., Khasanova D. Yu., Askarov I. R. On the safety of packaging containers and utensils made of polymer material for food products.– Standart scientific and technical journal "Uzstandard" – No. 1. 2019.– P. 34–37.

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39 GROUP OF COMMODITY NOMENCLATURE FOR FOREIGN ECONOMIC ACTIVITY OF THE REPUBLIC OF UZBEKISTAN: IDENTIFICATION AND THEIR CLASSIFICATION

Abstract. It is established that the studied samples of polyethylene products contain different types of organic and macromolecular structures. The ratio of substances in the composition of polyethylene materials was identified using IR spectroscopy, density, melt flow rate (MFR).

Objective: to study the composition and properties of a composite material based on polyethylene.

Keywords: polyethylene, classification of goods, commodity nomenclature of foreign economic activity (CNFEA) of the Republic of Uzbekistan, identification features.

The aim of this work is to study the physic-mechanical and physic-chemical indicators of polymeric materials, create a classification of goods based on a comprehensive analysis of code numbers for the commodity nomenclature of foreign economic activity (CNFEA RUz) of polymeric materials, develop new code numbers for polymeric materials that can protect Uzbekistan's economic interests in international relations.

The widespread usage of polymeric materials in industry and in everyday life is due to the availability of raw materials, ease of processing into products, and the possibility of obtaining products with predetermined properties. Many products are purchased in the form of semi-finished products from abroad. When transporting across the border of the state, products and materials from polymers undergo customs examination of quality.

With the improvement of CNFEA there are certain shortcomings in the classification of goods. Therefore, the creation of the National Commodity Nomenclature in International Economic Relations is considered the most urgent task.

Customs clearance and customs control of polymers in primary forms and products made of them is in most cases accompanied by the involvement of experts or qualified specialists in the relevant field of knowledge, since the control of the code of such goods in the HS of the Republic of Uzbekistan is difficult due to the specificity of classification criteria and the lack of a comprehensive information base. The application of the procedural mechanism of interaction with expert organizations lengthens the timeframes for decision-making; many issues arising in the process of customs control of polymers in primary forms and products from them can basically be resolved on the spot. In practice, in most cases, for the identification of many materials from which the goods are made, an examination is appointed, and the expert opinions obtained are used for insurance.

However, there are often problems determining an unambiguous classification code for a product, therefore, customs authorities resort to the appointment of a customs identification examination [1, 129–130].

VII section of the CNFEA of the Republic of Uzbekistan "Plastics and products from them; caoutchouc, rubber and articles" is intended for the classification of goods from plastic and rubber, both raw materials and products of their processing. The basic principle of building the section is the chemical composition of the goods. This section includes two groups 39 and 40. The general criterion for classifying goods as part of a section is structure – these are polymers, the difference is based on the criterion for the presence of elastic properties.

The structural content of the section groups defines the identification of goods as:

The objects of classification of Section VII of the CNFEA are plastics, caoutchouc and rubber. These products are presented in the following forms:

- Primary;
- Semi-finished products;
- Products.

For the classification of goods in this section, the priority classification principle is structure, since polymers are ordered units consisting of monomers.

Group 39 "Plastics and articles thereof" includes two subgroups depending on the degree of processing:

- I subgroup – these are primary forms;
- II subgroup – this is waste, scrap and scrap; semi-finished products; products.

For the purposes of classification, it should be noted which goods belong to the primary forms in group 39 – these are: liquids, pastes, powders, granules, irregularly shaped blocks, bulk forms which, upon receipt, are not processed. The goods of the second subgroup include: waste, scrap and scrap, pipes, tubes, hoses, plates, sheets, film, strips, tapes, porous plastics, products that are formed during processing or are formed during the disposal of polymer products. [2, 263]

The main features of the classification of plastics in primary forms are: the type of polymer, specific gravity, structure, physical properties, composition, shape and size of granules, state of aggregation, hydroxyl number, purpose and safety of their use.

3901 – **Polymers of ethylene, in primary forms**:
- 3901 10 – Polyethylene having a specific gravity of less than 0,94
- 3901 20 – Polyethylene having a specific gravity of 0,94 or more
- 3901 30 – Ethylene–vinyl acetate copolymers
- 3901 90 – others

Polyethylene (high pressure polyethylene (HPPE), low-pressure polyethylene (LPPE), etc.) are materials that are made from one monomer, but can be of different densities depending on the features of the technology for their manufacture. This indicator strongly affects the properties of polyethylene: an increase in density leads to increased stiffness, hardness, strength of products and their chemical resistance. But at the same time, other indicators fall: impact resistance, the possibility of stretching at break, permeability to liquids and gases. So, HPP has significant differences from other similar polymers:

- **HPPE and LPPE.** It is not for nothing that high-pressure polyethylene is also called low-density polyethylene (LDP or LDPE). Compared to it, such solid polymers as LPPE low-pressure polyethylene are more susceptible to rupture under the influence of impact, more often break in frost and crack when the load is increased, although they are more resistant to radiation, alkalis and acids. HPPE pellets and articles made of them are much better at transmitting ultraviolet radiation, and also have a more beautiful glossy surface.
- **LHPE and LLPPE.** Another polymer – LLPPE (linear polyethylene), like HDPE, has a rigid structure, but in terms of its technical characteristics it is between HPPE and LPPE. It is more resistant to chemically aggressive environments than LDPE, and has greater resistance to puncture and cracking than LPPE.

Low density polyethylene (LDPE), namely polyethylene having a specific gravity at 20 °C of less than 0.94 (calculated for the polymer without any additives), is mainly used in the form of a packaging film, especially for food products, as a paper coating, wood fiber plates, aluminum foil, etc., as an insulating material and for the manufacture of various household products, toys, etc. This heading also covers linear low-density polyethylene (LLDPE). High Density Polyethylene (HDPE) is a polyethylene having a specific gravity at 20 °C of 0.94 or more (calculated for a polymer without any additives). It is used for the manufacture of various products by blow molding and injection molding, the manufacture of woven bags, containers for gasoline and oil, pipes by extrusion, etc. Copolymers of ethylene and vinyl acetate are used for the manufacture of lids, container liners and stretch packaging [3].

We have studied the characteristics, physic-mechanical indicators and classifications of polyethylene grades of the joint venture LLC "Shurtan Gas-Chemical Complex". IR spectroscopic studies were carried out on a spectrometer (Perkin Elmer Spectrum Version 10.4.3).

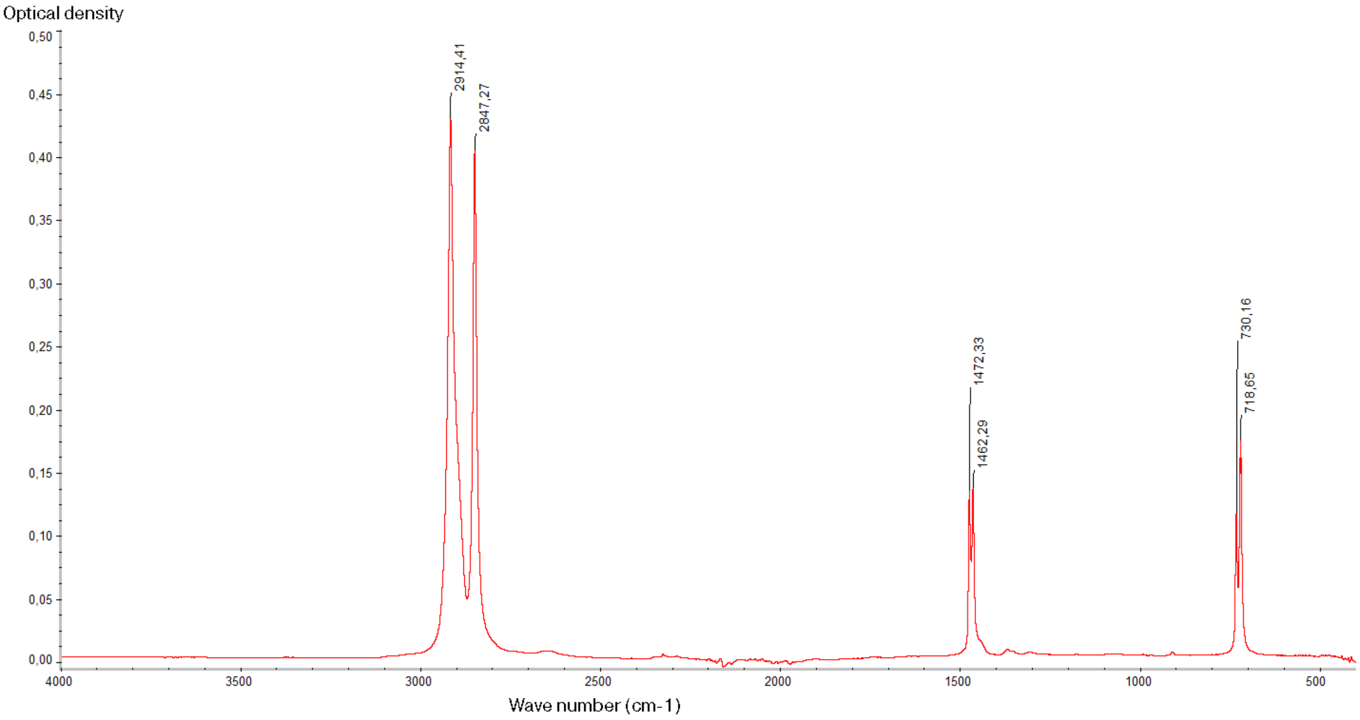
The polyethylene products of the Shurtan gas chemical complex are diverse, and polyethylene grades are used for different purposes (table-1).

Table 1. – Grades of polyethylene, Shurtan gas-chemical complex [4]

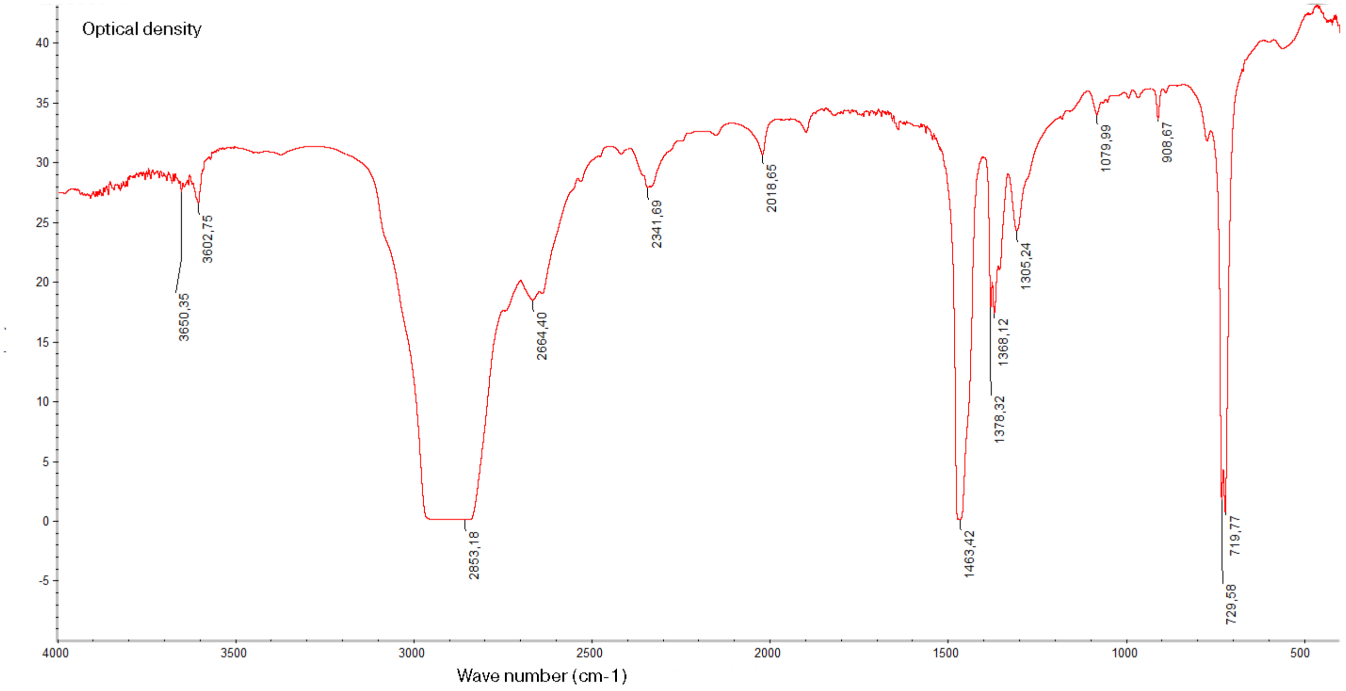
№	**Polyethylene grade**	**Density, g/cm³**	**MFR, g/10 min**	**Recommended processing method and scope**	
		range			
1.	**F-0120** Linear low density polyethylene **LLDPE** ***FILM BRANDS***	0.9180–0.9220	0.70–1.50	Extrusion	For films and film products of general purpose.
2.	**R-0333 U** Medium Density Polyethylene **Mdpe** ***ROTARY BRANDS***	0.9310–0.9355	2.50–3.30	Rotational molding	For large-sized products (tanks and boxes for agrochemical products, fuel).
3.	**I-0760** High Density Polyethylene **HDPE** ***CASTING BRANDS***	0.9580–0.9620	5.5–8.5	Injection molding	For the manufacture of containers – baskets, boxes, etc.
4.	**F-Y346** High Density Polyethylene **HDPE** ***FILM BRANDS***	0.9400–0.9480	0.19–0.31	Extrusion	For films and film products (bags).
5.	**P-Y342** High Density Polyethylene **HDPE** ***PIPE BRANDS***	0.9400–0.9440	0.24–0.36	Extrusion	For the manufacture of tubular products.
6.	**B-Y460** High Density Polyethylene **HDPE** ***CABLE BRANDS***	0.9580–0.9620	0.33–0.46	Blowing	For molding bottles, for packaging and storage of food liquids (water, juices, drinks).

Polyethylene grades have different physicomechanical and physicochemical properties. The properties of polyethylene depend on the method of its production. Currently, there are three methods for the production of polyethylene: high, low and medium density, which differ in structure and properties.

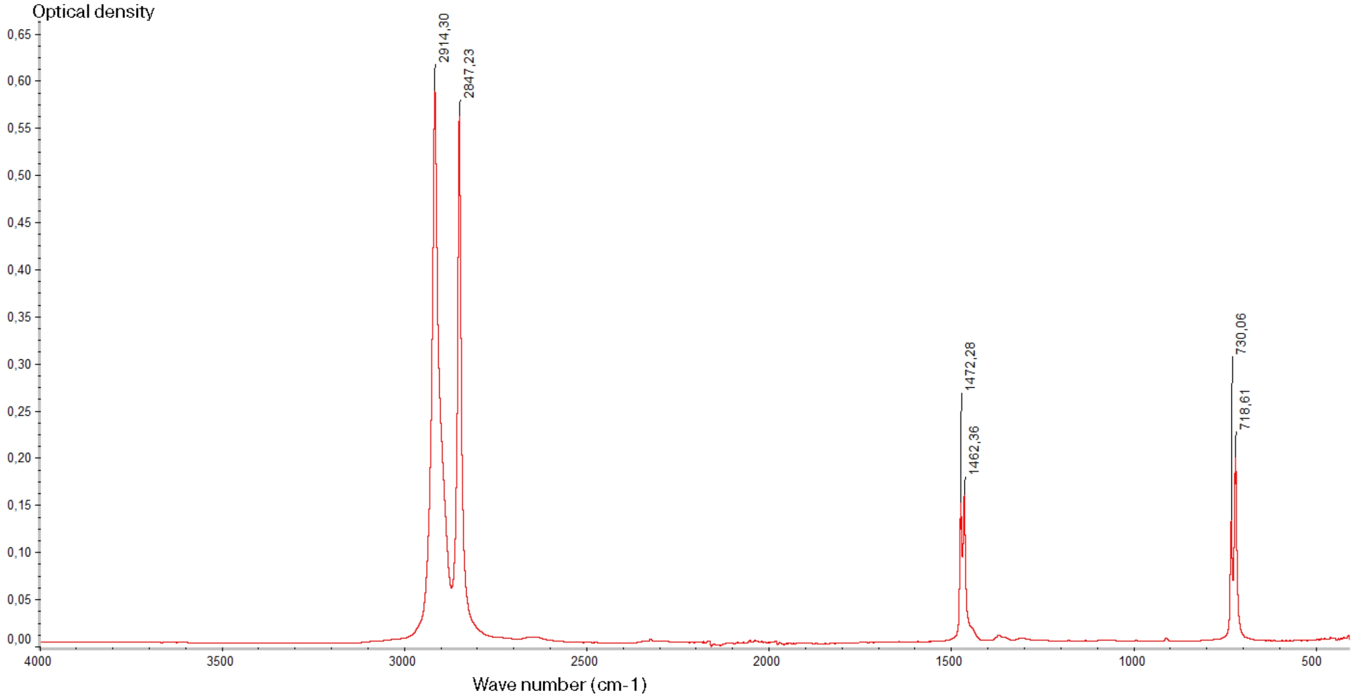
The test samples were taken in the form of granules. Using infrared spectroscopic analysis, the structures of six grades of polyethylene were studied (Fig. 1).



I-0760
High Density Polyethylene

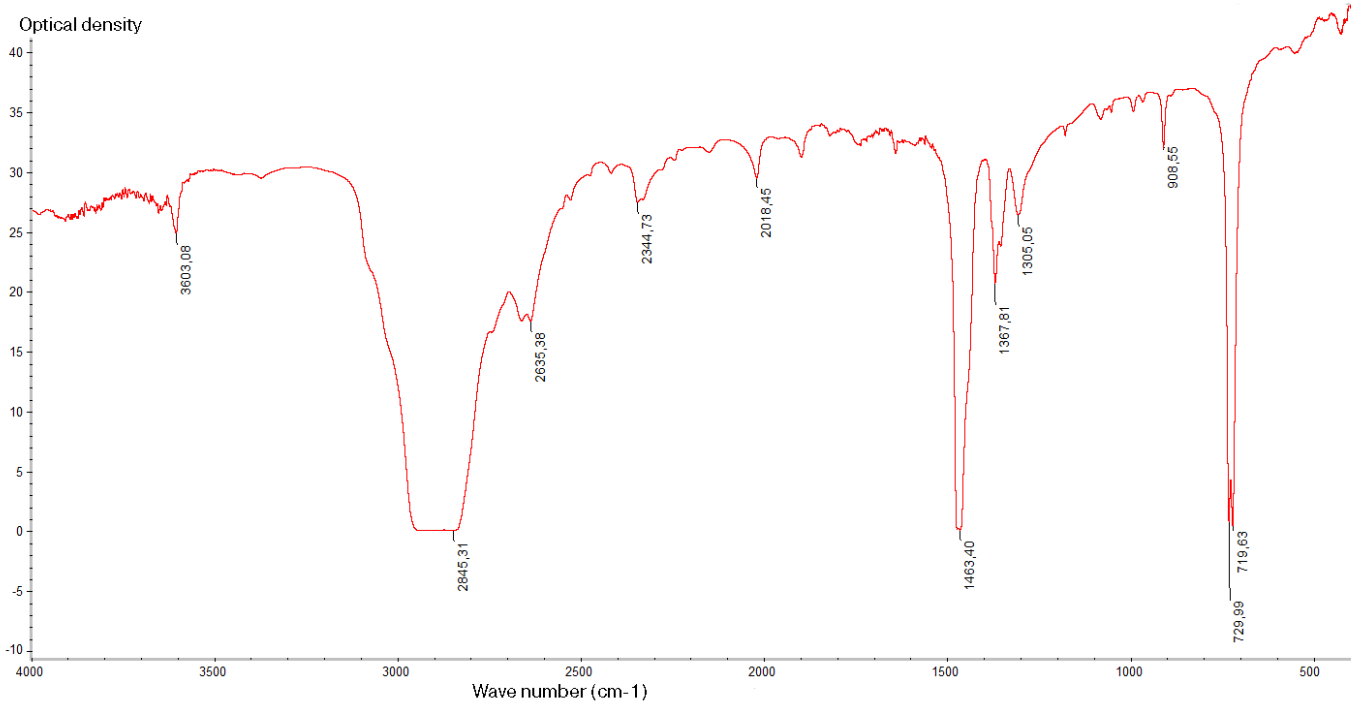


F-0120
Linear low density polyethylene



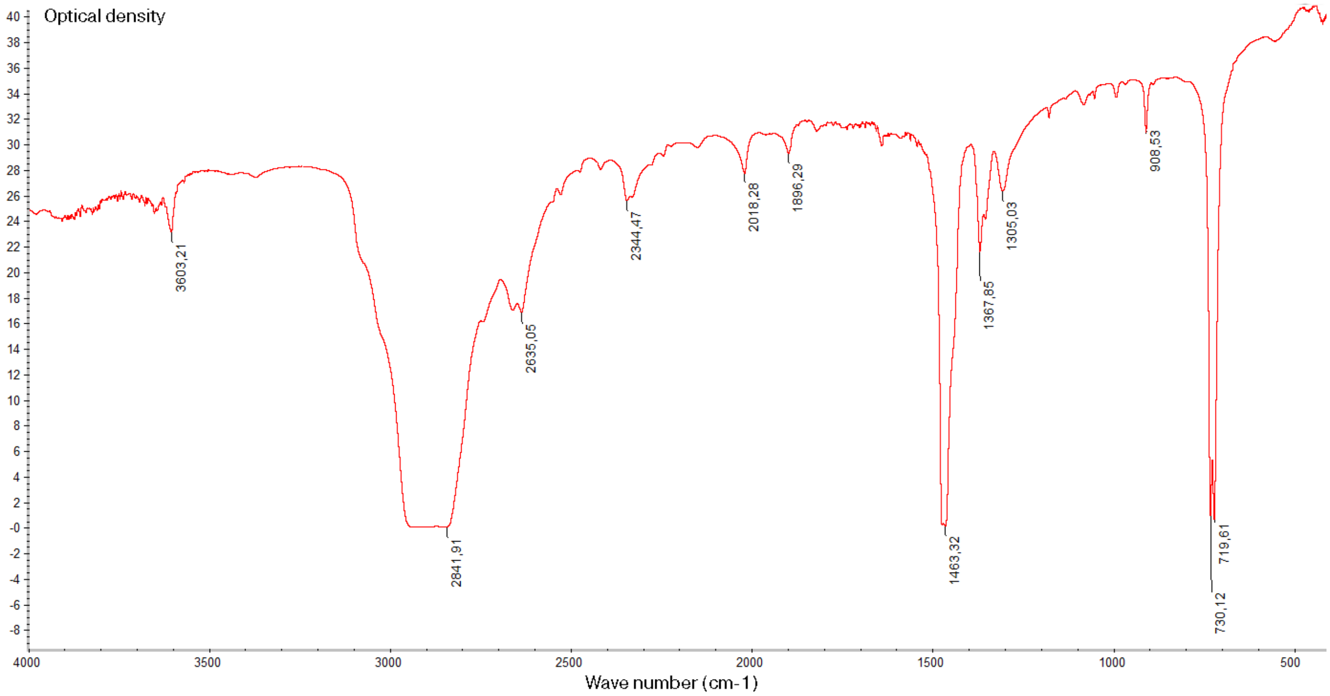
F-Y346

High density polyethylene



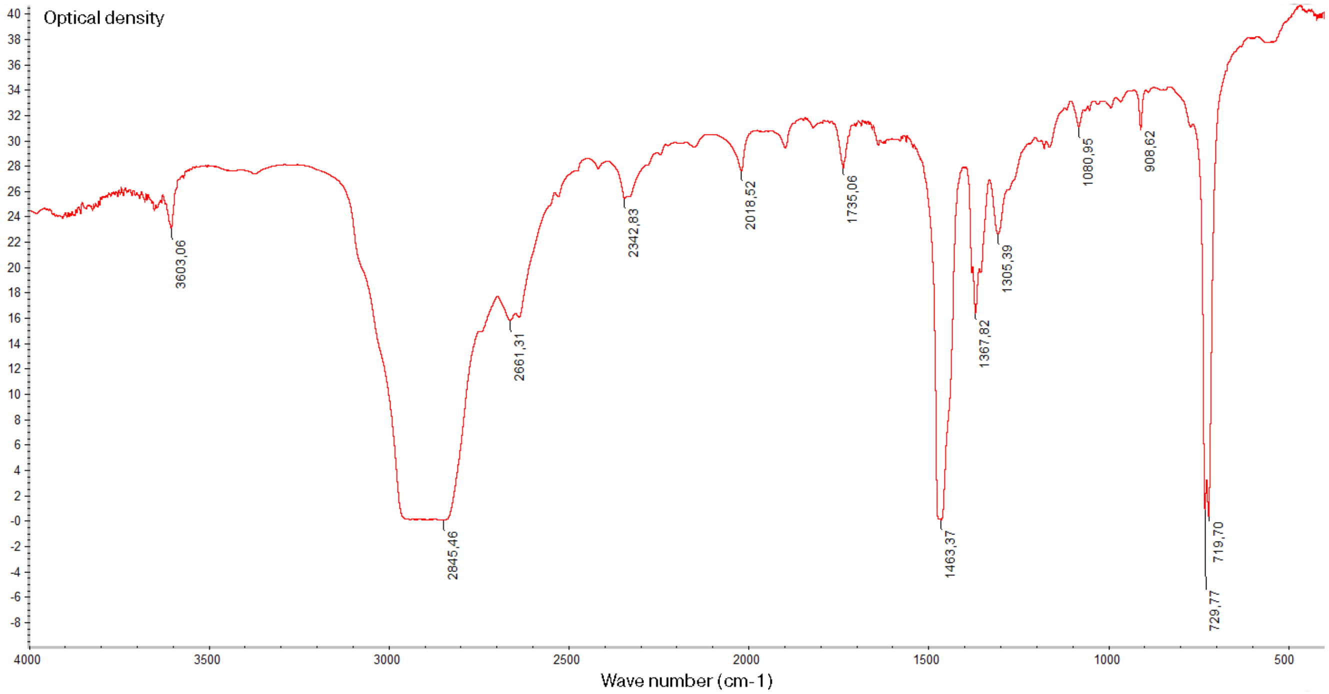
P-Y342

High density polyethylene



B-Y460

High density polyethylene



R-0333 U

Medium density polyethylene

Figure 1. IR spectra of polyethylene

And also, various organic inclusions of polyethylene were determined by determining the absorption bands in the IR spectrum.

From the analysis of the spectral results, it was shown that in all the studied samples there are aldehyde and chlorine derivatives of polyethylene (table-2).

Table 2.– Identification of the chemical composition of polymers by IR spectroscopy [5, 7–9]

№	Sample Name	Substance identified during analysis	Communication (frequency, cm^{-1})					
1.	I-0760 (HDPE)	– Aldehydes – Hydrocarbons – a) alkanes RCH3 – Chloro derivatives	ν_{CH} 2800–2900	δ^{a}_{CH3} 1450–1475	ν^{a}_{CCl3} 700–830			
2.	F-0120 (LLDPE)	– Amines: b) primary – aromatic: ArNH2 – Aldehydes – Hydrocarbons – a) alkanes RCH3 – Primary alcohols RCH2OH – Chloro derivatives	$\nu^{s}_{NH}{}^{2}$ 3325–3420	ν_{CH} 2800–2900	δ_{NH2} 1590–1650	δ^{a}_{CH3} 1450–1475	ν_{CO} 1000–1075	ν^{a}_{CCl3} 700–830
3.	F-Y346 (HDPE)	– Aldehydes – Hydrocarbons – a) alkanes RCH3 – Chloro derivatives	ν_{CH} 2800–2900	δ^{a}_{CH3} 1450–1475	ν^{a}_{CCl3} 700–830			
4.	P-Y342 (HDPE)	– Primary alcohols RCH2OH – Aldehydes – Amines: a) primary aliphatic: RCH2NH2 – Hydrocarbons – a) alkanes RCH3 – Chloro derivatives	ν_{OH} 3200–3400	ν_{CH} 2800–2900	$\delta_{NH}{}^{2}$ 1590–1650	δ^{a}_{CH3} 1450–1475	ν^{a}_{CCl3} 700–830	
5.	B-Y460 (HDPE)	– Primary alcohols RCH2OH – Aldehydes – Aromatic – Hydrocarbons – a) alkanes RCH3 – Phenols ArOH – Chloro derivatives	ν_{OH} ~3640	ν_{CH} 2800–2900	ν_{CH} 1660–2000	δ^{a}_{CH3} 1450–1475	δ_{OH} 1330–1390	ν^{a}_{CCl3} 700–830
6.	R-0333 (MDPE)	– Primary alcohols RCH2OH – Aldehydes – ArNO2 – Chloro derivatives	nOH ~3640	nCH 2800–2900	ns 1330–1370	ν_{CO} 1000–1075	ν^{a}_{CCl3} 700–830	

The rates of import / export customs duties, respectively, and the amount of customs duties paid, application of non-tariff measures, prohibitions and restrictions to goods and vehicles depend on the correctness of the classification code of the CNFEA of the Republic of Uzbekistan. In particular, the unambiguity of the classification of goods is also of great importance for increasing the objectivity of customs statistics of foreign trade used in the development of customs policy of the state and the adoption of specific measures for its implementation in the process of customs control of goods and vehicles. [6, 46–47]

Depending on the chemical nature of the monomer and the presence of intermolecular interactions between the macromolecules, the formation of polymers of a linear, branched and network structure is possible.

Most linear and branched polymers can crystallize. These include polyolefins, polytetrafluoroethylene, polyformaldehyde, isotactic polystyrene, rubber and others. During crystallization of polymers, strength, density increases and elongation and their solubility in solvents decrease. So, in polypropylene, strength increases from 14 MPa, in the amorphous state, to 37 MPa in crystalline. At the same time, a decrease in elongation ability from 500% to 240% is observed. Therefore, to select the optimal temperature-time regimes for processing such polymers, their storage and operation, it is necessary to have an idea of their crystallization and properties of the formed crystallites [7, 12].

The geometric shape of macromolecules significantly affects the properties of polymers [8]:

- linear and branched polymers are thermoplastic; when heated, linear polymers melt, can dissolve in appropriate solvents. Branched polymers dissolve poorly or do not dissolve at all and melt more difficult than linear ones;
- linear polymers have the highest density, their macromolecules are capable of orientation along the axis of a directed mechanical field (this property is used, for example, in the formation of fibers and films);
- crosslinked polymers do not melt and do not dissolve, but only swell in solvents; the determination of molecular weight for such polymers loses its meaning (there are no separate macromolecules, all chains are sewn into a single network). Mesh structures can be obtained from thermosetting polymers (table-3).

The results of the work make it possible to classify polyethylene in primary forms by molecular structure. In conclusion, it should be noted that the study of the classification of ethylene polymers by their physicochemical composition can clarify some controversial issues of the CNFEA of the Republic of Uzbekistan. And also it can be noted that, the studied brands of polyethylene are classified at position 3901 according to the CNFEA RUz [2, 265].

The development of new product codes makes it possible to protect the economic interests and security of the economy of Uzbekistan in international relations.

Table 3. – The main technical characteristics of various polyethylenes

Polyethylene	Structure	Mol. mass	Density, g/m^3	Melting point, °C	Elastic modulus, MPa	V solubility, MPa
1	*2*	*3*	*4*	*5*	*6*	*7*
Low density (high pressure)	Branched	50–800 thousand	0.913–0.914	102–105	100–200	7–17
High density (low pressure)	Branched	3.0×10^6	0.919–0.973	125–137	400–1250	15–45
Linear	Without branched	200–500 thousand	0.915–0.980	125–140	400–1600	15–60

1	*2*	*3*	*4*	*5*	*6*	*7*
Cross-linked	Cross-linked structure	5.0×10^6 and higher	0.920–0.970	145–160	600–1800	40–80
Super high molecular	Linear	10.0×10^6 and higher	0.940–0.980	160–190	700–2000	80–120

The listed varieties of polyethylene by chemical composition include polyethylene consisting of carbon and hydrogen. However, they differ significantly in molecular weight, structure, density, melting point, modulus of elasticity, price and other properties associated with the conditions of their production, their areas of application and their cost.

Given this, we believe that it is necessary and recommended to divide them and determine the code numbers for the indicated varieties of polyethylene according to the HS of Uzbekistan.

To identify varieties of polyethylene during the examination, it is sufficient to conduct their tests in accordance with the indicators given in tables-3.

References:

1. Islamova S. T., Ibragimov T., Ubaidullaev O. K. Identification of paints gas chromatography, Austrian Journal of Technical and Natural Sciences, AJT 3–4 / 2016.
2. Commodity nomenclature of foreign economic activity of the Republic of Uzbekistan (2017 version).
3. URL:http://issa.ru/tnvd/all/3901.html
4. URL:https://sgcc.uz/ru/products/view/polyethylene
5. Kovalenko V. I., Didenko T. L., Nesterov A. V. "Identification of substances in a mixture by infrared spectroscopy", Methodological guidelines,– Kazan, 2006.
6. Tudriy E. V., Galkina I. V., Sobanov A. A., Galkin V. I. Chemistry and Physics of Polymers: Teaching Aid Kazan University, 2015.
7. Islamova S. T., Khamrakulov G., Khamrakulov M. G. Identification and classification of goods of 32 groups according to the commodity nomenclature of foreign economic activity, Austrian Journal of Technical and Natural Sciences, AJT 7–8 / 2015.
8. Deryabin G. I. Organic chemistry [electronic resource]: web textbook.– / G. I. Deryabin, G. V. Kantaria, D. I. Groshev.– Electro. Text data – Samara: 1998–2019.– Access mode URL:http://orgchem.ru/vrml/link23.htm

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TECHNOLOGY OF INTENSIVE HEATING OF OIL RAW MATERIAL BY DEGREARED FACTORES

Abstract. a critical analysis of the technology of distillation of oil with superheated water vapor; proposed a new technology for the use of dehydrated vapors of distillate fractions during atmospheric distillation of oil and in the process of its heating; The technological efficiency of the use of this technology and the degree of intensification of the process in the heat exchangers of the oil refinery are shown.

Keywords: oil, distillation, steam, heat of condensation, heating, heat exchanger; intensification, effectiveness.

According to the existing technology of motor fuel production, the distillation of hydrocarbon raw materials (oil, gas condensate and their mixtures) and the distillate distillation of fuel fractions is carried out using superheated water vapor (1 MPa, 450 °C) [1–3]. Introduced in the bottom part of a complex distillation column and its stripping sections, the acute superheated water vapor increases the degree of evaporation of the raw material components by reducing the partial pressure of hydrocarbon vapors, which allows the process to be distilled at lower temperatures [1; 2; 4].

The consumption of water vapor in the process of atmospheric distillation of crude oil is 2.0 ÷ 6.5% [2; 5], depending on the consumption of raw materials, its composition and process parameters.

Analysis of the existing technology for the distillation of oil with water vapor showed [2; 5; 6] that:

– in the process of distillation, water vapor, being in close contact with raw materials and petroleum products, is saturated with hydrocarbon vapors and forms a heterogeneous steam mixture;

– water vapor, which is in the composition of vapor fractions, from a technological point of view is a foreign agent; it occupies a certain part of the technological volume of the apparatus, which leads to an increase in their overall dimensions and mass in the design stage;

– the steam mixture formed during the distillation is characterized with different values of the latent heat of condensation of the constituent components, which complicates the conditions of the process of condensation of the steam mixture, prevents intensive flow of the conducted heat and mass transfer processes during steam condensation and reduces the technological efficiency of the apparatus;

– the formed condensate of water vapor (acidic water) enhances the corrosion of the working surfaces of the apparatus and the pipelines to them;

– in subsequent stages, when the process condensate is separated from water, there is a probability of watering of motor fuel and the need for its subsequent drying.

In addition, "polluted" as with oil fractions, and sulfur, nitrogen and other impurities, waste water must also be cleaned, which will require additional costs.

For these reasons, from the technological point of view, it is advisable to drastically reduce the consumption of water vapor for the distillation of hydrocarbons or to conduct this process without its participation.

According to the results of research carried out by us under the leadership of academician of the Academy of Sciences of the Republic of Uzbekistan Z. Salimov, the technology of "dry" distillation of oil and gas condensate feedstock using alternative (instead of water vapor) coolant – fuel fractions leaving the atmospheric distillation column at high temperatures [6; 7].

According to the technology proposed by us, a pair of dehydrated distillates of fractions formed during the distillation will be used as a heating agent. In this case, due to the lack of water in the composition of the heating steam, part of the volume of the annular space of the heat exchangers of the refinery, previously occupied by water vapor, is released. At the same time, the released technological volume of the apparatuses is as much as the water vapor previously occupied (2.0 ÷ 6.5%).

Such an additional increase in the technological volume of the apparatus leads to the intensification of heat and mass transfer processes during the condensation of homogeneous hydrocarbon vapors and increases the technological efficiency of heat exchangers, which is confirmed by the results of our own experiments [8].

The lack of water eliminates the accumulation in the casing of the apparatus of air and non-condensable gases emitted from the composition of water vapor during its condensation. This helps to improve the condition of condensation of homogeneous composition of hydrocarbon vapors and leads to an increase in the coefficient of heat transfer from steam to the tubular heating surface of the apparatus.

The generalized positive impact of the above factors is the basis for the intensification of the processes of thermal preparation (heating) of crude oil during vapor condensation and cooling of distillates of fuel fractions in tubular heat exchangers.

As is known, one of the most important advantages of hydrocarbon vapors is the low heat of their condensation r_{el} compared to the heat of condensation of water vapor [9; 10].

A comparison of the heat of condensation of hydrocarbon vapors and water at $P = 250$ kPa showed that hydrocarbon vapors have a measured condensation temperature $t = 145$ °C and a calculated $r_{el} = 255.88$ kJ/kg [9]. According to [11], at 250 kPa, the tabular values of the corresponding indicators of water vapor are temperature.

Therefore, in this case, the ratio

$$r_{\mathrm{wv}}/r_{\mathrm{el}} = 2174.7/255.9 = 8.5, \quad (1)$$

indicates, as far as possible, to intensify the process of heat exchange in the apparatus at no additional cost, reduce the required heat transfer surface at a given heat exchanger capacity, or increase its thermal capacity.

The share of the released technological (annular) space of heat exchangers K_V (%) used to intensify the processes of heat and mass transfer can be defined as the ratio of the costs of water G_{wv} and hydrocarbon vapor G_{el}:

$$K_V = (\mathrm{G}_{\mathrm{wv}}/\mathrm{G}_{\mathrm{el}}) \cdot 100\% = (\mathrm{G}_{\mathrm{wv}}/V_{н}\rho_{н}K_{\mathrm{з}}K_{\mathrm{ф}}) \cdot 100\%, \quad (2)$$

where G_{wv} and G_{el} are determined from the material balance of the distillation process, kg/h; V_{H} – atmospheric distillation column capacity for raw materials, m^3/h; ρ_H – density of raw materials, kg/m^3; K_S – coefficient of loading of raw materials in an oil refinery; K_{fr} – the rate of release of target fractions,% of the mass.

The value of K_V can also be determined by the costs of leaving the oil fractions G_{fr}:

$$K_V=(G_{\mathrm{wv}}/G_{\mathrm{fr}})100\% = (G_{wv}/(G_{\mathrm{ga}}+G_{\mathrm{ker}}+G_{\mathrm{diz}})100\%, \quad (3)$$

where G_{ga}, G_{ker} and G_{diz} are the amount of the main product produced in the installation (gasoline, kerosene and diesel fuel), kg/h.

The value of K_V shows how much it is possible to increase the volume of the produced products using carbon vapors instead of water vapor, without overloading the composite apparatus of the refinery.

The increase in thermal efficiency K_Q of the heat exchanger, achieved due to the intensification of heat transfer in it, can be defined as:

$$K_Q = (r_{wv}/r_{ker}) \cdot K_V \qquad (4)$$

For example, for an oil refinery heat exchanger in which oil is heated during condensation of fraction vapors, the increase in its thermal efficiency in (4) is: $K_Q = (r_{\text{wv}}/r_{\text{el}}) \cdot K_V = (2019.9/245.3) \cdot 2.47 = 20.34\%$, where $r_{wv} = 2019.9$ kJ/kg is the heat of condensation of superheated steam at 180 °C and pressure of 1.0 MPa [11]; $r_{el} = 245.3$ kJ/kg – heat of condensation of vapors of distillate fractions at 180 °C.

The efficiency of using hydrocarbon vapors during the primary distillation of oil in the ELOU-AVT-3 unit of the refinery can be shown by calculation using the following integrated technological parameters of this unit: unit capacity for oil is 240 m^3/h, unit loading rate is $V_n = 180$ m^3/h; the number of factory days per year – $T = 365$ days; oil density – $\rho_n = 844$ kg/m^3; the coefficient of irregularity of the installation is assumed to be $K_{ir} = 0.9$.

At the same time, the minimum share of the released technological space K_v of the main apparatuses of the oil refining plant according to (4.2) is: $K_V = G_{wv}/(24 \cdot V_n \rho_n)100\% = 90/(24 \cdot 180 \cdot 0.844)100\% =$ $= 2.47\%$.

The value of $K_V = 2.47\%$ indicates the possibility of producing heat treatment of raw materials by 2.47% more or reducing the technological load on heat exchangers (condensers, heat exchangers, air and water coolers) by 2.47% at a given installation capacity (see Table 1).

Table 1. – Technological indicators of the effectiveness of the use of hydrocarbon coolant in the installation ELOU-AVT-3

№	Indicators	Units	Values of indicators
1	The load rate of the installation ELOU-AVT-3	m^3/hour	180
2	The number of products obtained (according to the regulations):		
	– gasoline	t/day	540
	– kerosene TS-1	t/day	465
	– diesel fuel	t/day	917
3	Consumption of water vapor for the distillation of oil	t/day	90÷120
4	(according to the regulations)	t/day	
	Daily amount of additionally produced products at $K_V = 2.47\%$:	t/day	13.338
	– gasoline	t/day	11.416
	– kerosene TS-1	t/day	22.65
5	– diesel fuel		
	Annual volume of additional output at Vr = 0.9:	t/year	4381.5
	– gasoline	t/year	3750.2
	– kerosene TS-1	t/year	7440.5

Judging by the data in the table and taking into account the large volume of oil refined by the plant (2 ÷ 10 million tons per year), the indicators of introducing its technology of thermal preparation for primary distillation using alternative heat carrier (instead of water vapor) will be significant.

Thus, the intensification of the process of heating the crude oil in tubular heat exchangers using dehydrated vapors of distillate fractions contributes to an increase in the thermal efficiency of the apparatus, the design of high-intensity compact apparatus and the development of scientific and practical fundamentals of an intensive technology of thermal preparation of the crude oil to atmospheric distillation.

References:

1. Skoblo A. I., Molokanov Yu. K., Vladimirov A. I. and others. Processes and devices of oil and gas processing and petrochemistry: Textbook for universities. 3rd ed., Pererab. and add. – M.: Nedra, 2000. – 677 p.
2. Glagoleva O. F., Kapustin V. M., Gulmisaryan T. G. and others. Technology of oil refining. In 2 parts. Part one. Primary oil refining / Ed. O. F. Glagolevoj and V. M. Kapustin – M.: Chemistry, Colossus, 2006. – 400 p.
3. Manovyan A. K. The technology of primary processing of oil and natural gas. Textbook for universities. 2nd ed. – M.: Chemistry, 2001. – 568 p.
4. Kasatkin A. G. The main processes and devices of chemical technology: A textbook for universities. – 8th ed., Pererab. – M.: Chemistry, 1973. – 743 p.
5. Akhmetov S. A. Technology of deep processing of oil and gas: a textbook for universities. Ed. 2nd, pererabot. and add. – SPb: Nedra, 2013. – 544 p.
6. Salimov Z. S., Khudayberdiev A. A., Sharipov K. K., Khurmamatov A. M. Effective use of hydrocarbon vapors in the primary distillation of oil and gas condensate raw materials // Journal of Oil and Gas of Uzbekistan, 2011. – No. 2. – P. 34–35.
7. Salimov Z. S., Abdurahmonov O. R., Saidakhmedov Sh. M. Intensification of the process of rectification of oil and gas condensate feedstock. – T.: FAN, 2011. – 150 p.
8. Salimov Z. S., Sharipov K. K., Khudaiberdiev A. A. Study of the processes of condensation of water and hydrocarbon vapors in a two-tube heat exchanger // Uzbek Chemical Journal, 2011. – No. 2. – P. 59–62.
9. Rabinovich G. G., Ryabykh P. M., Khokhryakov P. A. and others. Calculations of the main processes and devices of oil refining: a Handbook / Ed. E. N. Sudakova. – 3rd ed., Pererab. and add. – M.: Chemistry, 1979. – 568 p.
10. Sardanashvili A. G., Lvov A. I. Examples and tasks of oil and gas processing technology: a manual for students of oil specialties of universities. – 2nd ed., Pererab. and add. – M.: Chemistry, 1980. – 256 p.
11. Pavlov K. F., Romankov P. G., Noskov A. A. Examples and objectives for the course of processes and devices of chemical technology. Textbook for universities / ed. P. G. Romankova. – 10th ed., Pererab. and add. – L.: Chemistry, 1987. – 576 p.

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STUDYING OF A MINERALOGICAL COMPOSITION OF DEPOSITS FORMED BY VAPORIZATION CAUSTIC SODA SOLUTION

Abstract. In this article, we obtained data on the possibility of obtaining caustic soda by the lime method from soda ash in the presence of sodium sulfate. On the basis of X-ray, thermographic and mineralogical methods of analysis, the mineral composition of sediments was determined. A microscopic analysis of the precipitation was made.

Keywords: soda ash, caustic soda, radiograph, thermogram, microscopic analysis, solution, mirabilite, burkeite, filtration, caustification.

At the beginning of the 19th century, the development of caustic soda (NaOH) production was closely associated with the development of soda ash production. This relationship was due to the fact that soda ash was the raw material for the chemical method of producing NaOH, which was caustified with lime milk in the form of soda solution.

Under existing conditions, the most acceptable is to obtain a solution of caustic soda by the lime method, when at this enterprise there are lime and soda ash, which are raw materials.

This production method is characterized by low energy expenditure and simple instrumentation.

In the lime process, as a result of caustification reaction and subsequent separation of the sludge, a dilute solution of sodium hydroxide with a concentration of up to 120–140 g/l is obtained, which is further subjected to evaporation.

Considering the above, organizing the production of caustic soda solution at soda factories, for example, in Uzbekistan, will allow for the production of an import-substituting product, which will have a significant technical and economic effect.

However, the advantages of this method are the stages of filtration and evaporation.

It is known that the size of calcium sulfate crystalline hydrates, depending on the conditions of caustification, can be several times larger than calcium carbonates. This creates good conditions for accelerating the process of settling and filtering.

In order to intensify the filtration process, caustification was carried out with the addition of mirabilite. The bottom line is that during caustification two reactions proceed in parallel:

$$Na_2CO_{3(sol)}+Ca(OH)_{2(solid)}\leftrightarrow 2NaOH_{(sol)}+$$
$$+CaCO_{3(solid)}+Q_1$$
$$Na_2SO_4+Ca(OH)_{2(solid)}\leftrightarrow 2NaOH_{(sol)}+$$
$$+CaSO_4\cdot nH_2O_{(solid)}+Q_1$$

As a result of these reactions, caustic soda and a significant amount of sodium carbonate and sodium sulphate remain in solution with precipitation of sulphate and calcium carbonate crystalline hydrates.

To establish the relationship between the physicochemical properties of one of the evaporated caustic soda and the degree of evaporation, the process was carried out slowly with measuring the weight of the reaction mass and observing the state of the system.

From the analysis of the system $2Na^+$, $Ca^{2+}/2OH^-CO_3^{2-}$, SO_4^{2-} $-H_2O$ it follows that in increasing the NaOH content in the liquid phase, the solubility of sulfate and carbonate salts of sodium and calcium decreases with their transition to the solid phase.

Analysis of the lateral part of three- and four-component systems: $Na_2CO_3 - Na_2SO_4 - H_2O$; $Na_2SO_4 - NaOH - H_2O$; $Na_2CO_3 - NaOH - H_2O$; $Na_2CO_3 - Na_2SO_4 - NaOH - H_2O$ shows that from weak solutions of caustic soda containing the above salts, it is possible to obtain concentrated or even scaly sodium hydroxide. However, the evaporation process is carried out in stages with the separation of precipitated crystals during the evaporation. The number of stages and the degree of evaporation are determined in advance by theoretical analysis of the above systems. Analysis of systems $Na_2CO_3 - NaOH - H_2O$; $Na_2SO_4 - NaOH - H_2O$ revealed that by caustification of Na_2CO_3 and Na_2SO_4 with lime milk, caustic soda can be obtained with a concentration of 10–15% with a content of 2–5% calcium carbonate or sodium sulfate. At the first stage of evaporation at 100 °C, concentrated caustic soda will be obtained with the content, mass.%: 34.50–34.3% NaOH, 0.52% – Na_2CO_3 and 1.00% Na_2SO_4 with precipitation of the solid phase $Na_2CO_3\cdot H_2O$, Na_2CO_3 and Na_2SO_4, respectively.

From the analysis of the $Na_2CO_3 - Na_2SO_4 - H_2O$ and $Na_2CO_3 - Na_2SO_4 - NaOH - H_2O$ system, it follows that the conversion of carbonate-sulphate solutions with lime milk can also produce a 10–15% solution of caustic soda with a content of 2–5% carbonates and sodium and calcium sulphates.

At the first stage of stripping at 100 °C, one stripped off solution will be obtained with content, mass %: $NaOH\cdot Na_2SO_4$–0.32 and Na_2CO_3–0.28 with precipitation of Na_2SO_4, Na_2CO_3 of the burkeite composition and $mNa_2SO_4\cdot nNa_2CO_3$ in the solid phase.

Table 1. – The influence of technological parameters on the process of evaporation

№	Level of evaporation%	Filtration rate, $kg/m^2\cdot h$	Humidity, φ,%	The ratio of L: S after evaporation
1.	40	5306.93	33.09	14.11 : 1
2.	50	4570.72	28.58	6.36 : 1
3.	60	4103.07	4.0	2.03 : 1
4.	70	295.30	47.52	1.71 : 1

At the second stage of the process after separation of the solid phase at the boiling point, the solution is sent to the stage of obtaining solid caustic soda. You can get a solid caustic soda with a content of 2.42% – Na_2SO_4, 1.60% – Na_2CO_3, 0.64% – Na_2SO_4 and 0.56% – Na_2CO_3 concurrently when using sulfate, sodium carbonate or a mixture of these. Thus, analysis of the above systems implies that caustic soda from a mixture of sulphate and sodium carbonate is more effective in terms of the quality of the products, processability and technical and economic indicators. Therefore, we previously studied [1; 2] the process of caustification of soda ash in the presence of sodium sulphate and showed the possibility of evaporation of caustification products. In this paper, the physicochemical properties of one evaporated solutions and the composition of the precipitates formed are studied using modern physicochemical methods of analysis.

Table 2. – The chemical composition of the evaporated solutions of caustic soda

Correspond to numbers in Tab.1	Content of components, mass%					
	SO_4^{2-}	OH^-	CO_3^{2-}	Ca^{2+}	Na^+	Ratio SO_4^{2-}/ CO_3^{2-}
1	2.754	6.74	2.80	0.0146	12.71	0.98
3	0.50	11.80	2.24	0.0149	18.10	0.22
4	0. 32	14.50	2.99	0.0141	25.59	0.10

Table 3. – The chemical composition of the solid phase formed during the evaporation of the initial solutions

Correspond to numbers in Tab.1	Content of components, mass.%					
	SO_4^{2-}	OH^-	CO_3^{2-}	Ca^{2+}	Na^+	Ratio SO_4/CO_3
1	41.16	0.84	17.20	0.049	38.60	2.39
3	29.16	0.94	21.60	0.059	27.71	1.35
4	24.65	3.78	22.17	0.0594	34.12	1.11

As the original solution used caustic soda solution with content, wt.%: OH^-4.084; Na^+ – 7.811; SO_4^{2-}– 1.870, CO_3^{2-}–1.988, obtained from a mixture of soda ash and sodium sulfate at a ratio of 10:1. The original solution was evaporated to 40, 50, 60, 70 and 80% of the total mass, and the precipitation were separated by filtration. The obtained liquid and solid phases were analyzed for the main components by well-known methods [3; 4] with the determination of the following physicochemical properties of the liquid phase: density, viscosity, electrical conductivity, light refraction index [5; 6].

The mineralogical composition of the precipitation was determined using X-ray, differential-thermal [6] and microscopic analysis methods [7] (Tables 1–4).

From table 1 shows that with an increase in the degree of evaporation, the amount of the solid phase increases from 3.95 to 10.70% relative to the initial solution, and the ratio W: T decreases from 14.10 to 1.7. The filtration rate is very high and varies in the range 4103–5306 kg/m^{2}g, however, with an increase in the degree of evaporation to more than 70%, it sharply decreases to 295.3 kg/m^2, which is explained by the increase in viscosity of the liquid phase.

With an increase in the degree of evaporation, the SO_4/CO_3 ratio decreases from 0.98 to 0.10 and 1.11, respectively, in the liquid and solid phases. It should be noted that with an increase in the degree of evaporation, the amount of sulfate and carbonate ions in the liquid phase decreases from 5.55 to 1.8%.

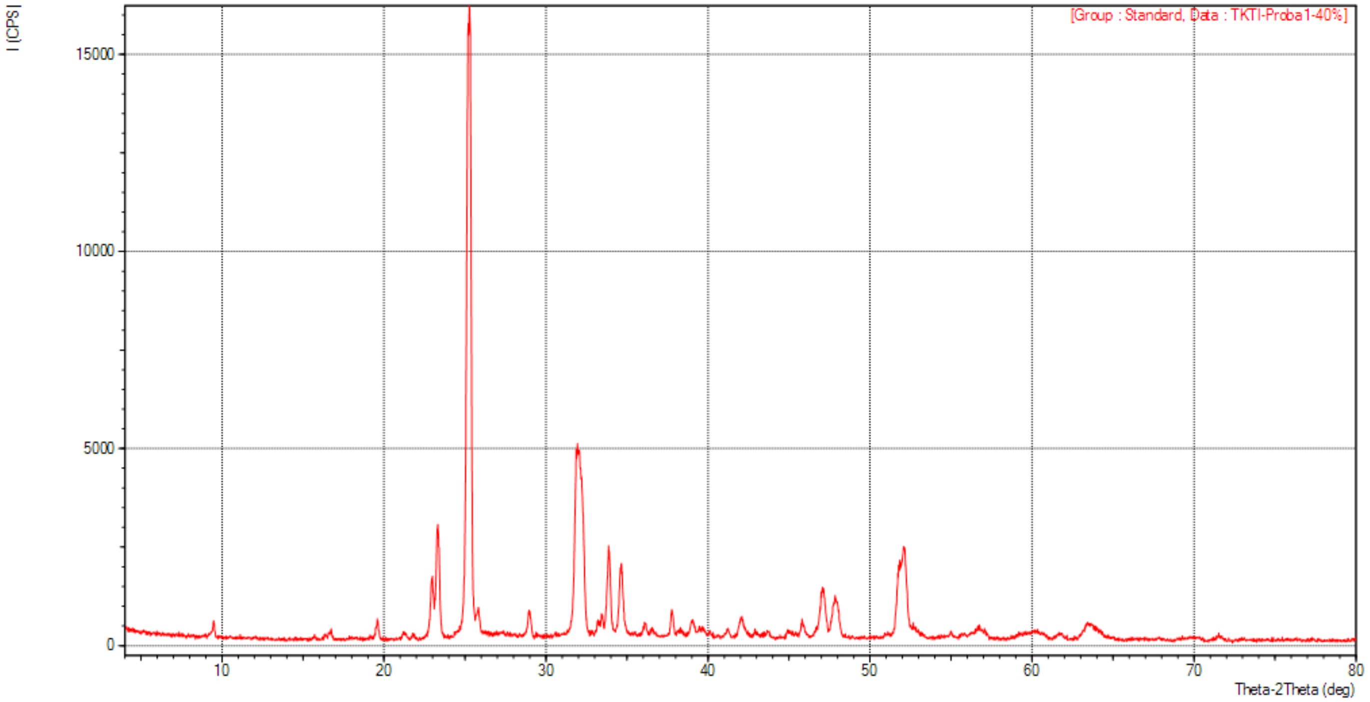
Table 4. – Physico-chemical properties of one evaporated off solutions

Correspond to numbers in Tab.1	**Viscosity, cPz**				**Density, kg/m^3**				**Electrical conductivity, at 25 °C. μS/cm**	**Indicator light refraction, at 20 °C**
	20 °C	**40 °C**	**60 °C**	**80 °C**	**20 °C**	**40 °C**	**60 °C**	**80 °C**	**43.11**	**140,1**
1	433.89	96.96	38.95	22.97	1.265	1.259	1.254	1.241	42.80	139.5
2	526.54	89.44	40.41	35.07	1.272	1.263	1.254	1.245	28.91	141.5
3	1337.1	207.82	72.43	47.20	1.354	1.343	1.338	1.331	19.77	143.5

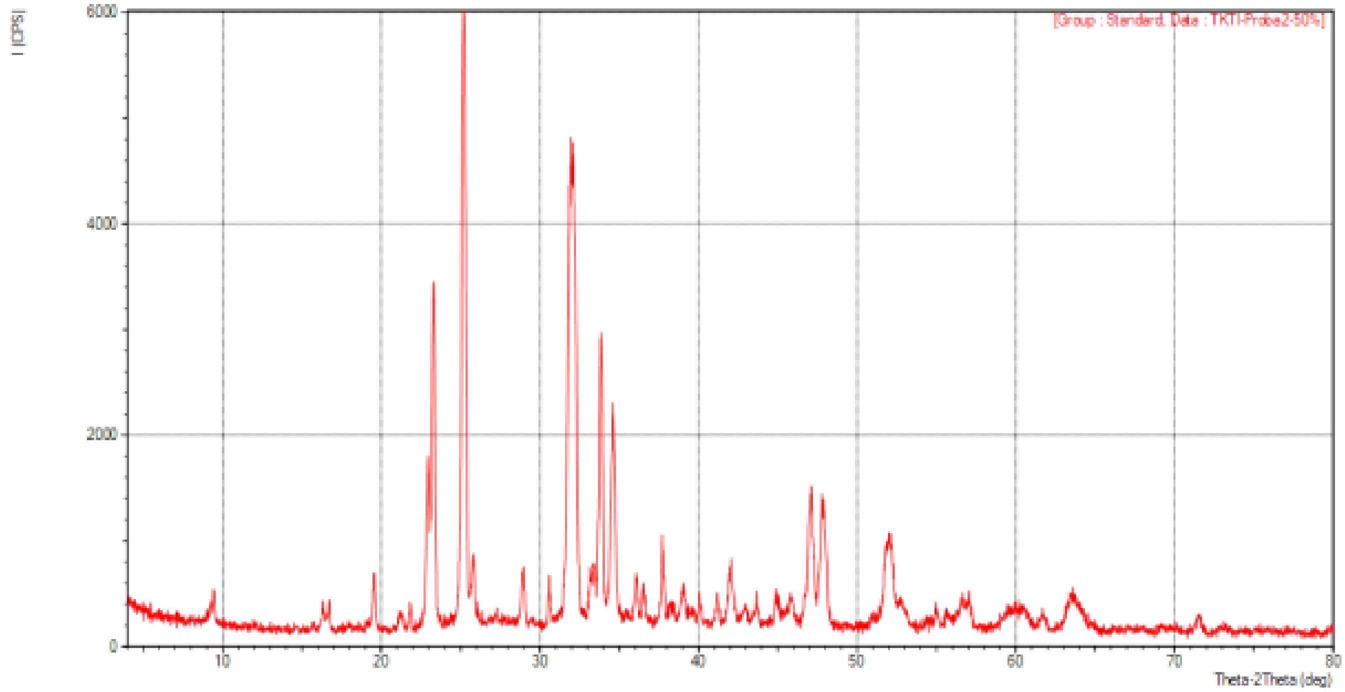
With an increase in the degree of evaporation more than 60% of the liquid mass becomes thicker. Even at 70% evaporation at 20–80 °C, the liquid phase thickens, and therefore, in Table 4, the physicochemical properties of the samples evaporated to 60% are given. In the studied intervals of variation of the degree of evaporation, viscosity, density, electrical conductivity, and refractive index vary in the intervals of 22.97–1337.10 cPz, 1241–1354 kg/m^3, 19.77–43.4 μS/cm) and 140.1–143.5, respectively. The degree of evaporation and temperature strongly affect the viscosity of the samples. An increase in the degree of evaporation from 30 to 60% leads to a viscosity increase of more than 2 times at 20 °C, and an increase in temperature from 20 to 80 °C leads to a decrease from 18.9 to 28, viscosity 33 centipoise, respectively, at 40 and 60% of the evaporation.

According to the results of physicochemical analyzes, the mineralogical composition of the solid phase consists mainly of burkeite and sodium carbonates, the ratio ($Na_2CO_3 \cdot Na_2CO_3 \cdot 2Na_2SO_4$) increases with increasing degree of evaporation.

```
File Name    : Standard\TKTI-Proba1-40%
Sample Name  :                          Comment :
Date & Time  : 04-22-19 16:05:53
Condition
  X-ray Tube : Cu(1.54060 A)   Voltage : 30.0 kV   Current : 30.0 mA
  Scan Range : 4.0000 <-> 80.0000 deg   Step Size : 0.0200 deg
  Count Time : 0.30 sec    Slit  DS : 1.00 deg  SS : 1.00 deg  RS : 0.30 mm
```



```
File Name     : Standard\TKTI-Proba2-50%
Sample Name   :                          Comment :
Date & Time   : 04-22-19 16:26:42
Condition
  X-ray Tube : Cu(1.54060 A)    Voltage : 30.0 kV    Current : 30.0 mA
  Scan Range : 4.0000 <-> 80.0000 deg    Step Size : 0.0200 deg
  Count Time : 0.30 sec     Slit  DS : 1.00 deg  SS : 1.00 deg  RS : 0.30 mm
```



```
File Name     : Standard\TKTI-Proba3-60%
Sample Name   :                          Comment :
Date & Time   : 04-22-19 16:47:28
Condition
  X-ray Tube : Cu(1.54060 A)    Voltage : 30.0 kV    Current : 30.0 mA
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  Count Time : 0.30 sec     Slit  DS : 1.00 deg  SS : 1.00 deg  RS : 0.30 mm
```
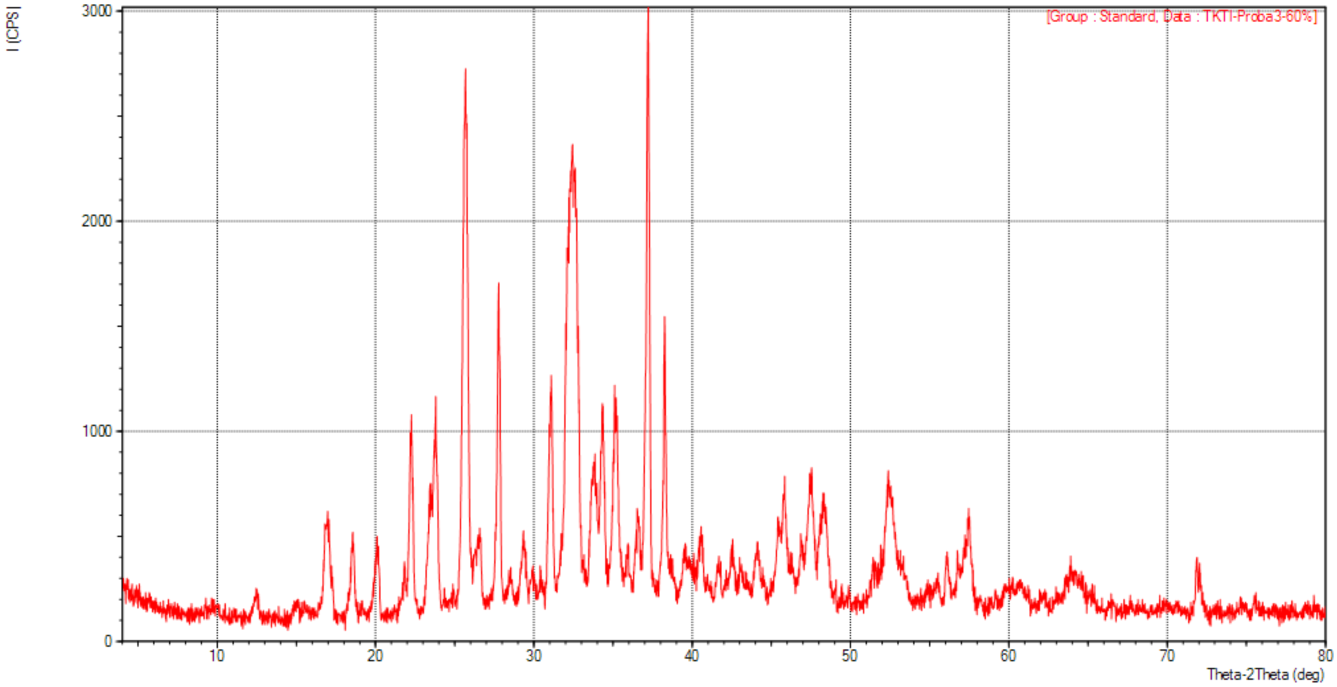
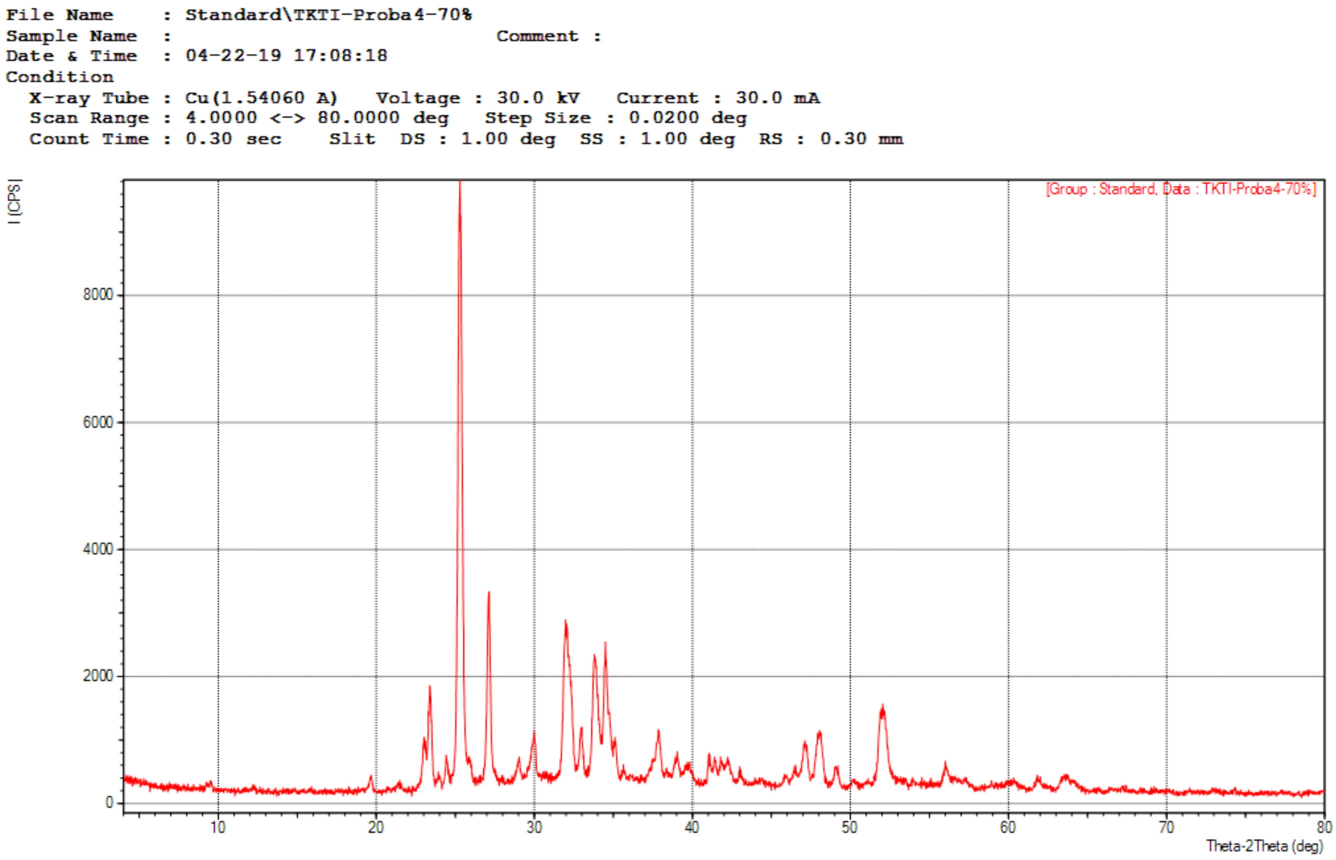





```
File Name     : Standard\TKTI-Proba4-70%
Sample Name   :                          Comment :
Date & Time   : 04-22-19 17:08:18
Condition
  X-ray Tube : Cu(1.54060 A)   Voltage : 30.0 kV   Current : 30.0 mA
  Scan Range : 4.0000 <-> 80.0000 deg   Step Size : 0.0200 deg
  Count Time : 0.30 sec    Slit  DS : 1.00 deg  SS : 1.00 deg  RS : 0.30 mm
```

Figure 1. The X-ray diffraction pattern of precipitation formed during evaporation of weak caustic soda solutions. Sample numbers correspond to the numbers in Table 1.

On the equipment of radiographic, thermographic and mineralogical methods of analysis the mineral composition of precipitation is determined. The X-ray diffraction patterns (Fig. 1) and the data show that table 5 at the beginning of the process and 40% precipitation evaporate the burkeite with a content of up to 12.5 tenardite, and with a 50% degree of evaporation, sodium carbonate appears in the precipitation. and calcium sulphate, and with more than 60% evaporation in the precipitate appears a small amount of calcium carbonate. In the case of more than 70% evaporation, the content of calcium salts decreases to less than 0.5%, and therefore their characteristic peaks disappear in the X-ray diffraction pattern.

Thermoanalysis data (Fig. 2.) indicate that mass loss in the temperature range of 20–270 °C occurs in one stage at – 80–95 °C, in the same range there is a loss of free water with a loss of 1.88% of the mass. Two endothermic peaks at 82.0 and 88.7 °C are indicated on the DSC curves. The process is endothermic with energy absorption – 60.35 J/g.

The data of thermal analysis (Fig. 2) of the second sample is similar to the previous one (sample 1): mass loss in the temperature range 20–27 °C occurs in one stage at 80–95 °C, and in the same range there is a loss of crystallization free water with a loss of 2.51% by mass. Here, DSC curves indicate two endothermic peaks at 82.9 and 89.0 °C. The process is endothermic with absorption – 86.62 J/g of energy.

It follows from the thermogram that the loss of mass in the sample does not exceed 1.88 and 2.51% and there is a double deep endo-effect corresponding to 82.9 and 88.7–89.0 °C characteristic of the modification transformation of burkeite.

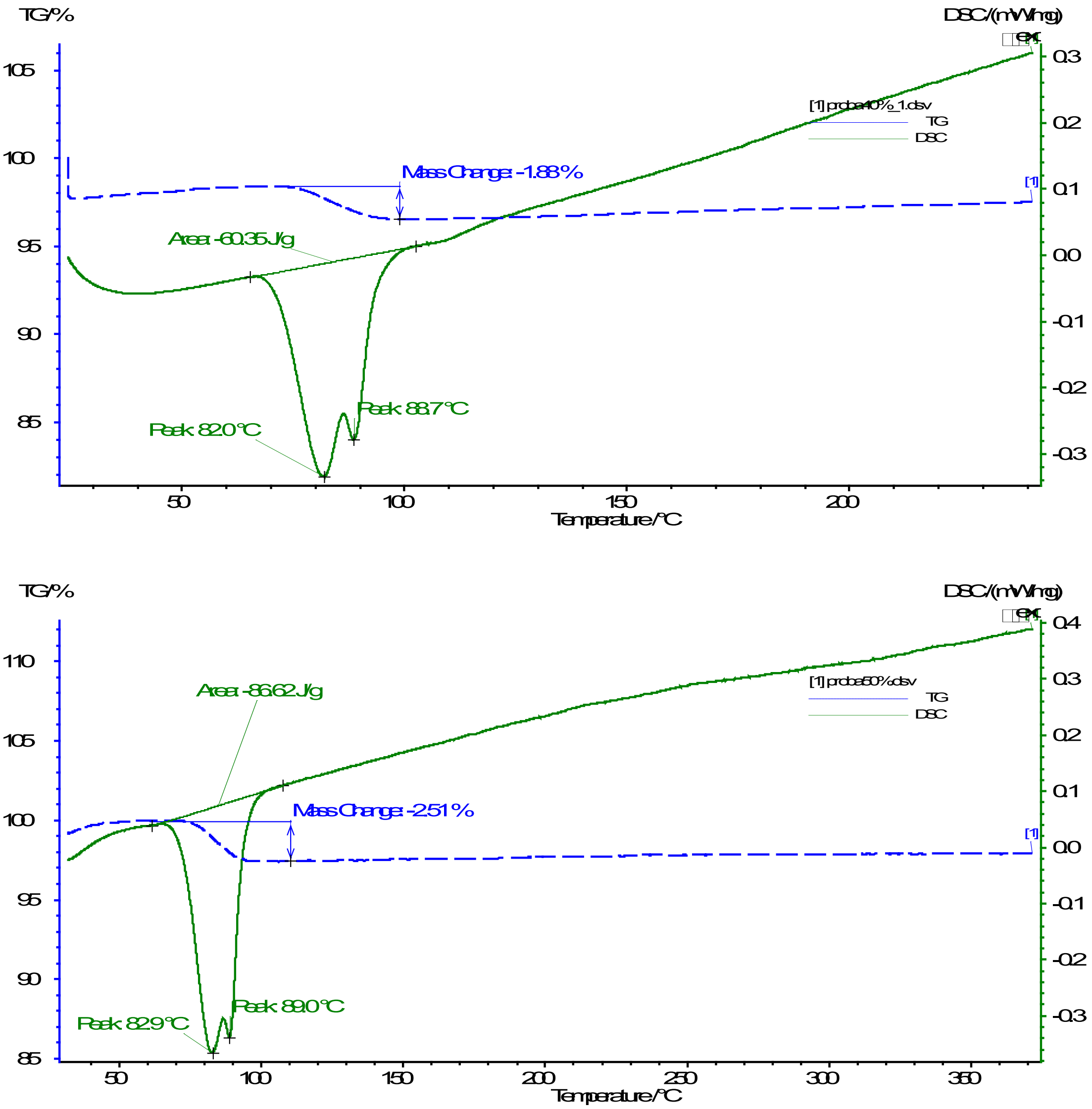


Figure 2. Thermogram of precipitation formed during the recovery of weak caustic soda solutions. The number of samples correspond to the numbers in Table 1.

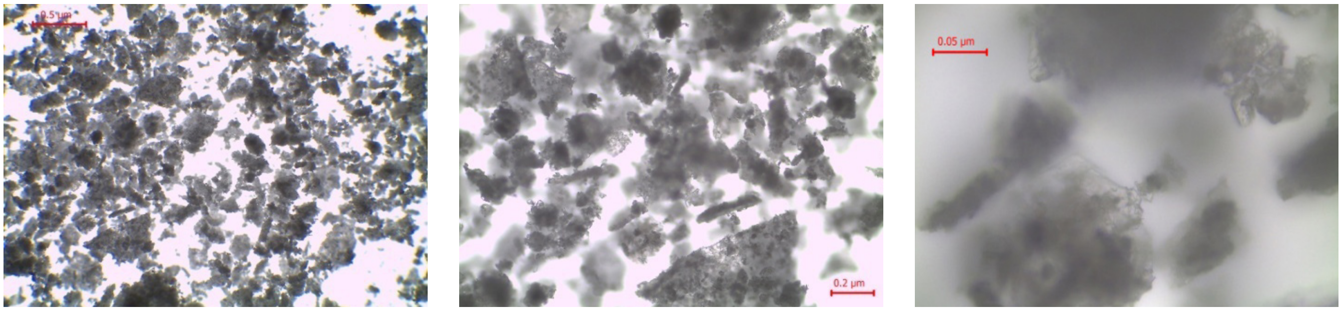
Table 5. – Mineralogical composition of precipitation formed during the recovery of weak solutions of caustic soda

The number of samples corresponds to the numbers of the tables	**Content of minerals, mass.%**				
	Na_2SO_4	**Na_2CO_3**	**$2Na_2SO_4 \cdot Na_2CO_3$**	**$CaSO_4$**	**$CaCO_3$**
1	12.50	–	87.50	–	–
2	7.30	26.90	50.20	15.60	–
3	10.70	24.60	52.05	11.80	0.85
4	6.81	60.07	33.12	–	–

From the micrograph of precipitation it can be seen that when caustic soda is evaporated, an unformed scaly is formed with a crumbly precipitate with dimensions of 0.2–2.0 mm.

Therefore, the filtration rate of the evaporated caustic soda is more than 4000 kg/m2ɳ.

Sample 1



Sample 2

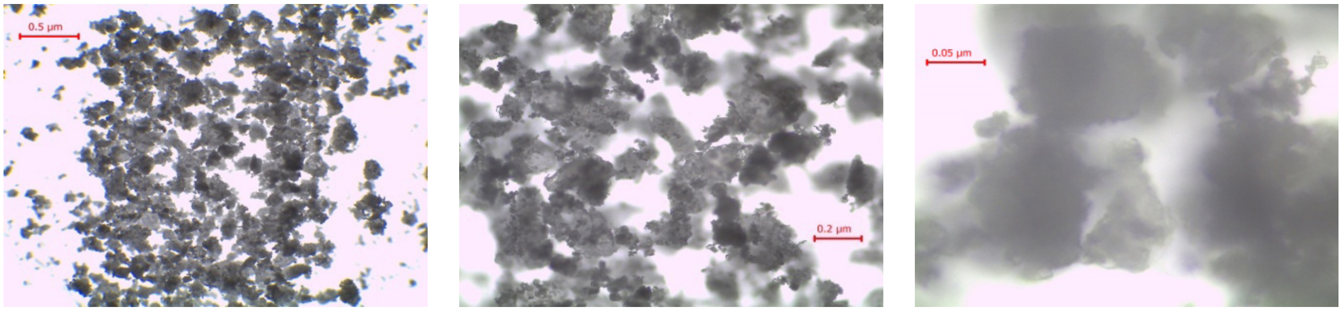


Figure 3. Microscopic analysis of precipitation. Sample numbers correspond to the numbers in Table 1.

Thus, the data obtained showed the possibility of obtaining caustic soda by the lime method of soda ash in the presence of sodium sulfate. In the future, the solution is stepped up to obtain liquid and solid caustic soda and sulphate – carbonate salts of sodium, corresponding to the composition: $mNa_2SO_4 \cdot nNa_2CO_3$. Sodium is circulated at the conversion stage or it can be used as an additive upon receipt of detergents and cleaning products.

References:

1. Исследования процесса упарка получения каустической соды химическим методом в присутствии сульфата натрия / Турсунова Д.А и др. // 2018 йил "Фан ва таълим – тарбиянинг долзарб масалалари" Республика илмий – назарий ва амалий анжуман материаллари.– Нукус-2018.– С. 67–69.
2. Исследования процесса получения каустической соды химическим методом в присутствии сульфата натрия / Турсунова Д.А и др.//2018 йил "Фан ва таълим – тарбиянинг долзарб масалалари" Республика илмий – назарий ва амалий анжуман материаллари.– Нукус-2018.– С. 58–59.
3. Ковилис С. С. Техника измерения плотности жидкостей и твердых тел.– М.: Стандарт, 1969.– 70 с.
4. Практикум по физической химии / Н. К. Воробьёв и др.– М.-Л.: Химия, 1964.– 384 с.
5. Doebelin N., Kleeberg R. Profex: a graphical user interface for the Rietveld refinement program BGMN // Journal of applied crystallography, 48(5).2015. – P. 1573–1580.
6. Wasag T. Otrzymywanie potazu metoda aminowa z zastosowaniem dwuetyloaminy / [T. Wasag, T. Wasag, U. Siewielec, G. Poleszczuk] // Przemysl chemiczny. 1974.– No. 2.– P. 94–97.
7. Wasag T. Zastoswanie amin do produkcji weglanow alkalicznych / T. Wasag, T. Wasag, G. Poleszczuk // Chemik. 1976.– V. 29.– No. 9.– P. 293–297.

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STUDY OF ADSORPTION PROPERTIES OF MONTMORILLONITE OF KARAKALPAKSTAN

Abstract. The physicochemical properties of montmorillonite in Karakalpakstan is studied in this article. The chemical composition, structure, adsorption properties, extra-geometric surfaces are established and the possibility of using composite elastomeric materials in production is determined.

Keywords: liquid rubber, composition, technology, montmorillonite, isotherms, adsorption, macromolecule, elastomer, physics, chemistry, diluted solutions, kinetics, mass, number, particle distribution, wettability, structuring.

Introduction. In recent years, natural montmorillonites abroad have been used in animal husbandry, agriculture, food production, pharmaceuticals, and petrochemical industries. Currently, it is directed to the study of the physicochemical properties of mineral resources for use in the production of composite elastomeric materials as a filler in the Republic. Up to now, a number of measures aimed at solving this common problem have already been implemented, which a large place belongs to the introduction of montmorillonite from Karakalpakstan (MMC) with different natures and structures.

As above-stated, the purpose of this article is to study the physicochemical properties and structural features of montmorillonite of Karakalpakstan and the possibility of their use in the production of composite elastomeric materials as a filler.

Objects and research methods. The objects of study are the montmorillonites of Karakalpakstan, Muinak, Turtkul, Khojakul, Kushkanatau, Beltauand Karateren deposits. Samples have been taken from seven deposits and the physicochemical properties of each sample have been studied three times and the average values have been obtained. The study has been carried out by physical-chemical methods to study the properties of mineral fillers, such as electron microscopy, IR-spectra, DTA, and standard chemical analysis methods.

The gained results and their discussion. The results obtained by numerous studies have determined [1; 2] that MMC is confined to the upper gloss deposits of the pH of an aqueous suspension of 7–9. The chemical composition of MMC has several characteristic features, the molar ratio between SiO_2 and Al_2O_3 ranges from 4 to 5. It has been established that there are oxides of iron, calcium, sodium, magnesium, titanium and othersin almost all MMC deposits (Table 1).

A study of the structure of MMC clays by electron microscopic studies showed that they consist of scaly particles, mostly dense and having a loose outline: in places there are also fibrous folds, apparently formed as a result of twisting of plate-like particles. The sizes of large particles reach to 0.6 microns. The scaly shape of the MMC particles is apparently explained by the specific crystal structure of montmorilloniteclay. The plane (0.001) of montmorillonite is covered with thelattice of hydroxyl ions (Fig. 1.), which exhibit a strong polarizing effect with respect to polar molecules. It is known that these hydroxyls are involved in the formation of both intramolecular hydrogen bonds and intermolecular hydrogen bonds.

Table 1.– The chemical composition of montmorillonite of Karakalpakistan

№	Name of indicators	Deposits of montmorillonite					
		Muinak (MM)	Turtkul (TM)	Khojakul (KhM)	Kushkana-tau (KM)	Beltau (BM)	Kranteren (KM)
1.	SiO_2	52.50	67.96	54.84	55.0	58.2	60.5
2.	Al_2O_3	17.20	12.80	16.76	13.5	15.7	16.8
3.	CaO	1.20	2.0	2.08	1.8	2.02	1.5
4.	Na_2O	5.06	0.28	2.48	1.8	2	3.02
5.	K_2O	0.27	0.13	1.22	1.03	1.10	0.3
6.	MgO	3.62	3.35	2.00	2.35	2.8	3.0
7.	Fe_2O_3	3.56	1.26	6.04	2.00	2.04	3.0
8.	FeO	0.13	0.10	0.07	0.12	0.11	0.9
9.	TiO_2	0.30	0.10	1.00	0.50	0.70	0.90
10.	CO_2	1.68	0.20	0.60	0.40	0.55	0.65
11.	SO_3	0.28	0.21	0.15	0.20	0.26	0.18
12.	H_2O^-	9.15	4.30	4.32	4.8	6.00	8.05
13.	H_2O	5.05	7.31	8.44	6.01	6.80	7.55

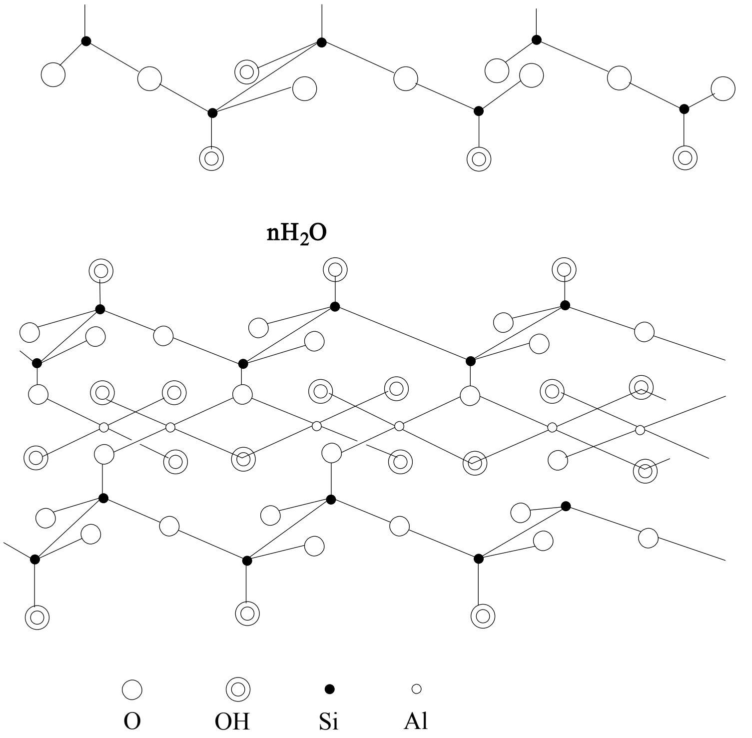

Figure 1. Scheme of the structure of montmorillonite according to Edilman and Fevaye

Therefore, in the clay crystal lattice there are both free and interconnected hydroxyl groups; the state of these groups is usually detected using infrared absorption spectra. The results of studying the IR-spectra of bentonite show (Fig. 2) that absorption bands appear in the region of 3700–300 cm^{-1}, which correspond to vibrations of free hydroxyl with a maximum at 3636 cm^{-1}, and hydroxyl bound by an intramolecular hydrogen bond with a maximum at 3440 cm^{-1}.

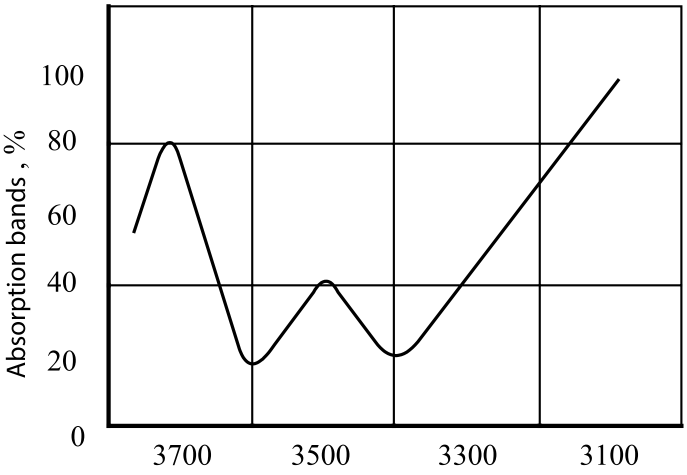

Figure 2. IR-spectra of MMC

In (Fig. 3) differential heating curves for MMC are given. It can be seen from this figure that the dehydration curves are characterized by two endothermic effects caused by the removal of interpackage (adsorbed) and constitutional (hydroxyl) water located in the absorbed base, respectively.

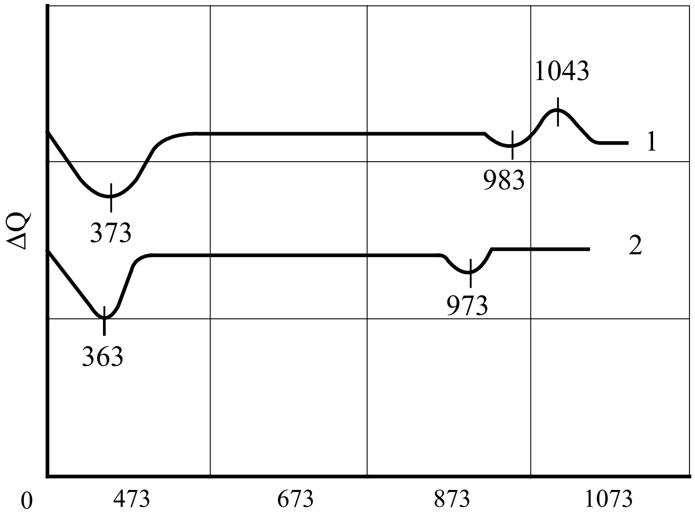

Figure 3. Thermograms of MMC: 1 – natural; 2 – purified

Removal of adsorbed water proceeds in the temperature range 363–463 K and depends on the type of cation. The bleeding of hydroxyl water and the formation of anhydrous clays occurs in the temperature range 933–983 K, and a dehydration temperature is observed to decrease. The degree of this decrease is due to the size of the cation atom. As a result of studies, it was found that MMC has a highly developed specific geometric surface due to this it has an increased oil absorption (Table 2). The latter indicator significantly decreases with increasing aromatic hydrocarbon content in the oil.

Table 2.– Specific adsorption surface and oil absorption of MMC various deposits before and after heat treatment at 673K

MM		**TM**		**KhM**		**KM**		**BM**		**KM**	
R*	**Ht***	**R.**	**Ht.**	**R.**	**Ht.**	**R*.**	**Ht.**	**R.**	**Ht.**	**R.**	**Ht.**
Specifically-geometrical surface. Ssp.. m^2/g											
29.1	36.2	29.1	35.4	28.3	4.1	27.1	34.0	28	31.0	33.5	33.8
Oil absorption. ml/100g											
flaxseed oil											
32.0	35.5	32.0	34.1	31.0	33.2	31.5	34.0	32.1	33.0	33.5	33.9
paraffinic oil											
32.0	35.5	32.0	34.1	31.0	33.2	31.5	34.0	32.3	33.2	33.7	33.8
dibutylphtholate											
38.2	46.1	38.2	44.2	35.6	39.6	33.2	40.2	32.2	33.1	33.6	33.7
dibutylsebacate											
36.4	45.2	36.4	43.0	34.3	39.2	32.9	40.2	32.1	32.0	33.3	33.6

R* – raw montmorillonite, Ht* – Heat-treated montmorillonite

As can be seen from the table, after heat treatment, MMCs have a more developed specific surface area, which is due to their high dispersion. Detailed information on the dispersion of fillers can be obtained by comparing their histograms. Mass and numerical distributions of the initial and heat-treated MMCs by the equivalent particle diameter have been determined by the method of small-angle scattering of a laser beam of drug suspensions in n-heptane with constant dispersion on a Molvern-SI 11800 instrument with automatic processing of the results using a special computer program and with fifteen step-wise numerical output histograms.

The results of the mass and numerical distribution of MMC particles by equivalent diameter (D) are given in (table 3). The table shows that the numerical and mass distribution of particles of R and Ht over the equivalent diameter indicate a unimodal distribution pattern. A nonlinear semilogarithmic anamorphosis of the numerical distribution of particles of IS indicates an exponential dependence of ND on D. Moreover, Ht is accompanied by a fragmentation of their particles and an approximation to the exponential dependence of N_D on D. Dispersion of bentonite particles at high temperature is probably due to the thermal explosion of some particles under the influence of evaporating constitutional moisture.

Table 3.– Equivalent diameter characteristics of the mass and numerical distribution of particles of the raw and heat-treatedMMCs

Name of fillers	**Dispersionmedium**	**D_N, MKN**	**γ**
R	n-heptane	84.0	1.0
Ht	n-heptane	94.0	1.0

Sedimentation analysis of MMC particles revealed that their most probable radius is in the range of 5–10 μm. A qualitative assessment of the wettability and structuring of MMC has been carried out according to the methods of sedimentation volumes [3]. The study showed that R and Ht particles precipitate in different ways and occupy different sedimentation volumes. At the same time, the sedimentation of R particles proceeds at a faster rate and an almost constant value of sedimentation volume is achieved in 210 minutes and in Ht in 3600 minutes. This, apparently, is due to their structural feature and high dispersion. When determining the wettability of R and Ht in heptane by sedimentation volume, differences are observed in the behavior of these systems as compared to water-filler systems. In heptane, fillers precipitate and occupy an almost constant sedimentation volume for 10 minutes. However, in terms of the sedimentation volume of Is and Tob, the fillers differ significantly from each other. For example, the sedimentation volume for Is and Tob is 20% and 31%, respectively.

It is seen that Ht occupies a larger sedimentation volume in comparison with R, which is apparently due to its high affinity for a nonpolar medium and a change in their structure after heat treatment.

It is known [1] that the main area of application of mineral resources is the production of composite elastomeric materials. One of the most important tasks in the field of physical chemistry of filled elastomers is the study of processes occurring at the phase boundary of the elastomer-filler, which largely determine the behavior of the compositions under conditions of their processing. In connection with this method of statistical adsorption from dilute polymer solutions, the interaction features of elastomer macromolecules with R and Ht have been studied.

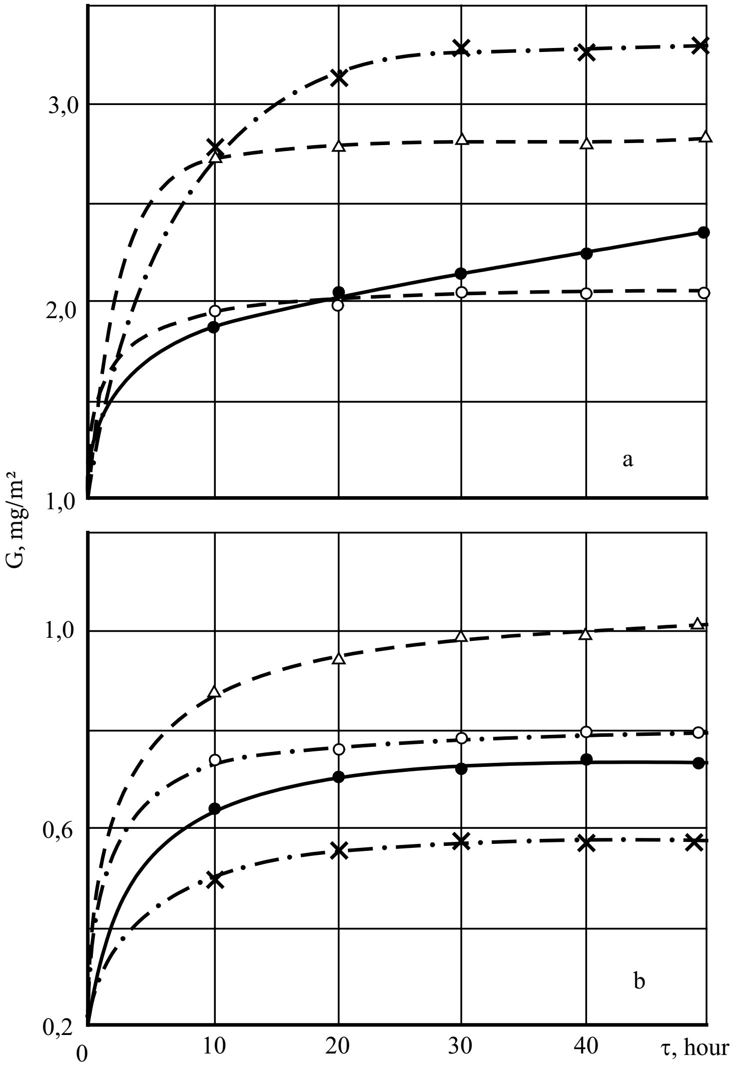

Figure 4. Dependence of the kinetics of adsorption of rubber macromolecules: SKMS-30ARKM-15 (a) and SKI-3 (b) in dilute solutions Cl4. MMR (– x–), MMHt (– Δ–), (– • –), TMHt (– ○ –), concentration 4.75 mg/g

A study of the kinetics of adsorption of elastomer macromolecules on R and Ht showed that with an increase in time (τ) the adsorption value (G) noticeably increases up to 20 hours (Fig. 4). The adsorption increment is determined mainly by the dispersion of the filler and their structural feature. So, for example, in the case of R and Ht, when their structure and dispersion change under the influence of temperature, the value of G noticeably changes. It has been found that the adsorption value also depends on the nature of the elastomers. In particular, in the studied system, the filler – SKI-3 solution, adsorption equilibrium is reached in about 48 hours, and the equilibrium adsorption value (**Gy**) is 0.8–1.4 m g/m^2. At the same time, in the case of SKMS-ZOARKM-15 solutions, the influence on the adsorption parameters is very pronounced. As can be seen from the figures, the adsorption mechanism is more complex, at the initial moment of time ($\tau \leq 4$ hours), an intensive increase in the adsorption rate is observed up to the value $G \approx 0.7$ mg/m^2, however, in the further slow adsorption, and after 48 hours of saturation is not achieved. It should be borne in mind that the magnitude of G_{max} is influenced by the chemical nature and segmental mobility of elastomer macromolecules.

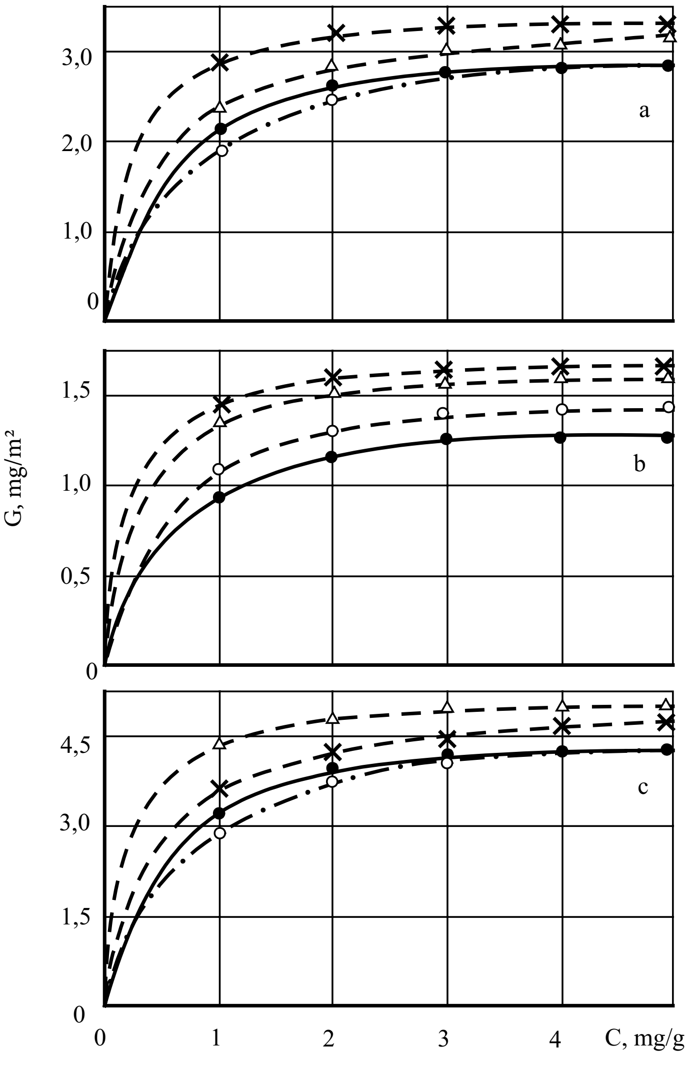

Figure 5. Dependence of the rubber adsorption isotherm SKMS-30ARKM-15(a) SKI-3 (b) and SKN-18 (c) in dilute CCl_4 solutions. KhMR (– Δ –), KhMHt (– • –), KMR (– ○ –), KMt (– x –), concentration 4.75 mg/g 48-hour exposure

Figure 5 shows the adsorption isotherms of macromolecules of elastomers on R and Hte, which are the dependence G = f (c). In the region of low concentrations (C≤ 0.5 mg/g), a sharp rise is observed on all isotherms, apparently associated with the adsorption of low molecular weight elastomer fractions. With a further increase in concentrations (C> 0.5 mg/g), high molecular weight macromolecules, adsorbing on the surface of the filler, displace low molecular weight fractions from it.

At the same time, isotherms are more individual in nature, depending on the adsorbent-elastomer system.

References:

1. Kurbaniyazov K. K., Zokirov M. Z. Bentonites of Karakalpakstan // Publishing house "Fan", 1979.– 250 p.
2. Fillers for polymer composite materials // Ed. G. S. Katz and D. B. Milevsky.– M.: Chemistry, 1981.– 736 p.
3. Teshabaeva E. U., Ibadullaev A., Negmatov S. S., Tadjibaeva G. S. Investigation of the adsorption of rubber macromolecules from their diluted solutions with modified mineral fillers // Composite materials – Tashkent, 2006.– No. 2.– P. 11–13.

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STUDY OF THE PROCESSES OF HYDRATION STRUCTURE FORMATION IN LIME-BELITE BINDERS ON THE BASIS OF MARLS OF THE REPUBLIC OF KARAKALPAKSTAN

Abstract. The possibility of improving the physicochemical and physic-mechanical properties of dispersions of lime-ware binding materials obtained on the basis of Akburly and Porlytau marls was revealed for the first time by regulating the processes of hydration structure formation using local mineral fillers in normal and hydrothermal conditions; the dosages of the fillers were established, the mechanisms of their action were clarified.

Keywords: marl, carbonate first mineral, Karakalpakstan, lime-ware binding, binder, hydration, structure formation, coagulation, I, crystallization, structure and.

Introduction. A large number of papers are devoted to the theory of hardening binders, but so far there is no single, generally accepted point of view on the processes of structure formation in the hardening of binders. Therefore, the study of the processes of hardening and structure formation of binders is relevant.

It has been established that the formation of strength is associated not only with the formation of different types of structures in the system – coagulation and crystallization, with the transition of the first to the second, but also different stages of the formation of a crystallization structure. Based on studies of physic-chemical and physic-mechanical properties considered lime-ware binding materials and second article n It turned whether opportunity use lime-ware binding materials for making high-strength construction materials and products autoclaved.

Objects and research methods. The object of this study on lime-ware material (LWM) produced on the basis of carbonate minerals in Karakalpakstan. LWM is close to the high-grade astringent substance, so it can be used to produce construction building x materials and products with high physical-mechanical properties.

The work also studies the kinetics of hydration structures and the physicochemical properties of LWM based on marl Akburly and Porlytau.

In accordance with the above, this work is devoted to the study of the fundamental possibility of optimal heat treatment, the study of the phase composition and properties of the products obtained, the development of ways to regulate the processes of obtaining and hydration structure formation in the considered IBI, their rational use for the production of some silicate products.

The study of physicochemical and mechanical properties, as well as the brand of LWM based on carbonate minerals of Karakalpakstan, was carried out according to GOST 23789–04.

Discussion and research results. The processes of hydration of clinker minerals and other binding materials, as well as hydration structure formation (HS) in these systems are interconnected, the latter usually follow from the first, so their consideration together is of scientific and practical interest from the point of view of their role in controlling the properties of binding systems.

In our case, natural marls from the Akburly and Porlytau deposits (the Republic of Karakalpakstan) served as the raw material for the LWM.

It has been established [1; 2] that the optimal heat treatment conditions for the production of LWM based on the studied marls are temperatures within 1000 °C with an exposure of 90 minutes. Under these conditions, the largest amount of free calcium oxide (50–60%) and β – dicalcium silicate -whit (25–30%) in heat treatment products are formed, in small amounts aluminates and calcium ferrites.

About the kinetics of hydration structure formation was judged by the change in plastic strength (P_m) of the system, measured on a Geppler consistometer.

The study of the processes of HS in concentrated pasta LWM allows to reveal the role of the nature of the hydrating phase in the kinetics of the formation of strength and its creation in the emerging spatial structure.

The nature of the kinetic changes in the plastic strength of the system at W/S = 0.90 (Table 1.) Differs from the nature of the change in the strength of the system at W/S = 1.0 and W/S = 1.2; plastic strength first increases, then, after three days of exposure of the system, drops sharply, followed by another sharp increase after 14 days. For other W/S relationships, there is also a sharp increase in the strength of the system after 14 days.

The presence of differences (W/S = 0.90) in the values of P_m is apparently connected not only with the formation of different types of structures in the system – coagulation and crystallization, with the transition of the first to the second, but also different stages of formation of the crystallization structure [3].

Table 1. – The kinetics of structure formation (P_m, MPa) in dispersions of LWM, depending on the water-solid ratio

No	Marl based LWM	W/S	Timing of measurement											
			minutes			clock			day					
			1	15	30	1	3	6	1	3	7	14	28	40
1.	Akburly	0.90	0.9	4.1	6.4	8.7	9.3	13.9	15.6	20.5	16.6	14.2	20.4	28.7
2.	Akburly	1.00	0.6	5.5	6.1	7.7	9.2	12.2	13.2	13.4	14.5	14.5	18.3	23.4
3.	Akburly	1.20	0.4	4.3	5.8	7.7	9.0	10.4	12.1	13.0	14.0	13.8	17.9	21.3
4.	Porlytau	0.90	0.9	4.4	6.5	8.9	9.3	13.5	15.5	20.4	17.1	16.4	21.0	30.3
5.	Porlytau	1.00	0.6	5.1	6. 1	7.3	9.4	12.9	12.1	13.5	14.6	14.8	18.5	28.4
6.	Porlytau	1.20	0.5	4.1	5.9	7.8	9.1	10.6	11.6	12.9	14.2	13.8	17.7	24.7

During the first two stages of the formation of the crystallization structure, i.e. respectively, the emergence of crystalline nuclei of hydro silicates and an increase in their number without accretion, as well as the formation of a crystalline intergrowth of the embryos, increases the strength of the system, which reaches a maximum, when going to the third stage of structure formation, the formation of crystalline particle contacts begins to weaken due to the destruction of the aggregations and recrystallization of contacts; the subsequent sharp increase in the strength of the system after the minimum is due to the formation of crystalline contacts, giving the system sufficiently high strength properties. This area coincides in time with the system's 14-day shutter speed, which is relevant to all W/S variants.

The fact that the minimum extreme point at 14 days corresponds to the beginning of crystal contacts is evidenced by the fact that the increase in strength after 14 days' exposure is sharp, since the strength parameters of crystallization structures usually always have relatively large indicators than coagulation structures, which is due to the nature of the forces that determine the contacts of the particles in these structures. It is known [4] that the contacts of particles in the first (coagulation) structures are formed due to low-strength van der Waals forces of intermolecular interaction through thin interlayers of the dispersion medium and therefore have relatively low rates; secondly (crystallization) structures, contacts are formed due to chemical forces with significantly higher binding energy, they arise in the process of formation of new phases from metastable supersaturated solutions, and these structures are accretion structures that differ from coagulation by several orders of magnitude higher strength due to the formation of phase accretion.

Systems based on heat treatment products of a marl from the Akburlinsk field at W/S = 0.90 under conditions of moisture-air storage have a maximum strength of about 28.75 MPa, and Porlytau deposit – 30.25 MPa after 40 days of exposure.

Table 2 shows the results of physical studies of dispersion based on LWM.

From the presented data it is clear that the water demand for LWM obtained on the basis of the studied marl more than that of Portland cement or gypsum. This is due to the fact that in the composition of LWM, together with dicalcium silicate (β-C_2S), free calcium oxide CaO (58.24 and 50.30%) is also contained in large quantities, which, upon hydration with a great need of water, passes in calcium hydroxide.

Table 2. – The results of physical research pastes LWM

No	Marl based LWM	normal density,%	setting time, min		specific surface, cm^2 /g
			Start	end	
1.	Akburly	90	48	131	3200
2.	Porlytau	90	46	144	3500

Table 3 presents the dependence of the mechanical strength of the LWM samples on the duration of hardening. As can be seen from the table, as in the conditions of moisture-air and thermo-moisture hardening, the mechanical strength of the samples increases with time, its greatest value takes place after 28 days.

Table 3. – The results of the study of the mechanical compressive strength of specimens of LWM in moisture-air and thermo-wet hardening

No	LWM based marl deposits	W/S	Compressive strength, MPa					
			moisture-air hardening			thermo-wet hardening		
			3 days	7 days	28 days	3 days	7 days	28 days
1.	Akburly	0.90	0.98	2.83	7.35	4.05	6.40	14.26
2.	Porlytau	0.90	1.86	4.77	9.41	4.30	7.81	14.53

Comparison of the strength values shows that the greatest difference in their values during compression is observed in LWM based on the marl from the Porlytau deposit, which indicates a relatively higher content of silicates, aluminates and calcium ferrites in the heat treatment products of the marl from this deposit compared to the marl Akburly.

The initial strength of LWM is provided by the hydration of free lime and belite with the formation of the corresponding hydrates. A further, very slow increase in strength (under normal conditions) is mainly due to the carbonization processes of unbound calcium hydroxide. Therefore, with an increase in the content of the active form of SiO_2, it is possible, up to known limits, not only to intensify the hardening processes, but also to obtain a significantly greater strength of the hardened product.

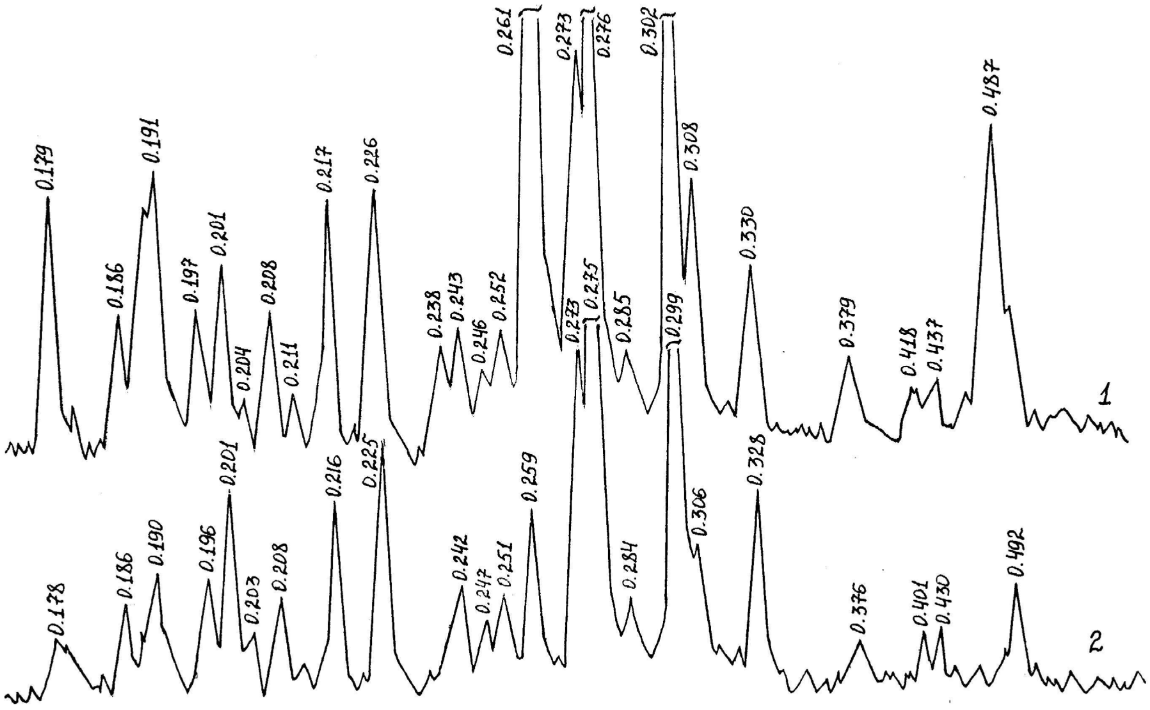

Figure 1. Diffraction patterns of products of LWM_1 hydration obtained on the basis of marl No. 1. and No. 2

Diffraction patterns of LWM hydrated for 28 days are characterized by the presence of more intense lines of hillebrandite (0.302; 0.276; 0.260 nm), portlandite (0.487 and 0.191 nm), calcium hydro silicate of C-S-H type (II) (0.308 nm), as well as less intense lines of tobermorite $5CaO \cdot 6SiO_2 \cdot 5H_2O$ (0.252 and 0.246 nm). Lines 0. 330; 0.204 nm and 0.186; 0.179 nm refers to hydroaluminate and calcium hydroferrite, respectively.

Activity, temperature and quenching time for LWM are presented in (Table 4).

Based on the data in the table, it can be assumed that LWM can be used in the production of high-strength silicate autoclaved products (cellular concrete, blocks, etc.), since The above properties of LWM meet the requirements for autoclaved products.

Table 4.– Activity, temperature and quenching time LWM

No	Marl based LWM	Quenching temperature, ºC	Blanking time, min	Activity%
1.	Akburly	44	14	71.89
2.	Porlytau	43	15	70.30

Conclusion. Thus, the processes of HS in LWM dispersions obtained on the basis of marl Akburly and Porlytau deposits, are characterized not only by the formation in the system of different types of structures – coagulation and crystallization, with the transition of the first to the second, but also by different stages of the formation of a crystallization structure. Based on studies of the physicochemical and physico-mechanical properties of the examined LWM, it can be concluded that they are an effective binder for the preparation of high-strength autoclaved products.

The introduction of LWM in the production of building materials can bring greater economic efficiency, since the binders are obtained by low-temperature calcination and fine grinding of raw materials without waste and, accordingly, the cost of building materials will be relatively low and the raw material base will be used rationally.

References:

1. Turemuratov S. N., Nurymbetov B. C. H. Synthesis and research of LWM on marl from the Akburlinskoye field // Science and the formation of Southern Kazakhstan. – Shymkent. 2000.– No. 11.– P. 223–225.
2. Turemuratov Sh. N., Kurbaniyazov S. K., Akeshova M. M. Influence of Hydrothermal and Physical Properties for Lime Ware Binding Materials // World Applied Sciences Journal, 23 (9): 2013; 1151–1156. ISSN1818–4952.
3. Turemuratov Sh. N., Kurbaniyazov S. K., Akeshova M. M. Physical-mechanical properties of chemicals and undergone hydro-thermal treatment // Journal of Materials and Applications, 2013.– P. 1179–1185.
4. Turemuratov Sh. N., Zhukov A. D., Asamaddinov M. O., Nurymbetov B. Investigation of the kinetics of hydration structure formation and properties of lime-whitewash binders on the basis of marls // Vestnik MGSU, Building Materials,– M. 2016.– No. 4.– P. 62–68.
5. Turemuratov Sh. N., Zhukov A. D., Asamaddinov M. O., Nurymbetov B. The effect of fine-dispersed filler on the formation of calcium silicates // Vestnik MGSU, Stroitel'noyematerialovedenie,– M., 2017.– No. 4.– P. 446–451.

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OBTAINING CELLULOSE FROM RICE STRAW FOR LIQUID WALL-PAPER

Abstract. A number of works are devoted to obtaining and research of cellulose from annual cereal plants. In order to remove non-cellulose parts of rice straw they were boiled in water, then in acid and alkali solutions. In the infrared region of 400–700 cm^{-1}, which is shown in (fig. 3), there are diffuse structurally sensitive bands with several indistinct maxima, which completely disappear only if the crystal structure of cellulose is destroyed. Thus, a method of removing parts easy and difficult to soluble from rice straw by boiling it in water and in solutions of acid and alkali has been developed.

Keywords: cellulose, non-cellulose parts, infrared region, destroyed, rice straw, decoration, spectrum.

Introduction. A number of works are devoted to obtaining and research of cellulose from annual cereal plants [1–4]. The main types of annual plants for the production of cellulose, the preparation of their cooking and cooking conditions are given in the work [1]. Using organic solvent delignification, technical pulp was obtained without the use of chlorine-containing reagents [4]. In the work [2; 3] the study of the structure of cellulose and lignin of annual cereal plants is presented. However, obtaining cellulose to use as a liquid wallpaper is not exposed in the literature.

The purpose of this article is to obtain pulp to use as part of liquid wallpaper, to study the properties and apply for wall decoration.

Methods of study. This article presents a method for delignification, extraction of cellulose from rice straw, the study of some of its physicochemical and structural features using IR-spectroscopy. KFK-2 a type of IR-spectrophotometer "IRAffinity-1", 2g KBr tablets and a 9 mg sample were used for the study. Well-known sorption methods as well.

Results and discussion. In order to remove non-cellulose parts of rice straw they were boiled in water, then in acid and alkali solutions. Figures 1, 2 show the kinetics of release easily and difficult to dissolve portions of rice straw. During cooking, the substance is released from the composition of rice straw and the optical density of the cooking solution changes. The completion of the isolation process, the optical density of the cooking solution remains constant. This indicates the completion of the release of substances from the composition of rice straw (Fig. 1).

Fig. 1 shows that the ending of the separating process of easily soluble part when boiling in water is completed in about 3.5 hours. In fig. 2 the kinetics of cooking rice straw in a solution of acid and alkali is presented.

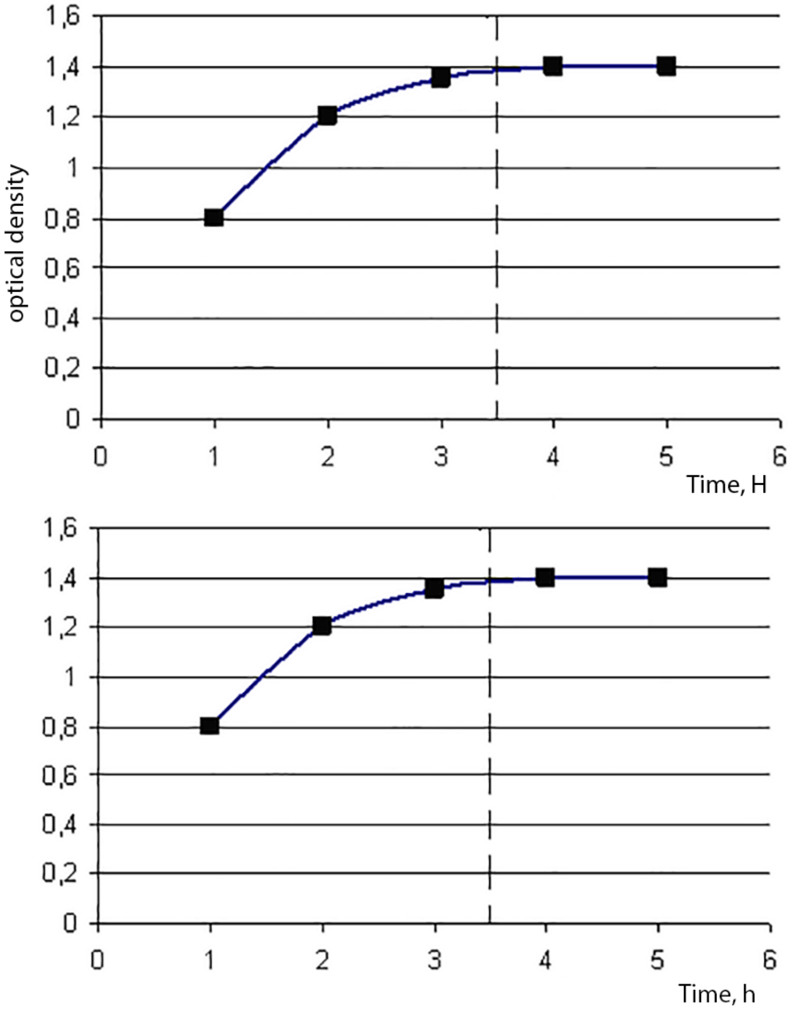

Figure1. Kinetics of change in optical density when cooking rice straw in water

When boiling rice straw for 50 minutes, the isolation of a substance difficult to soluble from the straw is completed. Moreover, an intense release is observed when boiling in an acid solution (curve 1, fig.2). After removal of the parts easy and difficult to dissolve, the chemical composition of rice straw is calculated:

1. Cellulose content – 47–52%.
2. Lignin – 11–12%.
3. Pentazans – 23–25%
4. Ash content – 16–18%.
5. The content of tar and oil – 1.65–1.75%.
6. The content of substances soluble in water – 12.5–13.5%.

Some physical-chemical indicators of rice straw pulp are given in table 1.

Table 1.– Physical- chemical indicators of rice straw pulp

Name of indicator	Indicators
Swelling in water,%	93,8
Swelling in 17,5% of solution NaOH,%	550
Water retention,%	220
Whiteness,%	56–60
Air permeability, at thickness 250 g/m^2, ml/min.	2000–2050

Cellulose swelling in water is about 94%, and in a 17.5% solution of alkali – 550%, water retains more than 2 times its mass. The whiteness is low, about 60%, as the pulp has not been bleached. The IR-spectrum of the cellulose sample was determined (Fig. 3. Table 2).

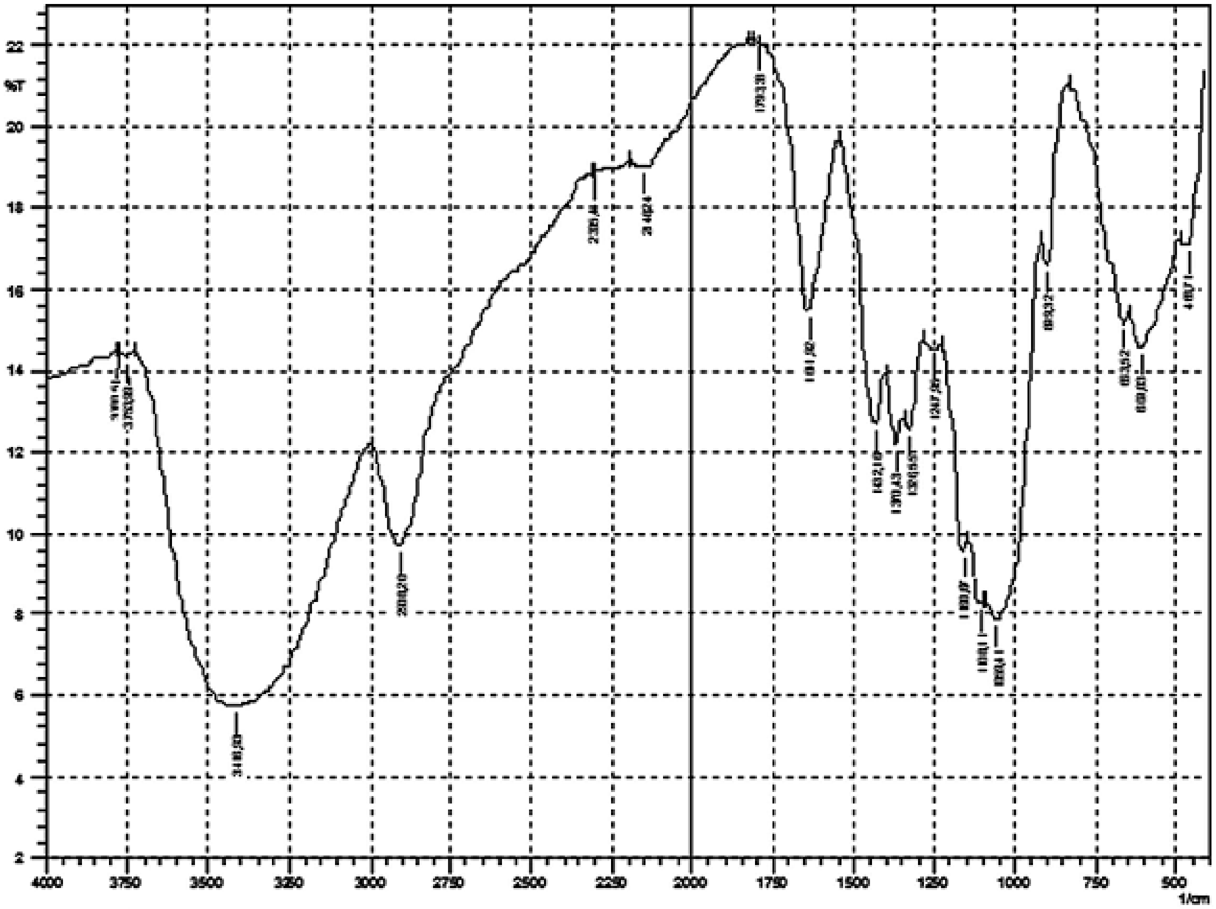

Figure 3. IR-spectrogram of rice straw cellulose

The IR spectrum was quantitatively processed according to the well-known method [5] using the baseline method and normalized according to the internal standard – 2950 cm^{-1} band (OH -, CH_2 and CH – stretching vibrations). In the region of stretching vibrations of OH groups, there is a band of about 3250–3500 cm^{-1}. In the region of 1653 cm^{-1}, absorption of adsorbed water molecules is observed.

Table 2. – IR-spectroscopic characteristics of cellulose samples obtained from rice straw

Assignment	Absorption band, cm^{-1}
Valence vibration of OH – groups (with hydrogen bond)	3250–3500
Asymm. valence vibration of –CH_3 – groups	2921,57
Asymm. deformation vibration –CH_2 – groups	1437,76
Asymm. valence vibration of –C–O–C– groups	1275,52
Valence vibration of – C – OH – groups	1197,20

In the region of 900–1500 cm^{-1}, absorption bands of a complex configuration with several maxima are located. Here the C–O, C–C stretching vibrations (≈ 1060, 1163 cm^{-1}), the associated vibrations of the CH, CH_2, and OH-groups (1150–1500 cm^{-1}), as well as the vibrations of the ring ($\approx$ 900 cm^{-1}) and C–O stretching vibrations in amorphous regions of cellulose. In the same area, the frequencies of the deformed O–H, CH– and C–OH vibrations appear. In table 2 shows the related absorption bands.

In the infrared region of 400–700 cm^{-1}, which is shown in fig.3, there are diffuse structurally sensitive bands with several indistinct maxima, which completely disappear only if the crystal structure of cellulose is destroyed.

Thus, a method of removing parts easy and difficult to soluble from rice straw by boiling it in water and in solutions of acid and alkali has been developed. Certain physical-chemical parameters of rice straw cellulose were determined. There has been determined through the IR-spectrum that in natural fibers of cellulose almost all hydroxyls are included in the hydrogen bond. Moreover, the low-frequency region of the 3400 cm^{-1} band characterizes hydroxyls included in the stronger hydrogen bond, and the high-frequency region – in the weaker hydrogen bond.

References:

1. Pulp and paper production technology. T.1. (part 2). Production of semi-finished products,– St. Petersburg: Polytechnic. 2003.
2. Kocheva L. S. Structural organization of the properties of lignin and cellulose of grassy plants of the cereal family. Abstract for the degree of Doctor of Chemical Sciences. Arkhangelsk-2008.
3. Kocheva L. S., Brovarova O. V., Sekushin N. A., Karminov A. P., Kuzmin D. V. Structural and chemical characteristics of non-wood pulp. Lesnoy Journal. 2005.– No. 5.– P. 87–93.
4. Minakova A. R. Production of cellulose by the oxidation-organosolvat method when processing non-wood plant materials. Abstract dis. for candidate of technical sciences – Arkhangelsk. 2008.
5. Jbankov R. G. Infrared spectra and carbohydrate structure.– Minsk. 1972.– 456 p.

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COMPOSITION OF LIQUID WALLPAPER BASED ON RICE STRAW

Abstract. Liquid wallpaper is a maximum of crushed natural fibers and a binder, which when mixed with water forms a paste mass. Every year in the market all new construction materials are appearing. The composition of liquid wallpaper was made, images were obtained, applied on the surface of the walls, the prostate was shown, the heat and sound insulation qualities of the material were higher than those of ordinary wallpaper, the warmth and softness of the finish.

Keywords: Liquid, natural fibers, composition, ordinary wallpaper, sleeping rooms.

Introduction. About a thousand years BC, woven canvases that decorate the walls appeared. At first it was and white canvases, which later became colored. Liquid wallpaper appeared in the 90s of the past century.

Liquid wallpaper is a maximum of crushed natural fibers and a binder, which when mixed with water forms a paste mass. The composition includes not only cellulose and glue, but also cotton, silk or flax fibers, as well as yarn. In order to enhance the decorativeness, various glitters of golden or silver shade are added.

Every year in the market all new construction materials are appearing. They are universal, environmentally friendly, easy to install.

One of these materials is liquid wallpaper. The monograph [2] summarizes the composition of the liquid wallpaper, the advantages and disadvantages, the methods of applying on the surface of the walls. This material is produced in the form of a dry mix packed in plastic bags. The composition of the liquid wallpaper is very simple:

- natural fibers (silk, cotton, cellulose);
- water based acrylic dye;
- adhesive component.

The composition of a liquid wallpaper made of cotton cellulose obtained from cotton linters was developed [3; 4].

Main part. Table 1 shows 5 basic compositions of liquid wallpaper — cellulose made from rice straw and decorative additives in the form of glitter, stone chips, crushed mica, paints and other things.

Glue additive is a link, connecting all components into one. Glue gives the mixture plasticity, ensuring the ease of its application up to the walls.

The dependence of the rate of air passage through the thickness of the cellulose layer (Fig.1), measured with the help of an instrument Bendtsen was studied (according to DIN53120).

When applying a layer of liquid wallpaper on walls with a thickness of 250 g/m^2, the air flow rate is more than 2000 ml/min. If you increase the layer thickness to 1000 g/m^2, it will decrease by almost 3 times.

The wallpaper is fallen on the walls in a uniform layer, without joints and seams. Their texture allows you to hide minor defects in the surface, acting as a finishing putty. The result is a homogeneous surface with a rough texture, decorated with inclusions of a different shade and small particles of various materials.

Table 1.– The composition of liquid wallpaper and the characteristics of structures on the walls

№	Composition	Amount,%	The color and nature of the structure on the surface of the walls
1	Cellulose Na-CMC Dyes (red, green, blue) Water	10 2 1 87	Smooth, red, green, blue
2	Cellulose Na-CMC Mica Water	10 2 2 86	Smooth, mica glitters on the light
3	Cellulose Na-CMC Cotton yarn Water	10 2 10 78	Nodes protruding size of 6–8 mm covered with cellulose on a surface of 100 cm^2.
4	Cellulose Na-КМЦ Песок Water	10 2 10 78	Small protruding nodes, covered with cellulose size of 2–3 mm, evenly distributed on the surface of the walls.
5	Cellulose Na-КМЦ Песок Water	10 2 10 78	Small protruding nodes, covered with cellulose size of 6–8 mm, evenly distributed on the surface of the walls.

A photo of the general appearance of the wall, recommended on the surface of which the wallpaper is applied, is shown below (Figures 2.3).

Thus, a method of producing cellulose from rice straw has been developed, and a number of its physical-chemical properties have been studied. The composition of liquid wallpaper was made, images were obtained, applied on the surface of the walls, the prostate was shown, the heat and sound insulation qualities of the material were higher than those of ordinary wallpaper, the warmth and softness of the finish.

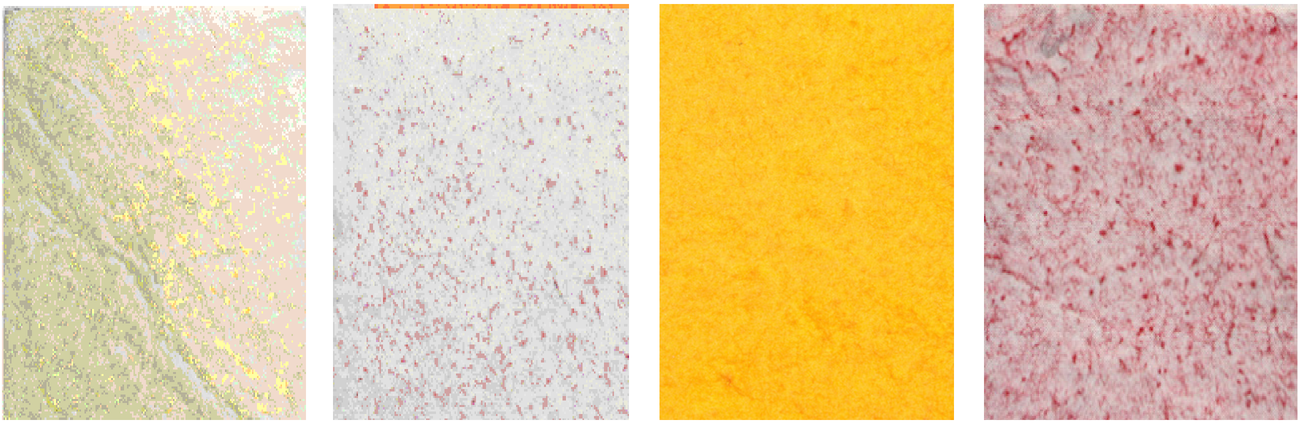

Figure 2. Liquid wallpaper covered walls sleeping rooms

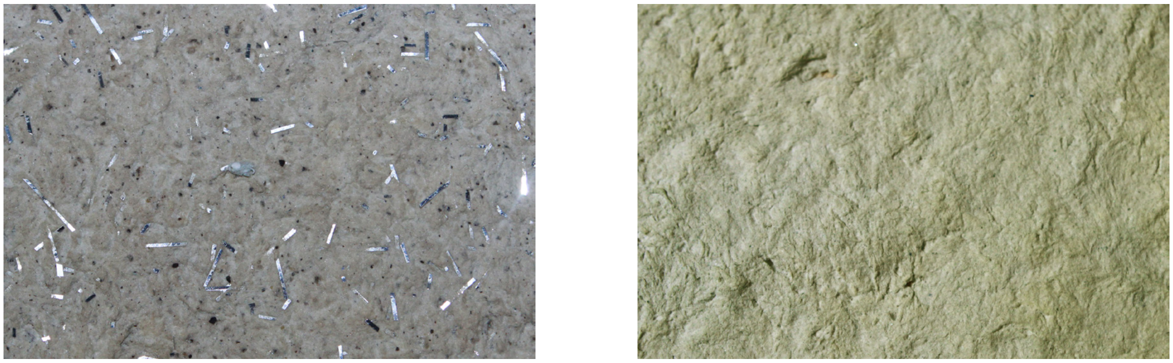

Figure 3. The surface structure of the wallpaper on the walls

References:

1. URL:https://stroyka-gid.ru/supplies/60-zhidkie-oboi-chto-eto-i-kak-vybrat.html.
2. Umarova V.K. and others. Technology of liquid flower decoration and wall covering. Tashkent-2017. "Fan and texnologiyalar Markazining bosmaxonasi", 84 p.
3. Primkulov M.T., Abdukarimov A.A. and others. The composition of the paper pulp to cover the surfaces of the premises // Rasmy axborotnoma, 3 (17), 1997. – 100 p.
4. Primkulov M.T., Abdukarimov A.A. and others. Liquid wallpaper from cotton cellulose // Uzbek chemical journal, 2000. – No. 5. – P. 40–43.

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DEVELOPMENT OF GASOLINE COMPOSITION COMPOUNDED WITH THE USE OF ANTI-KNOCK MODIFIER A-18

Abstract. The ecological safety of the use of anti-knock modifier A-18 in systems in the oil and gas-chemical industry is shown and their efficiency is determined.

Keywords: anti-knock modifier, amyl, isobutyl, n-propyl and ethyl, oxygen-containing modifiers**.**

Introduction: an Increase in the octane number of gasoline to the required level is possible either by expanding the production of high-octane hydrocarbon fuel components through optimization and modernization of oil refining schemes at the refinery, or by selecting new non-toxic octane additives and components of non-oil origin [1].

Oxygenates are called oxygen-containing organic compounds that act as antidetonators. Their use in concentrations of several percent allows us to consider them no longer additives, but components of motor fuel. The main advantage of oxygenates is the possibility of expanding the resources of motor fuels at the expense of raw materials of non-oil origin.

The use of fuels containing ethanol as a high-octane additive has been successfully implemented worldwide. In USA from 1978 to richen the fuel gasohol, which contains 10% ethanol. ASTM standard developed by the national Commission on alcoholic fuels of the United States, setting '!' gasohol for the following indicators: the density of 730–760 kg/m^3, the limits of boiling 25–210 °C, calorific value of 41.9 MJ/kg, heat of vaporization 465 MJ/kg, saturated vapor pressure (38 °C) 55–110 kPa, viscosity (40 °C) 0,6 mm^2/s, the stoichiometric factor 14 In Sweden and Finland is operated gasoline E85, which includes 85% ethanol. In Russia, OAO VNIINM together with JSC "AVTOVAZ" were tested gasoline containing 5–10% ethanol, the results of which gasoline with the addition of 5% ethanol has been approved for use in automotive vehicles, but has not yet received wide distribution.

Ethanol, like all high-octane additives, has its drawbacks:

- resence of traces of water;
- like all alcohols, it has increased corrosion activity, depending on the water content and the molecular weight of alcohol (the greater the molecular weight of alcohol, the less aggressive it is [2–3].

The introduction of alcohol fuel appropriate modifiers and stabilizers can overcome the difficulties. The greatest influence on the delamination of alcohol gasoline has a water content. To ensure the stability of gasoline with alcohols in the production, storage and use it is necessary: to prevent the ingress of water into them; to use stabilizing additives or, in other words, co-solvents, homogenizing the gasoline-water-alcohol system [4].

As stabilizers of gasoline-alcohol mixtures it is proposed to use: aliphatic alcohols C3 – C2 normal and branched structure, phenols, allylacetate, ethers and esters and their organometallic derivatives, ketones, amines, surfactants, and glycols and their ethers, aldehydes, catali, acetals, acylcarbene, carboxylic acids and mixtures of these compounds. The addition of stabilizers prevents the stratification of alcohol-containing gasoline to a temperature of –40–23 °C [5].

Good and at the same time cheap stabilizer are fusel oils that provide homogeneity of fuel at temperatures above –25 °C.

It should be noted that fuels comprising more than 40% vol. ethanol, have the required phase stability without prior dehydration of alcohol and the introduction of stabilizers.

When used in the composition of the fuel composition of watered ethanol to prevent delamination, stabilizers should be introduced (higher alcohols, aromatic amines, esters, ketones, So the addition of 2.5–3.0% Isobutanol ensures the stability of the gasoline-ethanol mixture containing 5% water at temperatures up to –20 °C. [6].

Experimental part.

The motor method was used to determine the octane number at the unit UIT-65 allowing to change the compression ratio from 4 to 9, where the detonation resistance of the studied gasoline is compared with the reference samples at a temperature of the combustible mixture of 150 °C and a rotational speed of 900 min-The detonation resistance is determined by the research method at a temperature of the combustible mixture of 25–35 °C (the mixture is not heated) and a rotational speed of 600 min-1. Since the determination of the detonation resistance by the motor method takes place under more severe conditions, the result will be slightly lower than it would have been obtained by the determination by the research method In both cases, after the heating of the engine, the compression degree gradually increases until the detonation of a certain standard intensity determined by the scale of the detonation index.Also, the octane number can be approximately calculated by the formulas obtained value corresponds approximately to the octane number determined by the research method.;

$$О\,Ч = 120 - 2\left(\frac{t_{ср} - 58}{5p}\right),$$

where $t_{ср}$ — the average temperature of the distillation fuel

$$t_{ср} = \frac{t_{нк} + t_{кк}}{2}$$

$t_{нк}$ — initial boiling point fuel; $t_{кк}$ — the temperature of the end boiling point of the fuel; p_{20} is the density of fuel at 20 °C, g/cm^3

Results and discussion.

In this paper, octane-boosting modifier synthesized on the basis of amyl, isobutyl, n-propyl and ethyl, oxygen-containing organic compounds were studied. the Reaction was carried out in a 500 ml flask equipped with a reverse refrigerator for 30 minutes at a temperature of+ 8 to +18 °C.

Octane-boosting modifier is applied by light car. One of the most effective octane oil system modifier is the A –18 modifier

In recent years, a promising direction-the production and consumption of harmless (environmentally friendly) high-octane additives instead of IES-is successfully developing. Figure-1.

Compared to the graph, the octane growth shown in figure 1 seemed to be the best. The correct fraction of gasoline was used. The maximum increase in the number of octanes was changed to 18 units by the method of the octane number of the motor (ONM) and 18 units according to the method of research octane number(ONR). It should be noted that the addition of the a-18 modifier To the concentration of up to 2% led to the fact that the increase in the octane content of gasoline was the highest.As the concentration increased, the number of octanes decreased.

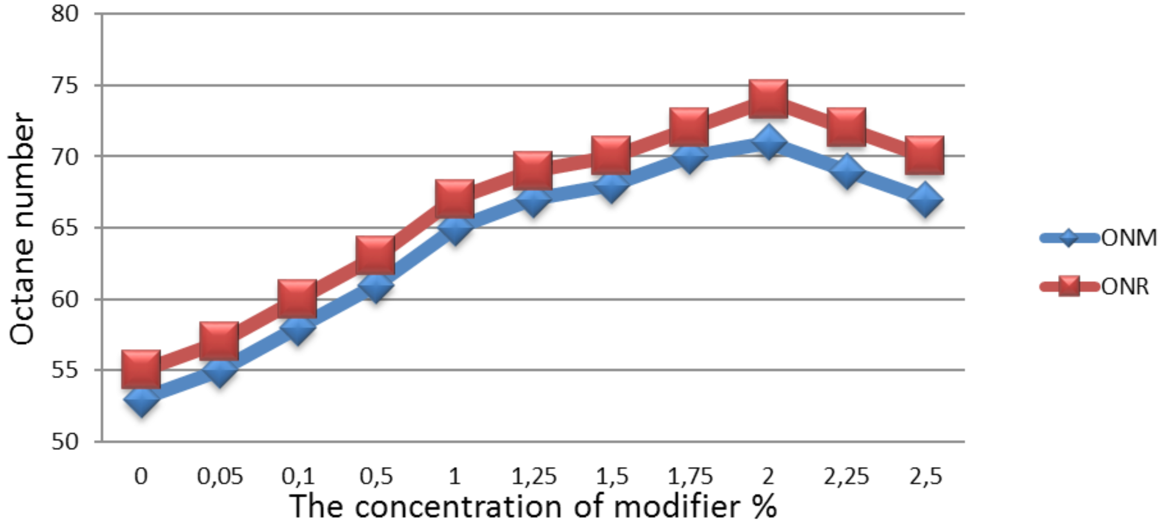

Figure 1 Change in the number of octanes when adding A-18 modifier in direct distillation of gasoline

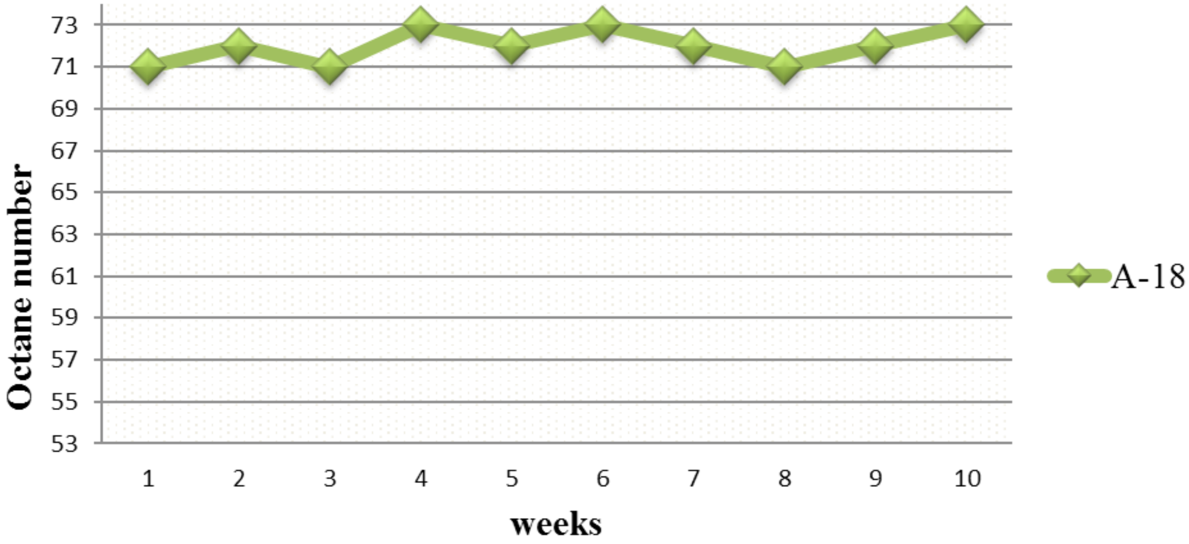

Figure 2. Storage stability of octane-boosting modifier

With the addition of the a-18 modifier to the feather distillation of gasoline 10 weeks waiting for the number of octanes, the number in gasoline decreased by 1–2 units. The modifier we offer keeps the octane number in gasoline in equilibrium for a long time.

References:

1. Developed GOST R52201–2004 – "Ethanol motor fuel for automotive engines with forced ignition. Bensaali, which operates from 1 July 2004.
2. Mirom W.L., Ragazzi R.A. //SAE Techn. Pap. Ser. 1986.– No. 860530.– 6 p.

3. Black F. // SAE Techn. Pap. Ser. 1991.– No. 912413.– P. 1–30.
4. Ivanov P. V., Onoychenko S. I., Emelyanov V. E. Automobile fuel: Bhepat today, tomorrow. Analyte. review.– M.: 2001.
5. Kaminsky E. F. Ecological characteristics of motor fuels and new technologies for their provision.– M.– Oil and gas,– P. 10–11.
6. Danilenko, Tatyana Viktorovna Development of fuel compositions of Gasoline with the addition of aliphatic alcohols Dis. … kand. That science.– M.: RGB, 2005.

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THE STUDY OF THE IR SPECTRA OF TECHNOPOLISES MODIFIERS

Abstract. The infrared spectra of additives increasing the number of cetanes on diesel fuel are investigated, their differences from each other are shown.

Keywords: cetane number of improving modifiers, Unj-20, U-1, U-2, U-3, U-4, oxygen-containing modifiers.

Introduction: Diesel fuel with poor ignition characteristics cause problems such as diesel knocking and engine start problems in cold weather. Such diesel fuel needs to have improved ignition properties. Ignition properties of diesel fuel can be estimated in terms of their cetane number.

In order to improve the fuel properties of diesel and obtain lower exhaust emissions, numerous studies of alternative liquid and gas fuels have been carried out. In addition, some studies on various additives and cetane improver used to improve combustion characteristics have been conducted [1].

This effect is greatest at lower temperature and density conditions corresponding to low load and start conditions in a diesel engine, and becomes negligible at the highest temperature and density conditions considered [2].

Experimental part. Shimadzu's LabSolutions IR use a database that provides secure management of analytical data.This avoids errors such as overwriting or delete data. The database also manages the following processing of analytical data. It automatically assigns the "adjustment number/version number" for each analysis result, which prevents overwriting analytical data. Just as easy to browse old data. LabSolutions IR. Body surface potential mapping (P/N206–74559–91) LabSolutions IR Connection kit Class I-Agent (P/N206–74557–91) Only spectra stored in the CLASS-Agent database. Mapping data, kinetic data, the calibration curve and quantitative results tables cannot be stored. Standard labsolutions IR functionality includes signal processing functions, such as ATR correction, and conversion Kubelka-Munch, quantitative features such as multipoint calibration and the classical least squares method as well as the function spectral search. However, the addition of the following additional software products allows you to expand the range of applications. Allows the measurement of spectra through certain (specified) interval. Changing the intensity of the band in the spectrum and its area can then be used to evaluate the kinetics reactions. The measurement results are saved and displayed as three-dimensional image or graphics. The scanning interval depends on the spectral resolution, the number of scans and the speed of movement of the mirror. The highest speed the scan is 7 seconds (1 scan) at 16 cm^{-1} resolution and the mirror speed is 9 mm/s.

Results and discussion. On the IR spectrum (figure 1), Unj-20 contains absorption bands, valence bond oscillations-CH_3 at 2957–1384 cm^{-1} and C-H 2850–2750 cm$^{-1.}$ In the areas of 2872–2728 cm^{-1} and 1464–1010,98 cm^{-1} there are absorption bands confirming the presence of CH_2 groups, all bands are usually weak.

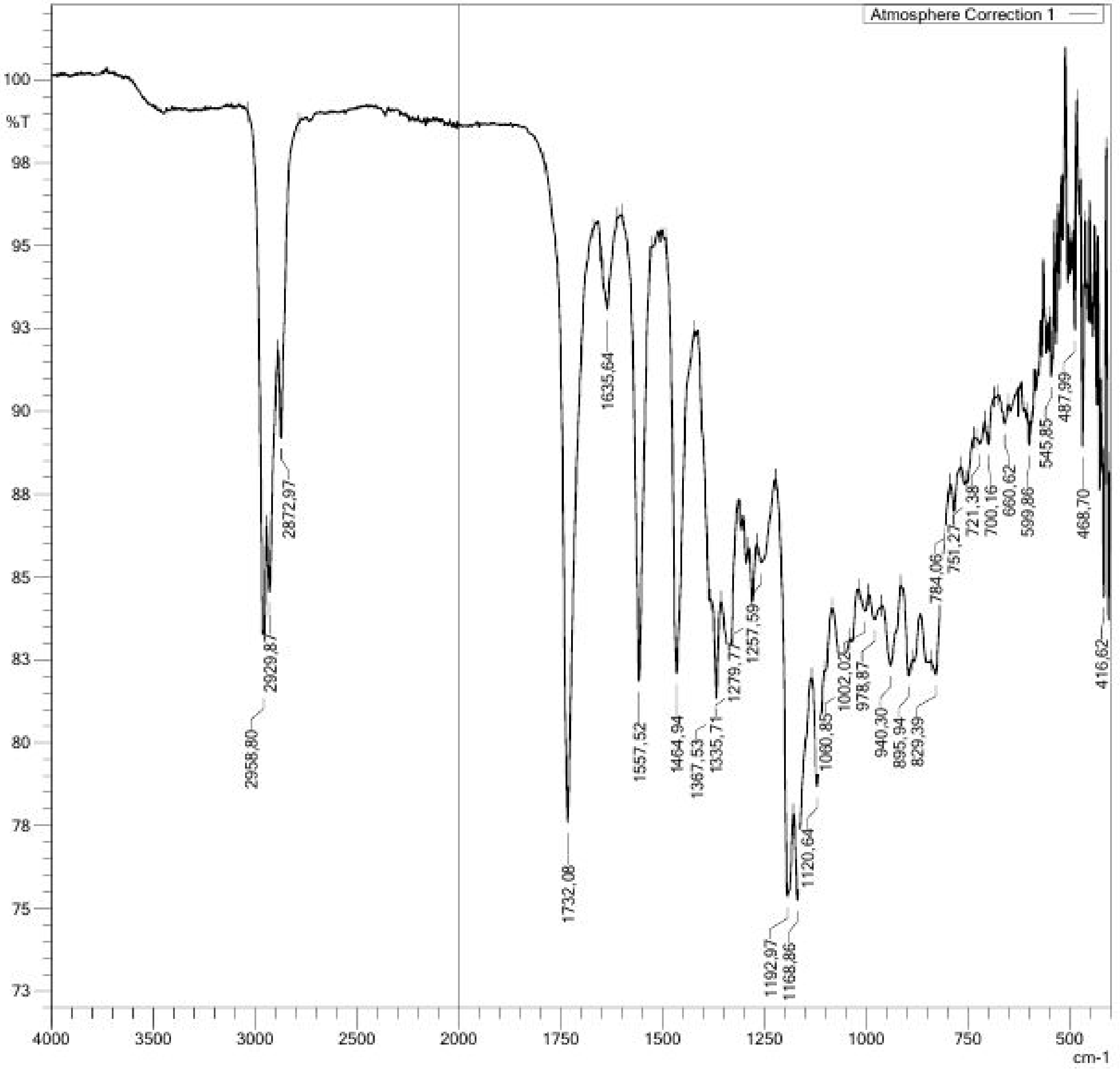

Figure 1. IR spectrum of Unj-20

Popoloca of absorption at 1552–1605 $см^{-1}$, v_s coincident effect of the nitro group. -spectrum contains absorption bands in the region 1313,67 cm^{-1}, corresponding With-NO_2руппам and absorption bands in the regions 835–871$см^{-1}$ corresponding to stretching vibrations of C-N groups. In the region below 1600–1616,33 cm^{-1}, absorption bands are manifested due to the stretching of single C-N bonds and the deformation of the angle between the bonds. It was mentioned above that the frequencies of deformation and valence vibrations of single bonds are located in the same region of the spectrum, however, the absorption bands of C-N valence vibrations can be detected quite easily, since they are stronger than the bands of C–C valence vibrations.

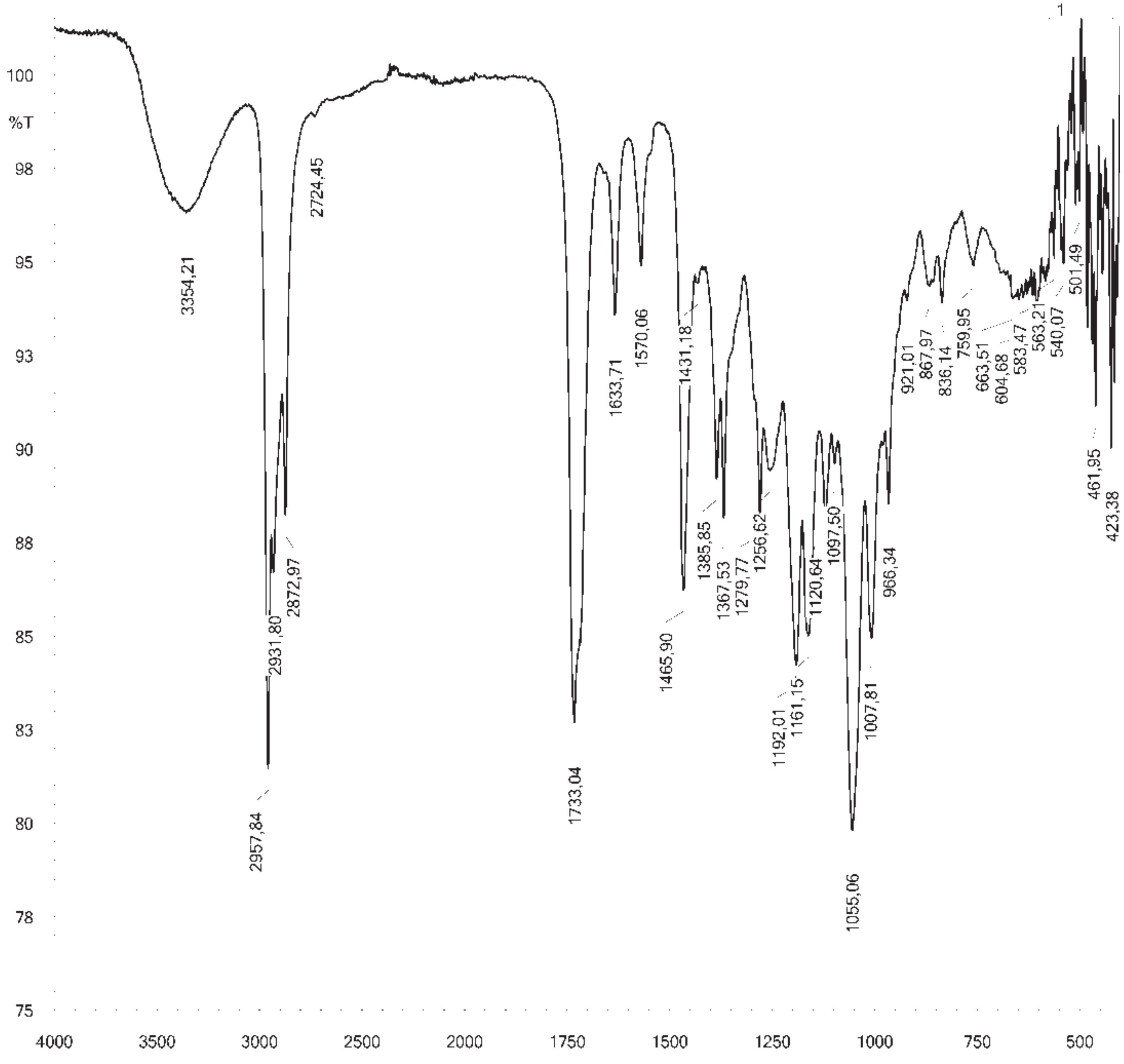

Figure 2. IR spectrum U-1

Deformation oscillations of all active groups are manifested in the form of strong narrow bands between the usual bands of deformation oscillations -O-NO_2 in the region of 1633–1278 cm^{-1}. Absorption bands in the regions of 793–871 cm^{-1} are confirmed by organic nitrates –NO_3 groups.

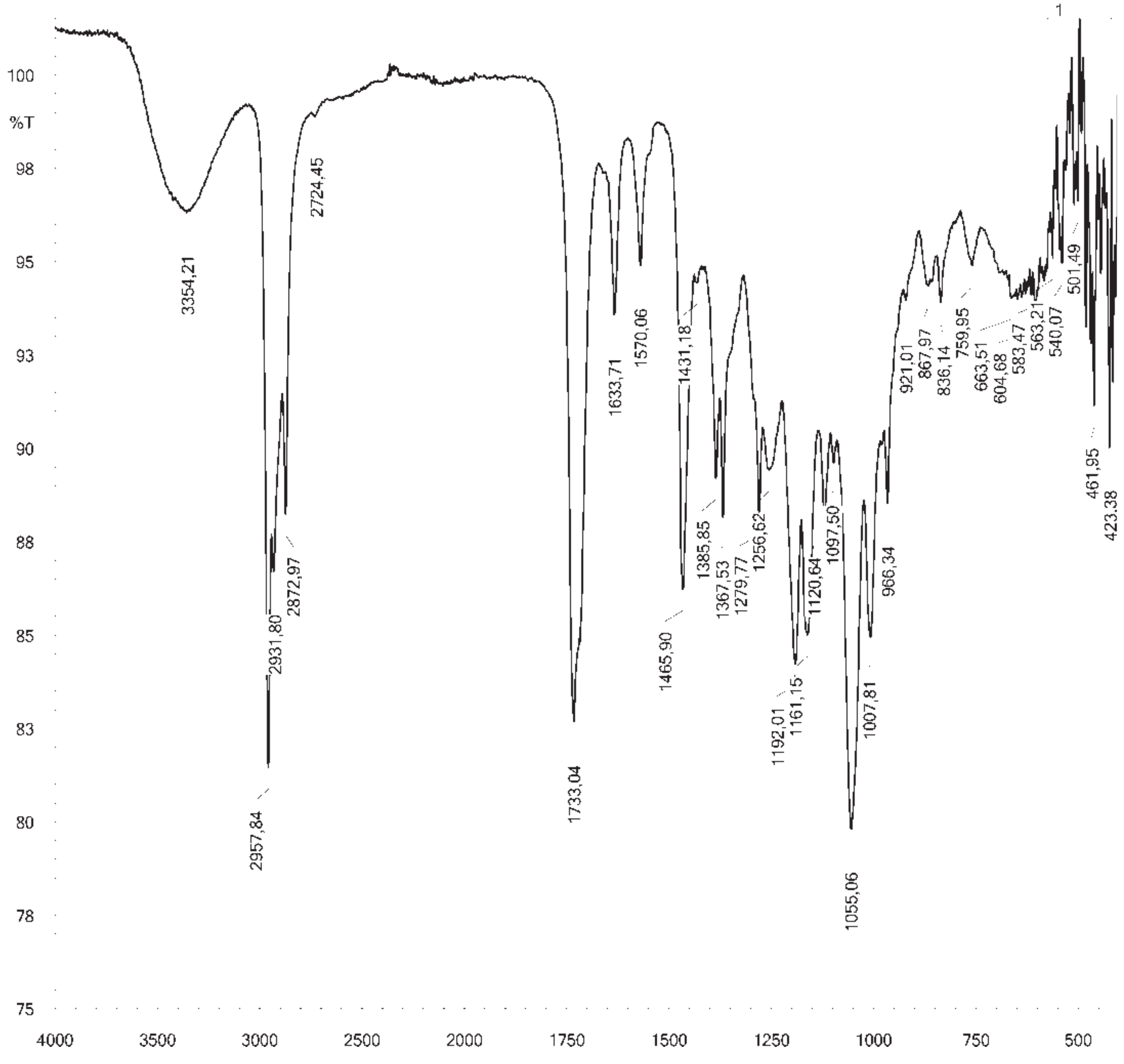

Figure 3. IR spectrum U-2

On the IR spectrum (figure 2), U-1 contains absorption bands, valence bond oscillations-CH_3 at 2959–1189 cm^{-1} and C-H 2850–2723 cm^{-1}. In areas 2873–2728 cm^{-1} and 1466–1042 cm^{-1} there are absorption bands, confirming the presence of-CH_2 — groups, all bands are usually weak. Absorption bands in the region 1571–1671 $см^{-1}$, v_s coincident effect of the nitro group. The IR spectrum contains absorption bands in the region of 1369 cm^{-1} corresponding to NO_2 groups and absorption bands in the regions of 824–870 cm^{-1} corresponding to the valence oscillations of C-N groups. Deformation oscillations of all active groups are manifested in the form of strong narrow bands between the usual bands of deformation oscillations -O-NO_2 in the region of 1632–1241 cm^{-1}. Absorption bands in the regions of 794–870 cm^{-1} are confirmed by organic nitrates –NO_3 groups.

On the IR spectrum (figure 3), U-2 contains absorption bands, valence bond oscillations-CH_3 at 2957–1059 cm^{-1} and C-H 2872–2750 cm^{-1}. Absorption bands in the region 1552–1605 см$^{-1}$, v_s coincident effect of the nitro group. The IR spectrum contains absorption bands in the region of 1385 cm^{-1} corresponding to C-NO_2 groups and absorption bands in the regions of 836–865 cm^{-1}. Deformation oscillations of all active groups are manifested in the form of strong narrow bands between the usual bands of deformation oscillations -O-NO_2 in the region of 1633–1278cm^{-1}. Absorption bands in the regions of 793–871 cm-1 are confirmed by organic nitrates –NO_3 groups.

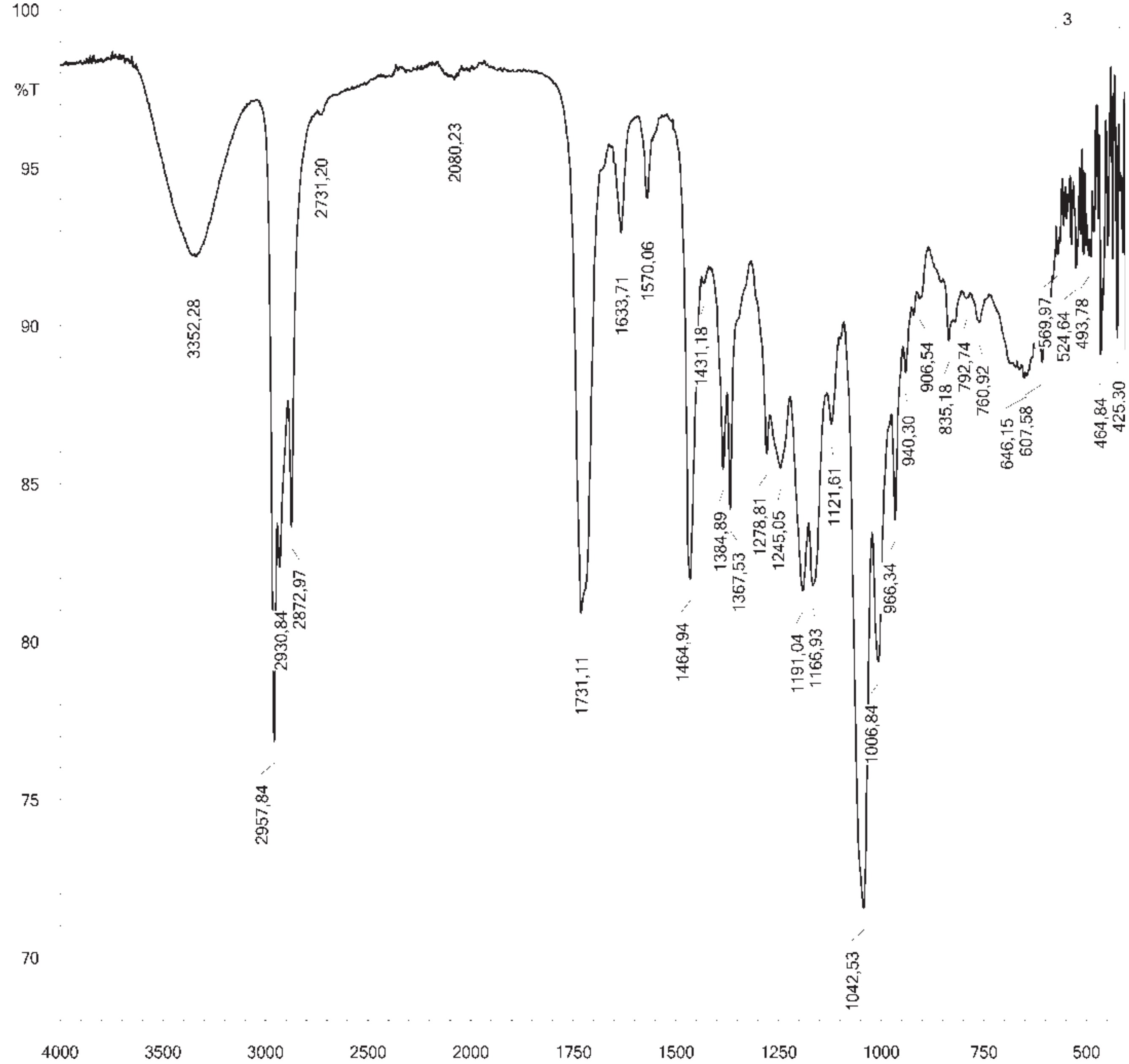

Figure 4. IR spectrum U-3

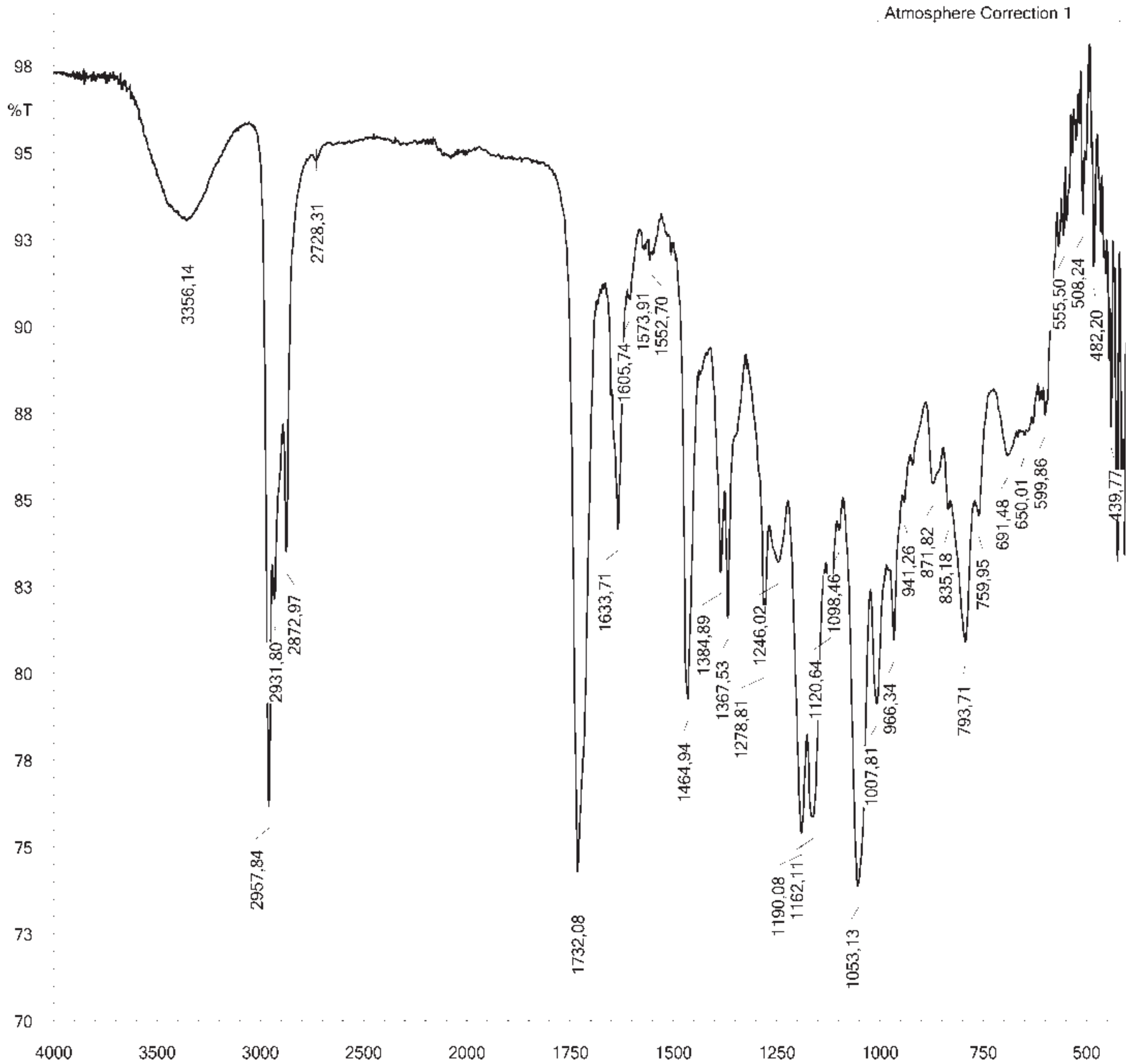

Figure 5. IR spectrum U-4

On the IR spectrum (figure 4), U-3 contains absorption bands, valence bond oscillations-CH_3 at 2930–1370 cm^{-1} and C-H 2850–2750 cm^{-1}. In the areas of 2872–2731cm^{-1} and 1464–1098 cm^{-1} there are absorption bands confirming the presence of CH_2 groups, all bands are usually weak. Absorption bands in the region 1570–1665 см$^{-1}$, v_s coincident effect of the nitro group. The IR spectrum contains absorption bands in the region of 1384 cm^{-1} corresponding to C-NO_2 groups and absorption bands in the regions of 835–890 cm^{-1} corresponding to valence oscillations of C-N groups. In the region below 1573–1633 cm^{-1} absorption bands are manifested due to the stretching of single C-N bonds and the deformation of the angle between the bonds. It was mentioned above that the frequencies of deformation and valence vibrations of single bonds are located in the same region of the spectrum, however, the absorption bands of C-N valence vibrations can be detected quite easily, since they are stronger than the bands of C–C valence vibrations.

Deformation oscillations of all active groups are manifested in the form of strong narrow bands between the usual bands of deformation oscillations -O-NO_2 in the region of 1633–1278 cm^{-1}. Absorption bands in the regions of 793–871cm^{-1} are confirmed by organic nitrates –NO_3 groups.

The IR spectrum (figure 5) U-4 contains absorption bands, stretching vibrations of bonds -CH_3 in the area of 2931–1384$см^{-1}$ absorption bands in the region 1552–1573$см^{-1}$, v_s coincident effect of the nitro group. The IR spectrum contains absorption bands in the region of 1367 cm^{-1} corresponding to C-NO_2 groups and absorption bands in the regions of 835–871 cm^{-1}. the Deformation oscillations of all active groups are manifested in the form of strong narrow bands between the usual bands of deformation oscillations -O-NO_2 in the region of 1633–1273 cm^{-1}. Absorption bands in the regions of 793–871 cm^{-1} are confirmed by organic nitrates –NO_3 groups.

References:

1. Frusteri F., Spadaro L., Beatrice C., Guido C. Oxygenated additives production for diesel engine emission improvement. ChemEng J 134: 2007; 239–245.
2. Karabektas M., Gokhan E., Hosoz M. The effects of using diethylether as additive on the performance and emissions of a diesel engine fuelled with CNG. Fuel 115: 2013; 855–860.

Section 5. Electroenergetics

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SIMPLE AND EFFICIENT MODEL-FREE CONTROLLER FOR AUTONOMOUS UNDERWATER VEHICLE DEPTH CONTROL

Abstract. In this study, we intended to design an efficient model-free controller for AUV depth control, which can overcome the difficulties of derive the mathematical models coming from the versatile environment where operate the AUVs. The model-free controller proposed here shows the ability to tract accurately a reference input signal and has good performances compare to H-infinity controller for AUV. It is also simple to design and implement, with few parameters to tune, when needed to refine the system performances.

Keywords: Autonomous underwater Vehicle (AUV), Remote Operating Vehicle (ROV), H-infinity controller, Model-free controller, Fuzzy logic controller (FLC), Sliding mode controller (SMC).

I. Introduction

Remotely operated vehicles (ROVs) and Autonomous Underwater Vehicles (AUV) are important tool for marine development and exploitation of resources located at deep oceanic environment [1] and are also used in risky and hazardous operations such as ocean rescue, underwater detection and observation, ocean floor analysis, and inspections or maintenance of underwater facilities.

AUV response depends heavily on its particular design and configuration, operating conditions, and environmental forces. Any automatic controller design for an AUV must satisfy two conflicting requirements: First, it has to be sophisticated enough to perform its mission in the realm of complicated and ever-changing vehicle/environment interactions; secondly, it has to be simple enough so that on-line implementation is possible by the onboard vehicle computer at a sufficiently high sample rate [2].

Inherently, nonlinear dynamics of AUVs make it more difficult to exert commonly used linear control. The dynamic characteristics of an AUV are quite complex due to its high nonlinearity, time-varying dynamic behavior, uncertainties in hydrodynamic coefficients, and disturbances caused by sea currents and waves [3].

Various control techniques have been proposed for AUVs. This includes linear controllers [4; 5], sliding Mode Controller (SMC) [6], Fuzzy Logic Control (FLC) [7], adaptive control [8], which have performed satisfactorily and have shown good robustness and tuning ability.

The objective of this paper is to develop a model free controller for attitude control system of AUV, that is simple, easy to use and efficient compare to advanced controllers. The goals are to:

- Achieve a suitable and simple controller to control depth of an AUV;
- Simulate the AUV's system and analyze the performances of the controller against the H-infinity Controller.

II. Problem statement

The problem that we want to solve here can be define as follow:

How can we design a controller that will be able to control the depth of an AUV, without relying on AUV system parameters?

Such controller should be model-free and its parameters should be easy to tune to improve the system performances (settling time, overshoot, error).

III. Model-free controller design

The idea is to supply the system with the right input signal, which derived from the closed-loop system output, plus the error signal. The error is passed through a compensator, which conditions it and makes it suitable to compensate the deficit that may occur in the first stage closed-loop. The following figure describe the model-free controller structure.

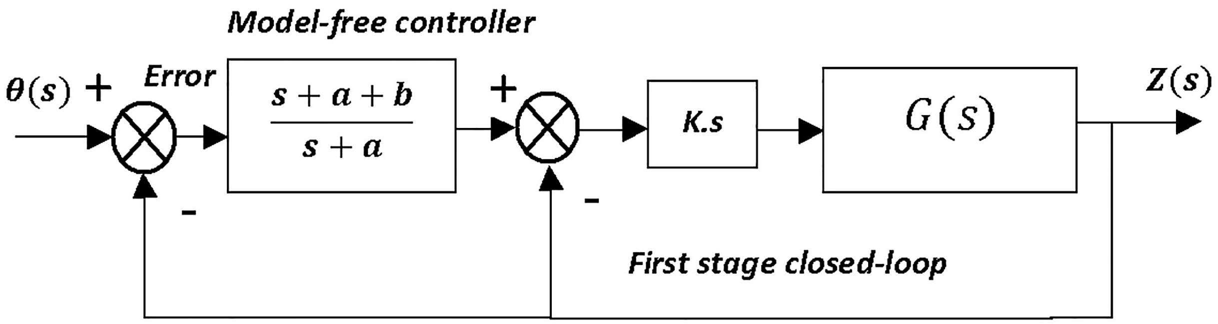

Figure 1. System with Model-free controller Block diagram

With, G(s): AUV transfer function

Suppose the AUV is represented by the following transfer function:

$$\frac{Z(s)}{\theta(s)} = \frac{N}{s^3 + l_1 s^2 + l_2 s} \tag{1}$$

With: $Z(s)$: *AUV depth*,

$\theta(s)$: *AUV pitch angle*

N, l_1, l_2: *AUV parameters*

From fig.1 we can obtain the overall system transfer function as:

$$\frac{Z(s)}{\theta(s)} = \frac{KNs + (a+b)KN}{s^3 + (l_1 + a)s^2 + (l_2 + al_1 + 2KN)s + a(l_2 + KN) + (a+b)KN} \tag{2}$$

Hypothesis

Our hypothesis is as follow: The System in (1) does not have any pole in the right half side of the complex plane nor in the imaginary axis, except at s=0.

This means, the system is stable; therefore, we can apply the final value theorem on it.

Final value theorem

$$V_{f=} \lim_{s\to 0} sZ(s) = \lim_{s\to 0} s\frac{KNs + (a+b)KN}{s^3 + (l_1 + a)s^2 + (l_2 + al_1 + 2KN)s + a(l_2 + KN) + (a+b)KN}.\frac{1}{s} \tag{3}$$

$$V_{f=}\frac{(a+b)KN}{a(l_2+KN)+(a+b)KN} \tag{4}$$

if we make a ⊕0,

$$V_{f=}\frac{bKN}{bKN}=1 \tag{5}$$

The more the controller parameter "a" is near to zero the more the system is accurate. We are left with two parameters "b" and "K" that will be used to drive system to the desired performances.

IV. Simulation

For the simulations we uesed, the AUV system described by [9], with AUV transfer function given by:

$$\frac{Z(s)}{\theta(s)}=\frac{4.16}{s^3+0.82s^2+0.69s} \tag{6}$$

The controller parameters are as follow:

$$K=-1, a=0.1, b=1$$

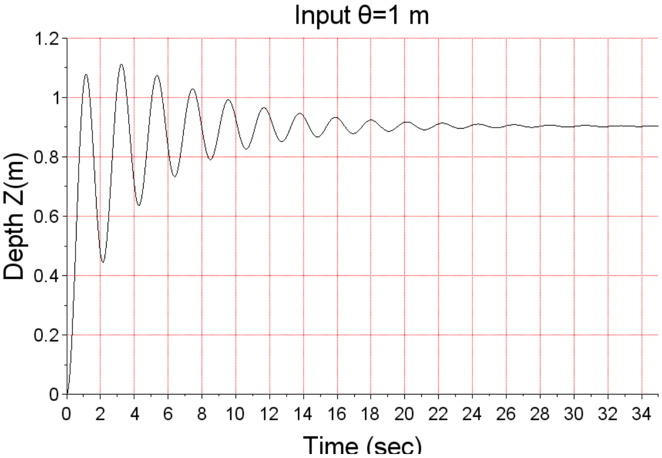

Figure 2. Step response simulation with K= −1, a=0.1, b=1

The system performances are resumed in the below table:

Table 1. – System Performances form the 1st simulation

Param.	Ts (s)	OS (%)	Error (%)
Model-free controller	14.94	18.87	9.60

In order to improve the system performances, to reach the performance of the H-infinity controller [9], we choose the following values for our controller:

$$K=-100, a=0.1, b=7\ .$$

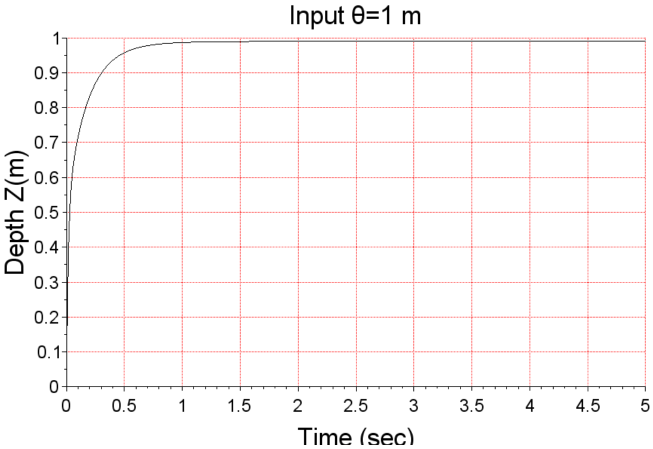

Figure 3. Step response simulation with K= −100, a=0.1, b=5

The Model-free controller performances are resumed and compared to H-Infinity controller performances [9], for the same system in the below table:

Table 2. – System Performances compared form the 2nd simulation

Param.	Ts (s)	OS (%)	Error (%)
H-Infinity controller	1	4	2
Model-free controller	1.36	NO	1.90

The model-free controller was able to control the system and drive system to performances similar to the one obtained with an advanced controller (H-infinity), without the need to know system parameters.

Conclusion

This study showed that a simple model-free controller can control AUV attitude efficiently, without the need to know neither system model nor system dynamics. The simulations confirmed that the proposed model-free controller also has good performances and is easy to tune. The simple structure of the model-free controller proposed here make it suitable for both hardware and software implementation. The controller performances are very closed to those obtained with H-Infinity controller.

References:

1. Kim Y. S., Lee J., Park S. K., Jeon B. H., Lee P. M. Path tracking control for under actuated AUVs based on resolved motion acceleration control. In Proceedings of the 4th International Conference on Autonomous Robots and Agents, IEEE, Wellington, New Zealand, 2009.– P. 342–346.
2. Cristi R., Papoulias F. A. and Healey A. J. "Adaptive Sliding Mode Control of Autonomous Underwater Vehicles in the Dive Plane". IEEE Journal of oceanic engineering,– Vol. 15.– No. 3.– July 1990.
3. Vahid S., Javanmard K. "Modeling and Control of Autonomous Underwater Vehicle (AUV). In Heading and Depth Attitude via PPD Controller with State Feedback", International Journal of coastal & offshore engineering, IJCOE No. 4 / Autumn 2016 (11–18).
4. Yildiz O., Gokalp R. B., Yilmaz A. E. A review on motion control of the Underwater Vehicles. In: Proceedings of electrical and electronics engineering, 2009. ELECO 2009, Bursa, 2009.– P. 337–341.
5. Wadoo S., Kachroo. "Autonomous underwater vehicles: modeling, control design and simulation." CRC Press, edn 1, 2010.
6. Buckham B. J., Podhorodeski R. P., Soylu S. "A chattering-free sliding-mode controller for underwater vehicles with fault tolerant infinity-norm thrust allocation." J Ocean Eng, 35(16): 2008; 1647–1659.
7. Jun S. W., Kim D. W., Lee H. J. "Design of T-S fuzzy model based controller for depth control of autonomous underwater vehicles with parametric uncertainties." In: 11th international conference on control, automation and systems, ICCAS2011, Gyeonggi-do, Korea, Republic of, 2011.– P. 1682–1684.
8. Qi X. Adaptive coordinated tracking control of multiple autonomous underwater vehicles. Ocean Eng 91:2014.– P. 84–90.
9. Nag A., Patel S. S., Kishore K. and Akbar S. A. "A robust H-infinity based depth control of an autonomous underwater vehicle" 2013. International Conference on Advanced Electronic Systems (ICAES), Pilani, 2013.– P. 68–73. doi: 10.1109/ICAES.2013.6659363.

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