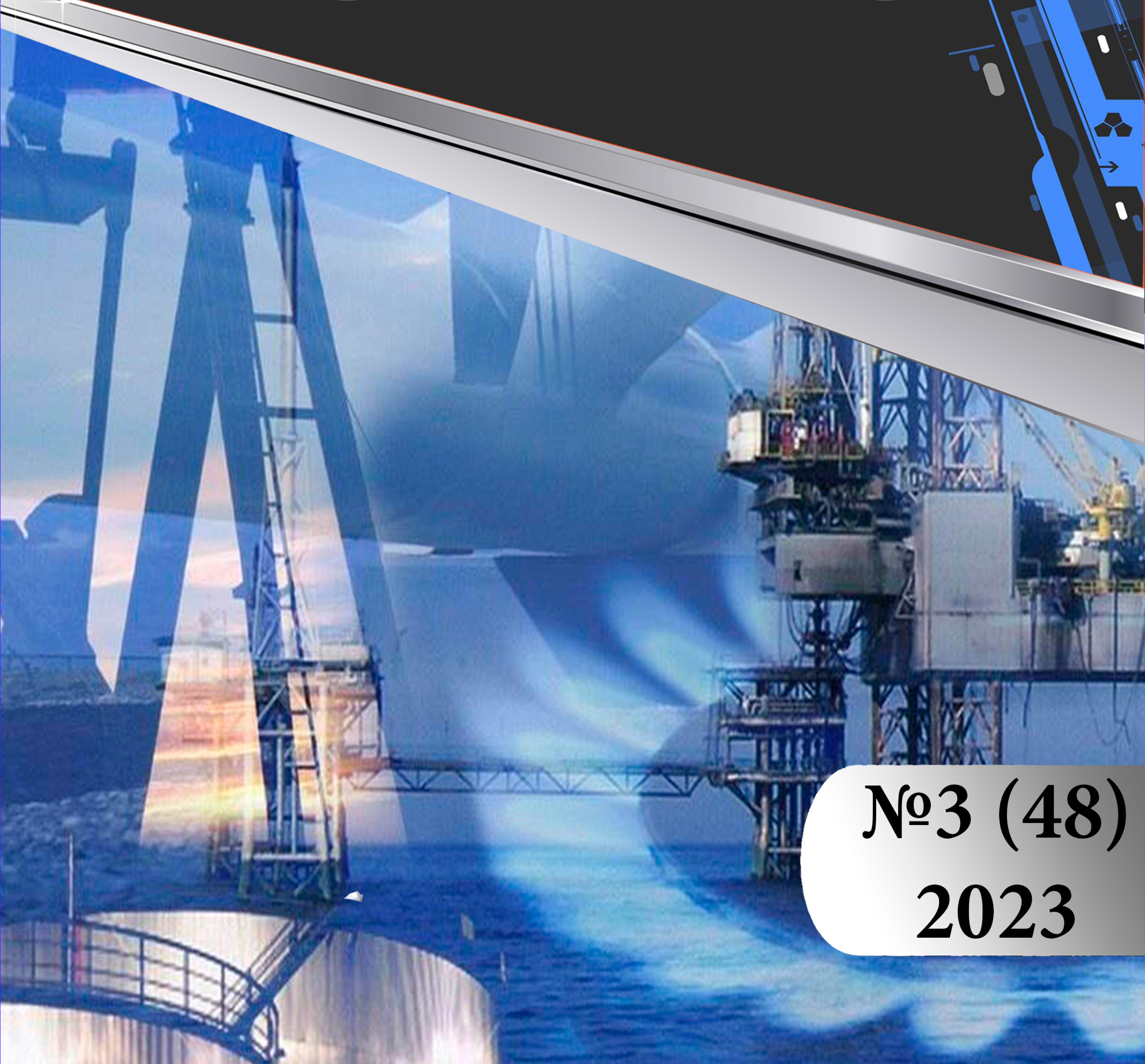
ISSN 2223-3911

INDUSTRIAL TECHNOLOGY AND ENGINEERING



№3 (48)
2023

ISSN 2223-3911

Industrial Technology and Engineering

№ 3 (48) 2023

The journal is being published since 2011, Periodicity: 4 issues per year

Editor in chief: *D. Kozhamzharova*

The Owner: Ministry of Education and Science of the Republic of Kazakhstan
Non-Profit Joint Stock Company «M. Auezov South Kazakhstan University»

Certificate of registration of the periodic printed publication and (or) news agency № 11566-Ж issued on 04.04.2011 by Ministry of Communication and Information of the Republic of Kazakhstan.
The journal is registered at the International Centre for Registration of serial editions (UNESCO, Paris, France) in June 2011 under registration number ISSN 2223-3911.

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2023, M. Auezov South Kazakhstan University *Printed in Kazakhstan*

IRSTI 52.47.27

CRITERIA FOR EFFECTIVE APPLICATION OF ENHANCED OIL RECOVERY METHODS

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ABSTRACT

This publication provides an assessment of the criteria for the effective application of enhanced oil recovery methods that determine the range of favorable fluid and bed properties. The conditions for the applicability of these criteria in various geological and physical conditions, methods for increasing oil recovery depending on the geological and physical conditions, as well as the main criteria for applying thermal methods for enhancing oil recovery are given. In addition, the potentialities and critical factors of enhanced oil recovery methods are presented. Based on the analysis of the presented material, the following conclusions were made: The main reasons for the incomplete recovery of oil by the oil bed are bedded forms of the residual oil existence: capillary-retained oil; oil in a film state; oil remaining in low impermeable areas, bypassed and poorly washed with water; oil in lenses separated from the bed by seals and not exposed by wells; oil in stagnant zones of homogeneous beds. All methods of enhanced oil recovery are based on flooding. The main methods of enhanced oil recovery used on an industrial scale are hydrodynamic; physicochemical; gas thermal. The main criteria for the applicability of enhanced oil recovery methods are geological and physical; technological; material and technical.

Keywords: efficiency criteria, enhanced oil recovery methods, geological and physical conditions.

INTRODUCTION

Increasing oil production is a priority for the oil and gas complex [1].

An important condition for the effective application of enhanced oil recovery methods is the correct choice of an object for a method or, conversely, a method for an object.

Methods applicability criteria determine the range of favorable fluid and bed properties, under which it is possible to effectively apply the method or obtain the best technical and economic development indicators. These criteria are determined based on the analysis of the technical and economic indicators of the application of the method, the generalization of the experience of its application in various geological and physical conditions, as well as the use of extensive theoretical and laboratory studies.

MATERIALS AND METHODS

There are usually three categories of criteria for the applicability of methods:

Geological and physical (properties of reservoir fluids, depth of occurrence and thickness of the oil-filled formation), parameters and features of the oil-containing reservoir (saturation of the pore space with reservoir fluids, occurrence conditions) and others;

Technological (rim size, concentration of agents in the solution, well placement, discharge pressure, etc.);

Material and technical (provision with equipment, chemical reagents, their properties, etc.).

The criteria of the first category are defining, the most significant and independent.

The technological criteria depend on the geological and physical ones and are selected in accordance with them.

For the most part, the material and technical conditions are also independent, remain unchanged and determine the possibility of fulfilling the technological criteria.

RESULTS AND DISCUSSION

On the basis of laboratory research and pilot testing of enhanced oil recovery methods, reliable data and ideas about the quantitative criteria characterizing the properties of reservoir oil, water and beds were obtained for their successful application (Tables 1-4) [3-7].

Table 1 – Methods for increasing oil recovery depending on the geological and physical conditions (according to M.L. Surguchev)

Oil, water	Bed	Method
1	2	3
Low-viscosity, light oil, water with a low content of salts, especially calcium and magnesium	Sandy undepleted, highly permeable, low permeable, heterogeneous	Flooding, cyclic influence, water-gas mixture, surfactant injection, high-pressure gas application
Low-viscosity oil, water with a low content of salts, especially calcium and magnesium	Carbonate undepleted, highly permeable, fractured, porous. Sandy depleted (flooded), highly permeable, monolithic. Carbonate flooded, highly permeable, weakly fractured, heterogeneous.	Flooding, cyclic influence, use of alkalis, depletion. Micellar solution, carbon dioxide, water-gas mixtures. Application of carbon dioxide, cyclic influence.

Table 1 continuation

Low-viscosity, tarry (active) paraffin oil, water with a low content of salts, especially potassium and magnesium	Sandy undepleted, highly permeable, low permeable. Carbonate undepleted, highly permeable, low permeable, fractured porous. Sandy flooded, highly permeable, monolithic, heterogeneous.	Flooding (hot water), application of polymers, injection of water-gas mixture, alkali. Flooding (hot water), cyclic influence, injection of alkali, carbon dioxide. Application of carbon dioxide, microemulsions, water-gas mixtures.
High-viscosity heavy oil, reservoir water with a high content of salts	Sandy deep-laying, highly permeable, low permeable. Sandy, highly permeable, low permeable, shallow	In-situ combustion, steam injection, steam cycle treatments

Table 2 – Main criteria for the use of physicochemical and gas methods of enhanced oil recovery (according to M.L. Surguchev)

<table>
<tr><th>Parameter</th><th>Displacement by carbon dioxide</th><th>Water-gas influence</th><th>Injection of micellar solutions</th><th>Polymer influence</th><th>Injection of water solutions of surfactants</th></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>Viscosity of reservoir oil, mPa*s</td><td><16</td><td><25</td><td><15</td><td>5-100</td><td>25</td></tr>
<tr><td>Oil saturation, %</td><td>>30</td><td>>50</td><td>>25</td><td colspan="2">>50</td></tr>
<tr><td>Reservoir pressure, MPa</td><td>>8</td><td colspan="4">Unlimited</td></tr>
<tr><td>Reservoir temperature, °C</td><td colspan="2">Unlimited</td><td colspan="3"><70</td></tr>
<tr><td>In-place permeability, mcm²</td><td colspan="2">Unlimited</td><td>>0.1</td><td>0.1</td><td>Unlimited</td></tr>
<tr><td>Bed thickness, m</td><td colspan="2">25</td><td><25</td><td colspan="2">Unlimited</td></tr>
<tr><td>Fracturing</td><td colspan="2">Unfavorable*</td><td></td><td colspan="2"></td></tr>
<tr><td>Lithology</td><td colspan="2">Unlimited</td><td>Sandstone</td><td colspan="2">Sandstone and carbonates</td></tr>
<tr><td>Reservoir water salinity, mg/l</td><td colspan="2">Unlimited</td><td>5</td><td colspan="2">20</td></tr>
</table>

Table 2 continuation

Water hardness (presence of calcium and magnesium)	Unlimited		Unfavorable	Unlimited	
Gas cap	Unfavorable	Unlimited	Unfavorable		
Well density, 104 m^2/well	Unlimited		<16	<24	Unlimited

Table 3 – Main criteria for the use of thermal methods of enhanced oil recovery (according to M.L. Surguchev)

Parameter	In-situ combustion	Displacement by steam	Steam cycle treatment	Displacement by hot water
1	2	3	4	6
Viscosity of reservoir oil, mPa*s	>10	>50	>100	>5
Oil saturation, %	>50			
In-place permeability, mcm^2	>0.1	>0,2	Unlimited	
Bed thickness, m	>3	>6	>3	
Fracturing	Unfavorable*			
Seam depth, m	>1500	<1200	<1500	
Clay content in bed, %	Unlimited	5—10		
Well density, 104 m^2/well		<6	Unlimited	

Table 4 – Potential opportunities and critical factors of enhanced oil recovery methods (according to M.L. Surguchev)

Working agent	Enhanced oil recovery, %	Critical factor in the application of the working agent
1	2	3
Water + gas	5-10	Gravitational separation. Decreased productivity
Polymers	5-8	Salinity of water and bed. Decreased productivity
Alkalis	2-8	Oil activity
Micellar solutions	8-20	Complexity of technology. salinity of water and bed. Decreased productivity

Table 4 continuation

Carbon dioxide	8-15	Decrease in influence coverage. Regeneration, corrosion
Steam	15-35	Heat loss. Shallow depth. Sand recovery. Technical problems
Air + water (combustion)	15-30	Complications in the initiation of combustion. Coverage of bed by combustion. Technical problems. Environmental protection

* An unfavorable factor in the application of the method is the fracturing of the bed.

CONCLUSION

1. Reservoir pressure is the main factor that determines the current energy state of the deposit. The pressure difference between the bed and the well bottom is the driving force that ensures the oil flow from the bed to the well.

2. There are two types of reservoir energy sources – natural and artificial.

Natural sources of the reservoir energy are the elasticity of the bedded system, the pressure of the reservoir waters, the presence of the free gas (in the form of a gas cap), the energy of the dissolved gas, and the pressure due to the gravity force.

Artificial sources of the reservoir energy are created by injection of water, steam or gas into the bed. Depending on which source of the reservoir energy prevails, a certain development mode is formed.

3. During the operation of the field, the reservoir energy is spent on performing work on moving fluids and gases in the bed and lifting them to the surface.

The main share of the reservoir energy goes to overcome the forces of internal friction due to the viscosity of fluids and gases, and the friction forces arising from the movement of fluid and gas phases relative to each other.

4. According to the predominant type of the reservoir energy, the following modes of operation of oil deposits are distinguished: water-pressure; elastic; dissolved gas; gas-pressure; gravitational; mixed.

5. The main indicator of the operation mode of deposits and the whole process of their development is oil recovery (the degree of completeness of oil recovery).

6. Depending on the bed operation mode, the final oil recovery factor can reach the following values:

Water-pressure – 0.4-0.7
Gas-pressure – 0.3-0.6
Dissolved gas – 0.15-0.3
Gravitational – rarely >0.1

Residual or non-recoverable oil reserves by industrially developed methods reach an average of 55-75% of the initial geological oil reserves in the subsoil.

7. The main reasons for the incomplete recovery of oil by the oil bed are bedded forms of the residual oil existence: capillary-retained oil; oil in a film state; oil remaining in low impermeable areas, bypassed and poorly washed with water; oil in lenses separated from the bed by seals and not exposed by wells; oil in stagnant zones of homogeneous beds.

8. In the process of field development, the composition and properties of the extracted oil (density, viscosity, composition, etc.) change.

9. All methods of enhanced oil recovery are based on flooding. The main methods of enhanced oil recovery used on an industrial scale are hydrodynamic; physicochemical; gas thermal.

10. The main criteria for the applicability of enhanced oil recovery methods are geological and physical; technological; material and technical.

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MISTI 338.43 (574)

THE ROLE OF THE AGRO-INDUSTRIAL COMPLEX IN THE ECONOMY OF KAZAKHSTAN

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ABSTRACT

The authors analyze the current state of development of agriculture in the country, show ways to improve the efficiency of the agricultural sector. The agro-industrial complex is designed to ensure the food security of the state, characterized by the level of satisfaction of the population with food, the quality of food. The article notes that its share in the structure of the gross national product is still low, and the republic is import-dependent for certain types of agricultural products. The analysis of agricultural production in the context of categories of farms is given. The main reasons hindering its development have been identified, such as the presence of a significant number of inefficient small farms, a weak material and technical base, and a low level of introduction of innovative technologies into production. It is proved that agricultural enterprises function most effectively in the agro-food market, while peasant farming predominates in terms of numbers in agricultural formations, their number is 94%, or 196 thousand units.

It has been established that in the context of the development of market relations, small peasant farms are also needed, which respond more flexibly to consumer demand, but they must be effective. The comparison of the main economic indicators of agricultural enterprises and peasant farming is carried out. In practice, 40% of peasant farming has no more than 10 hectares of land and mostly work unprofitably. The authors believe that large, commodity farms should be created in Kazakhstan, which should produce competitive, export-oriented agricultural products.

Keywords: agricultural sector, gross output, yield, livestock and poultry, investment

INTRODUCTION

The agro-industrial complex is the most capacious intersectoral complex, the purpose of which is the production and processing of agricultural raw materials with subsequent delivery to the final consumer of the initial product.

The agro-industrial complex includes four major areas: agriculture; supporting industries (agricultural machinery, production of fertilizers, chemicals); processing industries (food and light industry); infrastructure (industries engaged in harvesting, transportation, storage of agricultural raw materials, trade in finished products, training).

The ratio of these areas varies from country to country, in developed countries the largest share is occupied by processing and infrastructure industries, in developing countries - agriculture itself.

MATERIALS AND METHODS

Scientific works of domestic and foreign scientists on the research topic, laws, regulatory acts, official statistical data of the National Bureau of Statistics form the theoretical, methodological and informational basis.

In the preparation of the research work, methods of collecting, grouping, processing, systematization of information, comparative assessment, methods of economic and statistical analysis were used.

RESULTS AND DISCUSSION

The agro-industrial complex ensures the economic and food security of the country, therefore its development is a strategic goal of any state. Agro-industrial complex products have a high turnover, as they are consumed daily, i.e. the dynamics of the agro-industrial complex market is the most predictable and stable [1]. Due to this, the agro-industrial complex is a stable source of jobs. The number of people employed in agriculture in Kazakhstan is 1319 thousand people out of 8585.1 thousand people employed in the economy or 15.4%. A large share is occupied only by the wholesale and retail trade sector, along with vehicle repairs - 15.54% [2]. However, in 2010, this share was 28.3%, i.e. there is an outflow of labor from the agricultural sector. One of the reasons for this outflow may be low wages in the industry - in 2018, the average wage in the agricultural sector amounted to 80,049 tenge - the lowest value among other industries. With an average value of 152,442 tenge in the country and a maximum of 366,187 in the mining industry, outflow is natural [3].

The agro-industrial complex also affects other sectors of the economy - chemical, machine and instrument-making industries, wholesale and retail trade. Structural changes in the agro-industrial complex entail changes in related industries. Given the share of agriculture in the economy, these changes turn out to be significant.

Growth in the agro-industrial complex stimulates the inflow of investments, activates the trade and services sectors. Among other things, the features of the agro-industrial complex are the wide geographical coverage of the industry, the scale of the deployment of the material and technical base, and historically determined employment of the population [1]. All this makes the agro-industrial complex an important area of human activity, capable of influencing the internal economic policy of the state.

In Kazakhstan, due to historical circumstances, the most developed sector of agriculture was animal husbandry. However, due to the combination of geographical characteristics and a large territory, there is a potential for the development of almost any branch of the agro-industrial complex. More than 80% of the land is agricultural land, as of 2015 the area of agricultural land is 210 million hectares [4].

Demonstrating the importance of agriculture for the economy, the Government of the Republic of Kazakhstan during the period of independence has developed nine programs defining state policy in this area: «Auyl» for 1991-1995, the Conceptual program for the development of agriculture for 1993-1995, the Program for the development of agricultural production for 2000-2002, the State agri-food program for 2003-2005. The State Program for rural Development for 2004-2010, the Concept of sustainable development of the agro-industrial complex for 2006-2010, the Program of priority measures for the implementation of the Concept of sustainable development of the agro-industrial complex of the Republic of

Kazakhstan for 2006-2010, the Program for the development of agriculture for 2010-2014 and the Program for the development of agriculture in the Republic of Kazakhstan «Agribusiness – 2017». The State Program for the development of the agro-industrial complex of the Republic of Kazakhstan for 2017-2021 is relevant today. The purpose of the program is to increase the competitiveness of the agro-industrial complex industry.

It is planned to achieve the goal by increasing labor productivity from 1.2 million tenge per person employed in agriculture in 2015 to 3.7 million tenge by 2021.

In addition, it is expected to increase exports of processed products from 211.6 billion tenge in 2015 to 738.5 billion tenge in 2021.

The objectives of the program are:

1. Ensuring food security.
2. Increasing the availability of financing for agribusiness entities.
3. Ensuring optimal taxation of agricultural entities.
4. Improving the efficiency of land and water resources use.
5. Ensuring the availability of sales markets and export development.
6. The development of agricultural science, technology transfer, and the level of competence of agricultural entities.
7. Increasing the level of technical equipment and intensification of production in the agro-industrial complex.
8. Improving the quality of public services, including through the introduction of digital technologies.
9. Increasing satisfaction with the living conditions of the population living in rural areas [5].

The indicators used are labor productivity in agriculture, the volume of gross agricultural output, the volume of investments in fixed assets in agriculture and in food production, the volume of exports of agricultural products, the volume of imports of food products, irrigation water consumption, the level of satisfaction with the living conditions of the rural population.

Based on the main provisions of the program, it can be concluded that agriculture, rather than the processing industry, takes on the greatest role in the development of the agro-industrial complex of Kazakhstan.

This approach gives an advantage in the form of self-sufficiency in raw materials for the processing industry, but reduces the potential for exporting finished agricultural products.

Using official statistical data, we will analyze the development of agriculture in Kazakhstan. Since agriculture is a priority industry, let's start with its indicators. The dynamics of gross agricultural output is shown in Fig. 1.

As can be seen from Fig. 1, the volume of agricultural production is steadily growing. The output of agricultural products of the Republic of Kazakhstan in 2018 amounted to 4474.1 billion tenge, in 2019 -5151.2 billion tenge, in 2020-6334.7 billion tenge, in 2021 - 7515.4 billion tenge, and in 2022 9481.3 billion tenge, if we compare 2022 with 2018, the output of agricultural products of the Republic of Kazakhstan increased 2.1 times.

Gross agricultural output in 2022 amounted to 5.2% of the country's GDP.

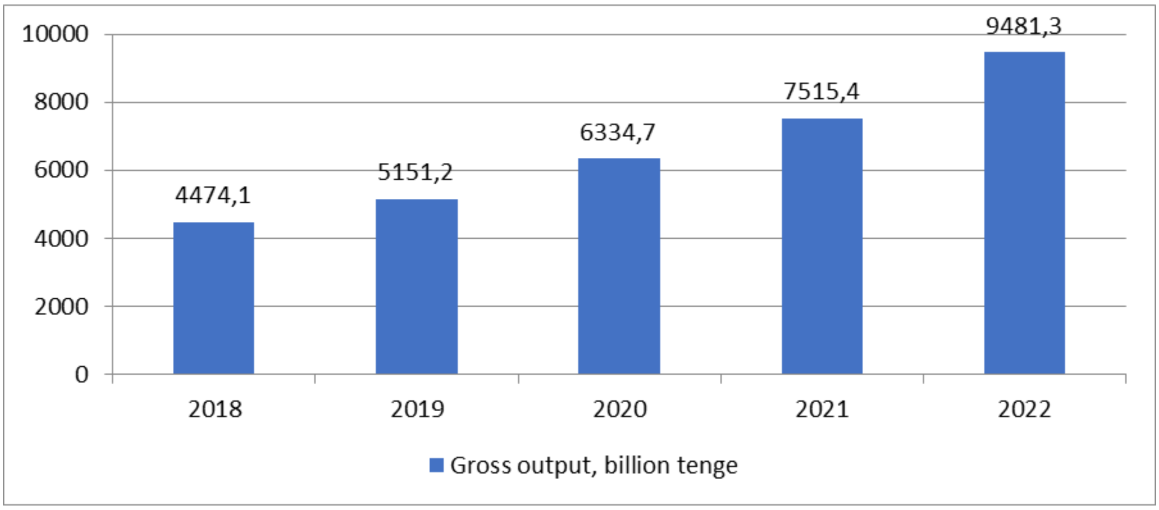

Fig. 1. Dynamics of gross agricultural output of the Republic of Kazakhstan in 2018-2022, billion tenge

To understand the role of agriculture, the structure of regions in gross output in the development of regions, consider the share of agricultural production shown in Fig. 2.

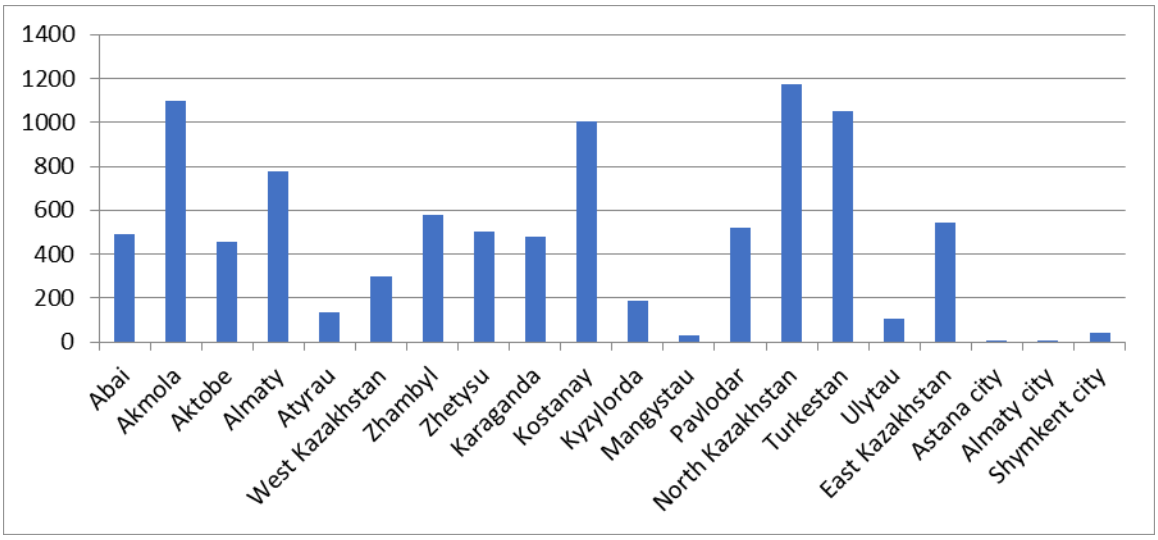

Fig. 2. The share structure of regions in gross agricultural output in 2022, billion tenge

Fig. 1 shows that the largest contribution (12.4%) is made by North Kazakhstan. Among the regions of the country, the largest share belongs to the Turkestan region (11.1%). This also allows us to talk about the priority of this region for the development of agriculture, including the material and technical base of the processing industry.

The industrial structure of the agro-industrial complex, as already mentioned, groups, each of which makes its own contribution, is divided into four major contributions to the development of the complex. Let's look at this structure in Table 1.

Table 1 - Industry structure of agricultural production volumes in 2022.

Branch	Production volume, billion tenge
Manufacture of tobacco products	285,1
Beverage production	770,3
Food production	3070,1
Animal husbandry	3658,8
And crop production	5808,3
Note - stat.gov.kz according to the website[2]	

As can be seen from table 1, the production of agricultural raw materials exceeds the production of finished products, while the excess is 2.2 times. The gross harvest of major crops from 2018 to 2022 is shown in Table 2.

Table 2 - Dynamics of gross harvest of major crops in 2018-2022, thousand tons

	2018	2019	2020	2021	2022
Cereals (including rice) and legumes (in weight	20 273,6	17 428,6	20 065,3	16 375,9	22 030,5
After refinement)	2 693,6	2 583,7	2 556,5	2 430,1	3 051,3
Oil-seed crops	343,6	344,4	326,6	290,4	361,8
Cotton	504,5	485,5	466,3	332,2	305,7
Sugar beet	1,6	1,2	1,2	1,1	1,2
Tobacco	3 807,0	3 912,1	4 006,8	4 031,6	4 080,5
Potato	4 081,9	4 355,2	4 590,9	4 768,5	4 792,6
Note - stat.gov.kz according to the website [2]					

From the data shown in table 2, it can be seen that if we compare the volume of gross harvest of major crops in 2022 with 2018, it can be seen that the volume of grain harvested amounted to 108.7%, increased by 8.7%, and in 2020 there was a sharp jump followed by a decline. The volume of sunflower seeds harvested amounted to 113.3%, increased by 13.3%, cotton (105.3%) - by 5.3%, potatoes (107.2%) - by 7.2%, vegetables (117.4%) – by 17.4%. At the same time, sugar beet volumes decreased by 60.6%, tobacco production decreased by 75%. In general, the dynamics for a large number of positions is positive.

The volumes of cereals and legumes fluctuate throughout the study period, but generally show a positive development trend.

Consider the indicators of animal husbandry in the form of the number of livestock and poultry (Table 3).

Based on Table 3, the number of cattle (119.4%) increased by 19.4%, sheep and goats (116.5%) - by 16.5%, horses (145.7%) - by 45.7%, poultry (112.3%) – by 12.3%, camels (124.8%) – by 24.8%. The number of pigs decreased by 88.3%.

So, we can conclude that, in general, the number of livestock and poultry, with the exception of pigs, has increased. The data shows steady grow stable in these positions.

In general, the main indicators of crop and livestock production volumes increased from 2018 to 2022, with the exception of three positions.

Table 3 - Dynamics of livestock and poultry in 2018-2022, thousand heads

	2018	2019	2020	2021	2022
Cattle	7 150,9	7 436,4	7 850,0	8 192,4	8 538,0
Sheep and goats	18 699,1	19 155,7	20 057,6	20 876,8	21 786,0
Horses	2 646,5	2 852,3	3 139,8	3 489,8	3 856,0
Pigs	798,7	813,3	816,7	776,1	705,0
Bird	44 337,9	45 041,4	43 335,0	47 884,7	49 787,7
Camels	207,6	216,4	227,7	243,4	259,1
Note - stat.gov.kz according to the website[2]					

At the same time, in 2022 (23162.1thousand hectares) the area of crops compared to 2018. (21,899,4 thousand hectares) increased by 1262,7 thousand hectares. The distribution of crops by area of crops has changed - the area of most crops has decreased, but wheat crops have increased - it accounts for half of the total area of crops. The largest contribution to crop production is made by peasant farms - they account for 42.2% of the total area of crops, while agricultural enterprises and households account for 37.1% and 20.8%, respectively [6].

Based on the above data, animal husbandry is less volatile, and therefore more promising for development. In addition, livestock production is 65.4% dependent on households, 17.9% on farms and only 16.7% on agricultural enterprises. This ratio indicates the possibility of cooperation and the creation of more agricultural enterprises. With the timely use of government development measures - subsidies, easing the tax burden for livestock farming enterprises, facilitating legal registration procedures - the livestock industry can grow even faster, thanks to easier access to machinery, technologies, and feed bases.

Investments in agriculture in 2022 amounted to KZT 850,346 million and increased compared to 2018. (365,001 million tenge) by 2.3 (233%) times.

The dynamics of investments in fixed assets in agriculture is shown in Fig. 3.

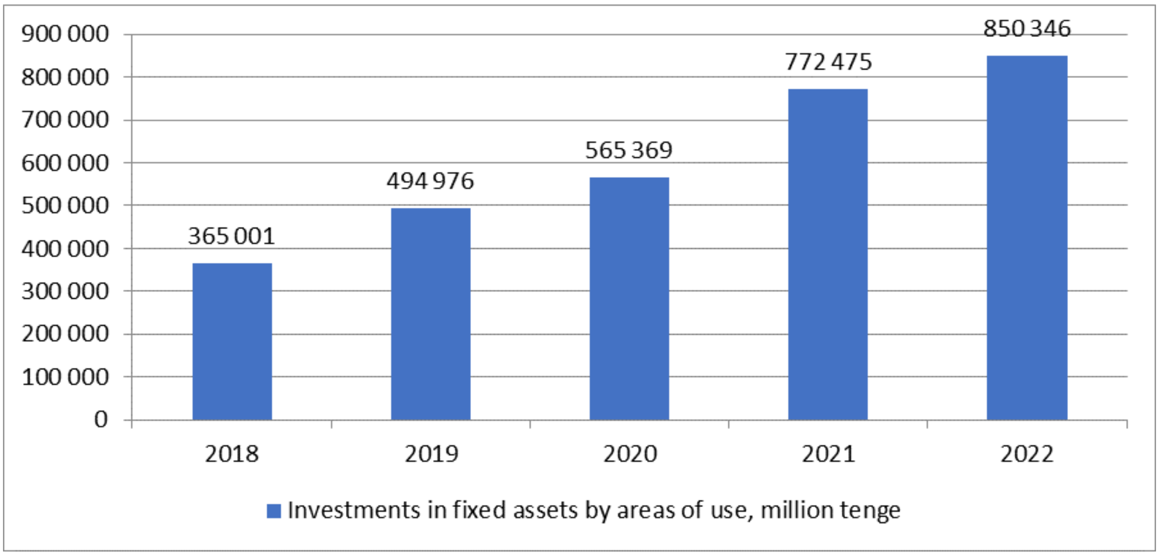

Fig. 3. Dynamics of fixed capital investments in agriculture, forestry and fisheries in the Republic of Kazakhstan in 2018-2022.

Fig. 3 shows that over the past 5 years, investments in fixed assets in agriculture, forestry and fisheries in the Republic of Kazakhstan have been growing, i.e. in the main grain-growing regions.

CONCLUSION

The experts of the World Bank Group identified five promising areas for the development of Kazakhstan's agro-industrial complex [7]:

1. Long-term competitiveness through openness to foreign trade. Kazakhstan's agricultural enterprises must learn to function in an open economic system with minimal protectionist measures.
2. Knowledge as a driver of productivity - the main way to increase production efficiency is based on scientific knowledge.
3. Development of the value chain towards post-production operations.
4. The support of personal subsidiary farms will increase the scale of production.
5. Revision of the mechanisms of state support - greater adaptability, less control in favor of more indirect support.

Based on the above, the following conclusions can be drawn:

1. The agro-industrial complex in Kazakhstan - the basis of food security - has a high potential for economic growth and development. This is facilitated by both geographical conditions and historically established social relations.

The agro-industrial complex can provide stable demand for jobs, food independence of the state and opportunities for the transfer of industrial technologies, and hence the development of related industries.

2. Agriculture occupies the largest share in the agro-industrial complex of Kazakhstan, and not post-production industries, including processing. This complicates the creation of jobs, the production of high-value-added products, and ensuring the competitiveness of national enterprises in the global market of agricultural end products. Nevertheless, the main indicators of crop production and animal husbandry are growing annually, less for crop production, and more stable for animal husbandry.

3. The problems of the domestic agro-industrial complex are low wages of those employed in this field of activity, technological backwardness of enterprises, inflexible state regulation of processes in the agro-industrial complex.

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IRSTI 62.09.37

STUDY THE PHYSICOCHEMICAL COMPOSITION AND BIOLOGICAL ACTIVITY OF GRAPE POMACE OF TURKESTAN REGION WINE GRAPE VARIETIES

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ABSTRACT

This article presents studies to determine physicochemical composition and biological activity of grape pomace of Turkestan region wine grape varieties on order to provide enzymatic extraction ofbiologically active substances from secondary winemaking raw materials.It should be noted that different grape varieties were tested; the most effective were *Saperavi* and *Cabernet Sauvignon*. One of the effective biotechnological methods for the controlled transformation of plant raw materials in order to extract biologically active substances is the use of enzymes.The object of the study was grape pomace of *Saperavi* and *Cabernet Sauvignon* varieties from winery of Turkestan region. Organoleptic and physico-chemical indicators of the research objects were determined by analytical methods established in national and interstate standards.The optimal drying temperature of grape pomace can be considered 50-52 °C. Based on the analysis of experimental data, it was established that grape pomace is a promising raw material for the production of biologically active substances, which determines the feasibility of developing a technology for their production.

Keywords*:* secondary resources, waste, biological origin, grape pomace, biologically active substances, enzymes, physical properties

INTRODUCTION

Nowadays, one of the main challenges in ensuring the productivity of processing industries is the utilization of secondary resources [1]. The accumulation of waste from wine production has a negative impact on the ecological situation in wine-growing regions. Grape pomace is the most important by-product of wine production which can be used as an additional raw material [2]. Grape pomace contains components, including polyphenols, pectins and trace elements. Approximately 10-15% of this by-product is used as biofertiliser to improve soil structure [3]. Grape pomace can also be a source of fiber, natural food colours, grape alcohol, tartaric acid, acids, extracts and concentrates. Grape oil is obtained from the seeds and is widely used in cosmetology. There is therefore an urgent need for efficient methods of processing grape pomace.

In this case, the main factor is the goal, on the one hand, to reduce the environmental impact and, on the other hand, to obtain additional new types of products.This trend is especially relevant in industries involved in the processing of agricultural raw materials, since in this case production waste is of biological origin and can be the starting material for the production of biologically active substances, and in some cases, food products[4]. In the production of wine products, the main wastes are sweet and fermented grape pomace, yeast and glue sediments, grape seeds and others [5,6]. Grape pomace has a moisture content of about 70 % and makes up 11-15 % of crushed grapes. One tone of pomace consists of 249 kg of stems, 225 kg of grape seeds and 425 kg of grape skins.

According to the Statistics Agency of the Republic of Kazakhstan, the gross harvest of own grapes is only about 80 thousand tons annually.Considering that Kazakhstan annually produces 80 thousand tons of grapes, as a result of its processing, each winemaking season produces over 16 thousand tons of grape pomace and a significant amount of yeast and glue sediments.

It is necessary to pay attention to obtaining science-intensive products, including dietary supplements. Secondary raw materials after grape processing have a large supply of antioxidants and other valuable bioactive substances. Thus, new aspects concerning the use of these by-products for further exploitation on the production of food additives or supplements with high nutritional value have gained increasing interest because these are high-value products and their recovery may be economically attractive [7].

Currently, a large number of preparations with a high content of bioactive substances possessing a pronounced biological activity and beneficial effects for human health are appearing on the Kazakhstan market. Recently, a dietary supplement based on grape fruit extract has appeared on the Kazakhstan pharmaceutical market [8].Its basis is a concentrate of polyphenol of grapes and other berries. According to experts, the miracle elixir is not yet a medicine, but it is already able to protect people from some viral diseases and prevent many age-related ailments. Grapes for the biological supplement are brought from the Turkestan region to a special factory in Zhezkazgan. It should be noted that different grape varieties were tested; the most effective were *Saperavi* and *Cabernet Sauvignon* [9].

Leovit LLP is the largest Kazakhstan manufacturer of biologically active food supplements - natural complexes of biologically active substances that are extremely necessary for human life. For example, it produces tablet dietary supplements with grape seed extract [10].

One of the effective biotechnological methods for the controlled transformation of plant raw materials in order to extract biologically active substances is the use of enzymes. Enzymes catalyze hydrolysis with a high level of selectivity, reducing the amount of extractant used, shortening the duration of extraction of biologically active substances and making it possible to obtain high-quality substances with less resource and energy consumption [11]. In addition, the use of enzymes to extract biologically active substances from plant materials provides a higher yield of the target component [12]. In this regard, conducting research aimed at studying the process of enzymatic extraction of biologically active substances from secondary winemaking raw materials is relevant.

The aim of the work was to study the physicochemical composition of grape pomace of local wine grape varieties and their biological activity in order to provide enzymatic extraction of biologically active substances from secondary winemaking raw materials.

MATERIALS AND METHODS

The object of the study was grape pomace of *Saperavi* and *Cabernet Sauvignon* varieties from winery of Turkestan region. Organoleptic and physico-chemical indicators of the research objects were determined by analytical methods established in national and interstate standards. Mass concentration of the total phenolic compounds in terms of gallic acid (GA) was determined spectrophotometrically with using the Folin-Ciocalteu reagent. The maximum absorption of the solution was measured at a wavelength of 750 nm. Dual-beam scanning spectrophotometer Cary-50 (Varian) was used for measurements. The width of the cuvette is 10 mm. Mass concentrations of the total flavonoids in terms of catechin, was measured by using an extract or a standard solutionof with the additionof solutions of sodium nitrite and aluminum chloride.The absorbance ability is measured at 510 nm.

RESULTS AND DISCUSSION

Grape pomace consists of a solid and liquid phase. The solid phase is represented by 66% of grape skins and 34% of seeds. The standard humidity of pomace when squeezed on screw presses is no more than 56%. The structure and physical properties of the pomace and its components are shown in Table 1and Fig. 1 [13].

Table 1- Structure and physical properties of pomace and its components

Components	Quantity of total mass, %	Moisture, %	Density, g/cm^3	Bulk mass, g/dm^3	Moisture capacity, per 100 cm^3
Pomace	100	48-55	1.05-1.2	350-470	30-60
Peel	73-59	48-56	1.0-1.1	300-450	40-80
Seeds	23-39	35-42	1.1-1.3	500-675	7-15
Ridgeresidue	1,0-3,3	46-55	1.0-1.1	150-250	40-80

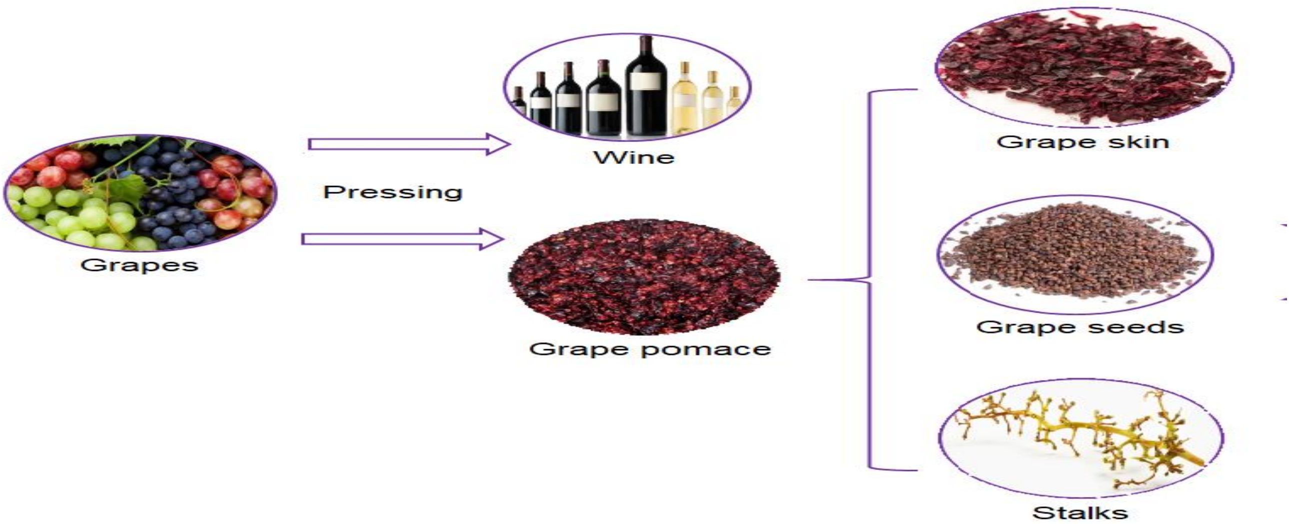

Fig. 1 - Composition of grape pomace

In terms of chemical composition, grape pomace is valuable because it has a rich polysaccharide complex, contains a significant amount of phenolic substances and lignin (Table 2)[14]. These data are consistent with the authors' of [15] data in which the main component of the cell walls being pectin substances and cellulose (40–54%) and lignin (20-25%).

Table 2 - Chemical composition of grapes pomace of some technical varieties

Components, mg/100 g of dry preparation	Content in grape varieties	
	Saperavi	*Cabernet Sauvignon*
Polysaccharides, Including cellulose	42-44 24-25	41-45 24-25
Phenolic and lignin-like substances	36-38	37-39
Nitrogenous substances (by nitrogen)	1.4-1.6	1.5-1.8
Ash residue	2.5-2.7	2.6-2.8

The main amount of pomace and seeds is formed during the period of grape harvest and processing into wine. This amount of perishable waste cannot be stored without additional treatment. Drying is one of the ways to store perishable foods.The results obtained are in the Table 3.

Table 3 provides a comparative analysis of the biological activity of grape pomace based on the content of polyphenolic substances (PS, g GA/100 g) and flavonoids (Fl, g K/100 g) before and after convective drying at certain temperatures.

Table 3 - Comparative analysis of the biological activity of grape pomace

Indicators / t of drying, °C	Content of polyphenolic substances (PS, g GA/100 g)	Content of flavonoids (Fl, g K/100 g)
Fresh pomace	2.72	2.29
50-52	3.32	3.05
100-102	2.84	3.01

Analyzing the data in Table 3, it is clear that heat treatment affects the biological activity of grape pomace. When plant cells are exposed to high temperatures, they are destroyed and the extraction of phenolic substances and flavonoids is facilitated. At the same time, at a drying temperature of 50-52°C, the indicators differ little from the data at a drying temperature of 100-102°C. Therefore, the optimal drying temperature can be considered 50-52°C. A further increase in temperature leads to a decrease in the concentration of phenolic compounds, which is associated with the activation of oxidative processes.

Based on the analysis of experimental data, it was established that grape pomace is a promising raw material for the production of biologically active substances, which determines the feasibility of developing a technology for their production.

The next stage was the research and development of technological processing modes that ensure maximum release of biologically active substances from grape marc. Determine the optimal duration of enzymatic treatment to ensure maximum release of biologically active substances. For this purpose, the treatment of grain pomace with an enzyme composition was carried out at a temperature of 26-28°C for 14 hours. The results are presented in Fig. 1.

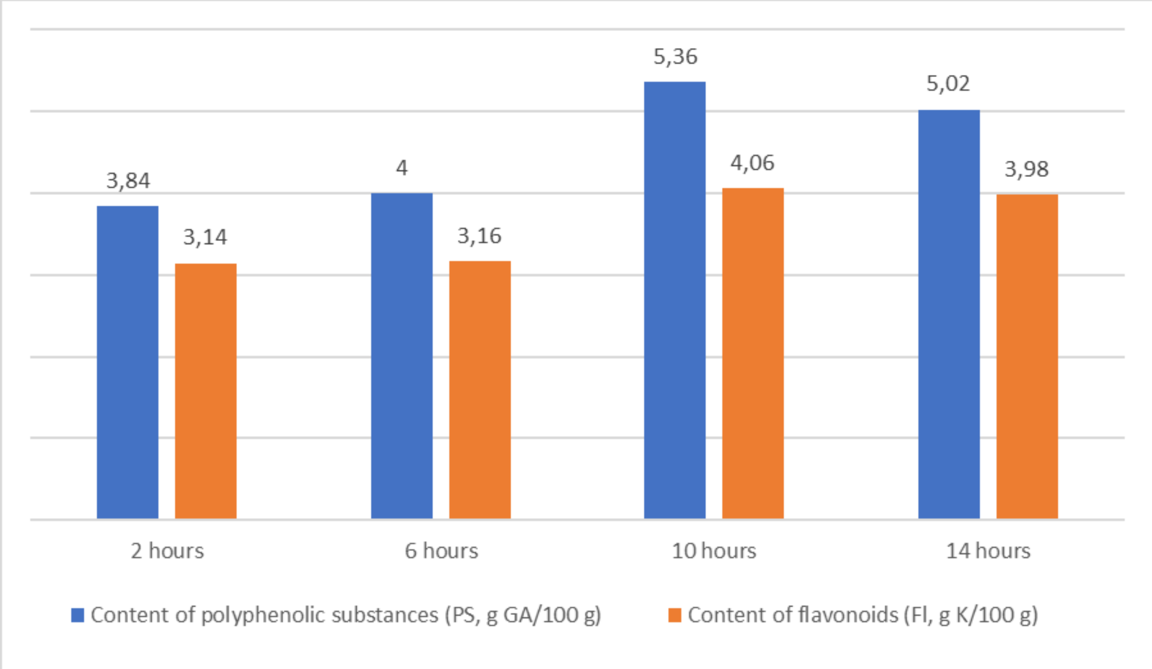

Fig. 2. Dependence of the yield of biologically active substances on the time of enzymatic treatment

It has been established that an increase in the duration of processing of explosives is accompanied by an increase in the yield of biologically active substances up to a certain limit, after which there is a decrease in their concentration due to redox processes. Thus, the optimal time for enzymatic treatment was 10 hours.

CONCLUSION

The availability and potential of winemaking by-products as grape pomace obtained from two grape varieties (*Vitis vinifera L.*) from winery of Turkestan region as raw materials for the production of biologically active substances were evaluated. The total chemical composition, polyphenols and flavanoids analysis and functional properties of grape pomace from these grape varieties were analysed. Hence, grape pomace which is secondary product of winemaking can be considered a promising raw material for the production of biologically active substances, which determines the feasibility of developing a technology for their production.

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IRSTI 52.47.15

DEPENDENCE OF THE OIL CORE'S CONTACT ANGLE ON THE INFLUENCE OF POLYMER'S AQUEOUS SOLUTION

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ABSTRACT

A description and results of experimental studies to determine the oil core's contact angle with a polymer solution is presented in this work. An experimental setup's diagram, a description of its design and operating principle are presented. The uniqueness of the installation is its sufficient simplicity and, at the same time, obtained results' reliability. It allows the use of an oil reservoir model containing artificially prepared oil reservoir cores by conducting studies of the tested oil components' wetting process with aqueous solutions. Information on the rock wettability theory and research methods and reference data for the Nuraly deposit is provided. The contact angle's value depends on the pumped component's concentration in the stratum water solution and the used reagent's type. The contact angle of the oil core's surface from the Nuraly field dependence on the pumped fluid's concentration was obtained. With an increase component's concentration in the stratum water, a significant decrease in the oil core's surface contact angle is observed. Thus, a core model's hydrophobic surface saturated with oil, with a contact angle by stratum water more than 105º, after treating the core surface with a 0.25% polyacrylamide wt. solution, becomes hydrophilic, and the contact angle's value, under the experiment conditions is 75º. Based on the experiments results, we can conclude that treating the oil core's surface with these components solutions leads to significant its surface hydrophilization.

The dependence of the Nuraly field's oil interfacial tension on the boundary between oil and aqueous solution on the pumped component's concentration was obtained.

Keywords: contact angle, core, polymer, collector, concentration.

INTRODUCTION

It is known that concentration of the aqueous solution of the reagent and interfacial tension are the important factors influencing the increase in oil reservoir's water flood oil recovery [1,2]. The oil reservoir wettability plays an equally important role in oil recovery's optimization in addition to reducing interfacial tension. The wettability nature influences many aspects of reservoir behavior, especially during waterflooding and enhanced oil recovery techniques.

The oil-wet reservoir's residual oil saturation (ROS) is usually higher than in the hydrophilic ones' case. Therefore, in order to reduce the residual oil saturation in a porous medium, it is necessary to change oil rock's surface wettability.

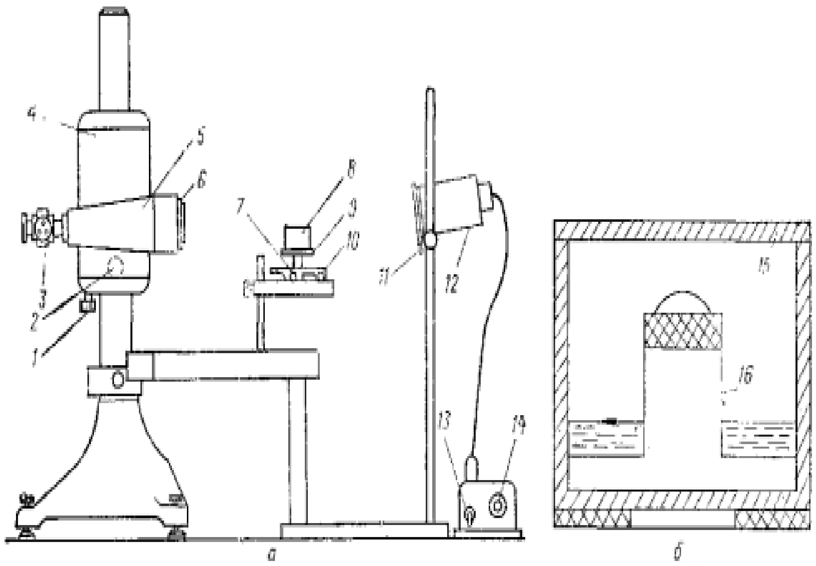
In this regard, following experiments series was carried out to study the various reagents influence on the hydrophobic oil core's surface wettability from the Nuraly field. Wettability is one of the main parameters that influence on reservoir fluids' location, flow and distribution [3-4]. Reservoir wettability affects capillary pressure, relative permeability, water injection behavior, dispersion, and electrical properties. Wettability represents the connection criterion that a rock is referenced to oil or water in an oil-water-rock system. [5]. The reservoir rocks wettability (productive formation) varies from highly water-wet to highly oil-wet. Some reservoirs exhibit wettability that is heterogeneous or localized, with existing crude oil components that are highly adsorbed in specific areas. Thus, part of the rock becomes heavily oil-wetted, while the rest may be heavily water-wetted. Mixed wettability can be in other reservoirs because the oil remains confined within the larger oil-wet pores as continuous channels through the rock, while the water remains confined within the smallest water-wet pores. Wettability determines the specific surface forces manifestation, which effect on pore fluids' multiphase filtration dynamics (oil, water and gas) and their volumetric structure in the formation's effective part.

The oil recovery's increasing problems are involved in the remaining reserves development, increase efficiency of enhanced oil recovery (EOR) and enhanced oil recovery are directly related to wetting processes' insufficient knowledge occurring at phase boundaries in the pore channels microvolume and on the down hole equipment surface [6,7]. The reservoir rocks' pore surface wettability directly effects on efficiency of almost all known developing hydrocarbon deposits technologies using waterflooding [8]. Depending on the multicomponent systemsэ specific interaction the following rock wettability types are distinguished: predominantly hydrophilic, predominantly hydrophobic, intermediate, heterogeneous, selective and microstructural [9-14].

MATERIALS AND METHODS

Experiments.

Research to determine the oil core's contact angle from Nuraly field with pumped component solutions was carried out with the spreading drop method according to the method [10]. The drop parameters h and d are measured with an installation [14-15], Fig. 1, its main components are a cathetometer (KM-6), a measuring cell-cuvette and a lighting device that provides studied drop and the surface's contrast image.



1,7,10-adjusting screws; 2-screw for raising (lowering) the carriage; 3- eyepiece-micrometer; 4-carriage; 5-spotting scope; 6-lens; 8-measurement cell; 9-holder; 11-illuminator diaphragm; 12-illuminator; 13-toggle switch for turning on the transformer; 14 - handle for voltage regulation, 15 - cuvette cover; 16-stand

Fig. 1. Measuring contact angles (a) and cell cuvette's (b) setup scheme

The cathetometer (KM-6) is a telescope 5 mounted horizontally, which can move along a column with a scale; a microscope is rigidly connected to the tube.

To install the column in a vertical position, it is mounted on a tripod with lifting screws, on which a level is installed.

The telescope 5 focuses on the object using attached lenses and a focusing mechanism.

Measurements are carried out as follows. The measuring cell-cuvette 8 is installed on a metal holder 9. A test substance plate is placed on the stand 16 in the cell-cuvette 8 and the illuminator lamp 12 is turned on. The telescope 5 is installed accurately, and a sharp image of the profile plate in the eyepiece-micrometer 3 is achieved.

Then test liquid's 1 ml is poured into the cuvette's annular recess, using a microsyringe or pipette, a drop of this liquid is carefully applied to the plate's surface at its edge, facing the objective 6, and the cuvette is closed with a cover 15.

Thus, an equilibrium environment is created that imitates the real one. To obtain reproducible results, it is necessary to apply a drop so that the diameter of its base does not exceed 2-3 mm, then, due to the small weight of the drop, the influence of gravity can be neglected

Contact angle measurements can be done applying a water drop after few minutes when studying the surfaces wetting with water. When studying the surfactant solutions wetting, liquid drops first should be kept for 15–20 minutes on the plate (this is due to the rather surfactant adsorption layers' slow formation at the interfaces). Using screws 10, the position of the holder 9 is finally adjusted to obtain the sharpest image of the drop and the plate contours.

Parameters h and d are determined using eyepiece micrometer 3. Contact angle measurements for each surfactant concentration are carried out three times with droplets of approximately the same size and the θ values are found as the arithmetic mean.

The Nuraly field's reservoirs are sandstones and siltstones (porosity - up to 20%, permeability - up to 0.5 μm^2).

The studies were carried out on the Nuraly field's natural core samples. The core samples' main filtration and capacitance characteristics are given in Table. 1.

Table 1 - Filtration and capacitance characteristics of core samples

No.	Characteristics	Core sample from the Nuraly field
1	Collector type	sandstones and siltstones
2	Length, cm	100
3	Diameter, cm	50
4	Open porosity, %	15-19
5	Permeability, µm2	0.002-0.308
6	Oil saturation coefficient unit	0.689
7	Initial reservoir pressure, MPa	19.4-21.5
8	Reservoir temperature, 0C	85-90
9	Total mineralization, g/l	63.7-87.7

Before conducting research, core samples were washed with an alcohol-benzene mixture (ratio 1:2) and distilled water using a squeezing centrifuge. After this, the core samples were placed in a heating cabinet at a temperature of 105 ºC and dried until a constant weight was achieved. To model an oil-saturated reservoir with bound water, the formation element model was evacuated, saturated with a stratum water model, and the formation element's model permeability was determined by this water. Then the formation water model was displaced from the flow tube by oil at a constant flow rate until an irreducible residual water saturation was achieved.

Components of three brands were used in the experiments - 1- polyacrylamide, 2- Sulfanol (nonionogenic surfactant), 3- anionic surfactants (DS-RAS). The components concentration in stratum water varied within the range of 0.25-0.2 wt%. The studies were carried out at a temperature of 50 °C, which corresponds to this field's reservoir temperature. The studies' results are shown in Fig. 2.

RESULTS AND DISCUSSION

Based on the experiments results, we can conclude that oil core's surface treating with these components solutions leads to significant its surface hydrophilization. The latter phenomenon can be explained by the surfactants action, which sharply reduce the surface tension at the interface between pumped component's oil and the solution, increasing the oil's wettability.

Thus, it is obvious that the contact angle's value depends on the pumped component's concentration in the stratum water and the used reagent's type. With component's concentration increasing in the stratum water, an oil core surface's contact angle significant decrease.

Thus, the core model's hydrophobic surface saturated with oil, with a stratum water contact angle more than 105°, after core's surface treating with 0.25% wt. polyacrylamide solution, becomes hydrophilic, and the contact angle's value, under the experiment, is 75°, line 1, figure 2.

If at polyacrylamide concentration is 0.25 wt. %, the contact angle is 75°, then at a concentration of 2.0 wt%, the contact angle is 63.5°, line 1, Fig. 2

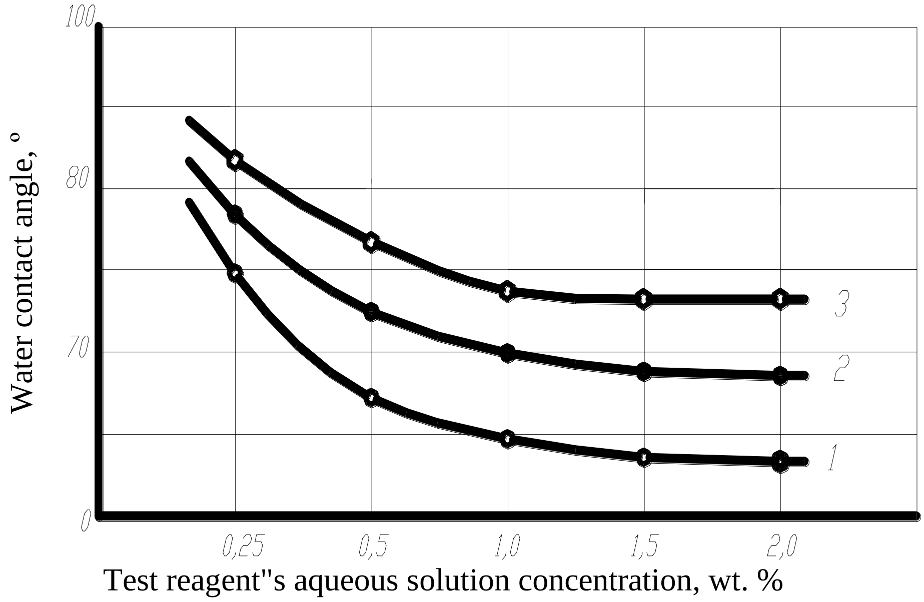


Fig. 2. Dependence of the oil core's surface contact angle from the Nuraly field on the pumped fluid's concentration. 1-polyacrylamide, 2-anionic surfactants (soviet detergent-refined alkylaryl sulfonate), 3-Sulfanol (nonionogenic surfactant).

A similar influence dependence of the contact angle's pumped component concentration is observed when using the soviet detergent-refined alkylaryl sulfonate and Sulfanol reagents, lines 2, 3. It should be noted that the best efficiency is achieved when using the polyacrylamide concentration reagent, which may be due to the used reagents' physicochemical properties.

At the next stage, the boundary tension of Nuraly's oil field at the oil-aqueous solution boundary dependence on the pumped component's concentration was determined. Boundary tension at the "reagent solution – oil" boundary was determined by the drop volume method according to GOST R 50097-92.

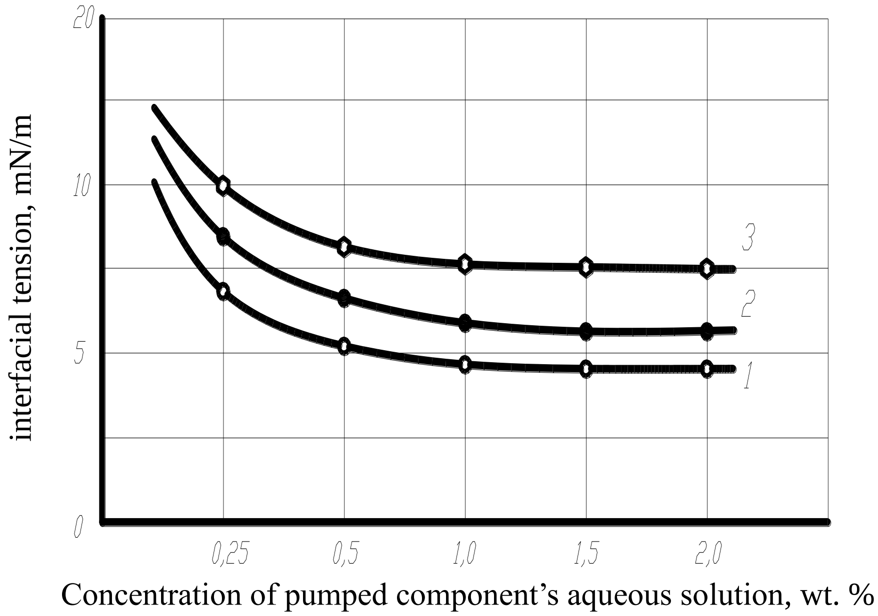
The studies were carried out at a temperature of 50°C, which corresponds to this field's reservoir temperature.

The study's' results are shown in Fig. 3.

Experimental results' analysis shows that boundary tension depends on the reagent concentration in the stratum water solution as the reagent

Noticeable decrease of surface tension at the oil–pumped solution interface is observed, with component's concentration increasing in the stratum water.

The best reduction in boundary tension was obtained using the polyacrylamide reagent (Fig. 3, line 1).



1-polyacrylamide, 2- sulfanol (nonionogenic surfactant), 3- anionic surfactants (soviet detergent-refined alkylaryl sulfonate)

Fig. 3. Oil interfacial tension of the Nuraly's oil field dependence on the pumped component's concentration at the oil-aqueous solution boundary.

Oil interfacial tension of the Nuraly's oil field at the boundary with a test component's solution in stratum water decrease is connected with the oil-soluble components' transition from this solution.

CONCLUSION

1. The contact angle's value depends on the pumped component's concentration in the stratum water solution and the used reagent's type.
2. With an increase of the component's concentration in the stratum water, we can observe a significant decrease of the oil core surface's contact angle.
3. Interfacial tension depends on the reagent concentration in the stratum water solution and the reagent's type

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IRSTI 339.5 (574)

FOREIGN TRADE POLICY OF THE REPUBLIC OF KAZAKHSTAN AND INSTRUMENTS OF ITS IMPLEMENTATION

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ABSTRACT

The authors ' scientific article deals with topical problems of Kazakhstan's foreign trade. Over the past ten years, there have been no serious changes in the composition of exports. A positive balance remains in Kazakhstan's foreign trade.

Customs tariffs and non-tariff approaches to regulating the policy of protecting the national market from foreign competition, classifications of trade policy in Kazakhstan with the necessary basic concepts related to the sphere of foreign economic activity. Particular attention is paid to the managerial side of foreign economic activity.

Since the basis of this activity is foreign trade relations and operations and a description of their pace and structure, they are given the greatest attention.

Undoubtedly, one of the main tools for the development of the economy is international trade. With its help, labor productivity improves and increases, and the volume of production increases. International trade is a tool for improving specialization.

The work also deals with issues of international relations, the organization and management of procurement, rental and contract works, coordination of the activities of trade intermediaries, supervision of Interstate settlements, etc.

Keywords: foreign trade, trade policy, customs tariff, international trade, import, export.

INTRODUCTION

Trade policy is of particular importance in society as one of the most pressing issues. Because a systematic and effective trade policy is an integral element of the rule of law and a democratic society. Therefore, trade policy is a very important economic sphere for Kazakhstan.

Today's world is developing at a rapid pace, globalization and information technologies are gaining strength day by day. Kazakhstan is strengthening its economic potential and strengthening its position in the international market.

The unification of the political, economic, social, technological background of modern international relations and the strengthening of the general trend of globalization require constant monitoring and effective control over the external economic activities of each state. The fact that this requirement will become more and more stringent is explained by the fact that the control object will continue to expand and become more complex in the future, as is the case with the new one.

The law of the Republic of Kazakhstan on regulation of trade activities States: «foreign trade is the activity of participants in foreign trade activities related to the export and (or) import of goods from the Republic of Kazakhstan» [1].

The strategy «Kazakhstan – 2050» states: We must develop new production based on the expansion of the export-oriented non-resource sector» [2].

Therefore, one of the main tasks facing our entrepreneurs at the moment is to achieve the production of quality products, because if they cannot compete with foreign products, representatives of domestic businesses will be subjected to boncrot.

The problem of Sustainable Development has been solved on a global scale. Economic policy in this sense is determined by the intersection of objective laws that have economic interests and values at the national level. In recent decades, the collective interests of economic blocs have been increasingly entering this space. Certain contradictory actions may occur on the part of a block of developed states or an individual state.

Because any national policy can protect their real economic interests, or put pressure on them. In this case, the interests of states should be aimed at achieving a balance sheet, transaction or mutual concessions between them. It predetermines the need for foreign economic policy to be replete with a set of alternative options, primarily attempts to exert pressure or counterattack.

The trade policy of the «North-South» system reflects a vertical model of the international division of Labor, where developing countries bring significant types of resources to the sidelines, as well as machinery, food and goods in long-term use.

In comparison with the content of the interaction of economies in the «North-South» system, it is established that in the previous model there is no mutual complementarity of economies, in any case, when talking about trade in the North or South, we can talk about two types of policies implemented:

- on foreign trade policy;
- on international trade policy.

The world experience of implementing trade policy is based on 2 principles: free trade and protectionism.

MATERIALS AND METHODS

Scientific works of domestic and foreign scientists on the research topic, laws, regulatory acts, official statistical data of the National Bureau of Statistics form the theoretical, methodological and informational basis.

RESULTS AND DISCUSSION

Studies have shown that by the time parameters of the launch of these measures, all states differ from each other. For example, a number of states begin their reforms with a strict course of import policy management; now some begin with its complete liberalization.

For example, South Korea, Brazil and other countries initially created conditions (a number of privileges) for the export of imported goods intended exclusively for export production, and the import of goods not related to export production was restricted or prohibited.

A similar technique was used by Taiwan. There was a policy of import substitution. Overly differentiated methods were reflected in the practice of Malaysia, where restrictions on the export, production of a particular product were set depending on the quantitative parameters of the firm or the industry as a whole.

At the same time, for the effectiveness of trade policy, it is very important to choose a way to implement import substitution.

In the context of a dynamic, changing environment of the world market, the Argentine version was a brake on the development of the economy, and in Brazil, development is considered more locomotive, since it initially envisaged the development of the production capacity of the national economy by an extensive, not intensive method [3].

From this, the following conclusion follows: that is, trade policy provides a wide variety of economic sectors, both in the case of the implementation of the first or second method. But it should be noted that depending on the timing of the beginning of reforms, in the conditions of opening dams for the development of the economy, joining international economic organizations, strengthening regional principles, the choice of instruments of economic regulation for countries is diverse, sometimes limited.

As a result of the study of foreign economic policy of different countries, it is established that the developing world should follow the path of using such an optimal option as the effective entry of national economies into the complex world of a single complex of world economic ties.

In this regard, the measures taken for this in the country's export policy consist of the following actions:

- creation of conditions for the development of export industries or orientation to export production sectors;
- assess the development of some industries and adopt a program to close industries that do not have the opportunity to compete with imported production;
- if a particular industry has the opportunity to secure a certain place in the world market in the future, but at the moment there is no situation to implement these opportunities:

1) Customs Protection;
2) financial and fiscal incentives;
3) creation of favorable conditions and other types of benefits.

And the implemented industrial policy requires the adequacy of a foreign trade policy with the concept (the protection of industries undergoing intensive modernization, the development of production of goods that are not produced in a particular country; the stimulation of imports of goods that priority industries cannot serve).

Putting forward the concept of integration of World Economic Relations will ensure a gradual change in the vector of relations.

When implementing import policy, the following methodology is also used: analysis of National opportunity in the production of goods; determination of its place in the export position in the structure of the national economy; analysis of world market trends.

In conditions of unequal balance of payments, reduced export efficiency, a wide arsenal of tools is used to ensure the protectionist regime.

When a certain specific goal and degree of protection is achieved, these means of the protectionist regime are replaced by other measures and regulators [4].

Such an example is widely known in Latin America, East Asia. The feeling of the need to raise economic development led the state to adopt a long-term program for the development of future sectors of the economy.

The need for structural transformations ensured a number of changes in a number of industries, in which protectionist protection was carried out by the state.

It should be noted that measures to regulate foreign trade, the arsenal of which includes the following tools (Table 1). They can be grouped into 8 groups.

Table 1 - Measures to regulate foreign trade

Regulatory measures	
Tariff: - import customs tariffs	Financial measures: - rules for conducting currency transactions
Paratariphic: - duties; - fees charged during the introduction of imported goods; - customs assemblies; - internal taxes; - target sets.	Automatic licensing: - documents for import and export of goods from abroad;
Price control measures: - anti-dumping; - compensation; - imported sets.	State monopolies - monopolies on exports and imports
Somatic regulation: - quotas	Technical measures: - standards; - quality norm; - safety norm

The Basic Rules in trade are regulated by the rules of the Foreign Trade Organization. In accordance with the rules of this organization, the customs tariff is used as the main instrument for regulating foreign trade. States that are not members of a Foreign Trade Organization cannot enjoy the benefits that membership provides.

In these cases, the basis for regulating trade is agreements with two simple trade negotiations. It includes a mode of creating very favorable conditions (KZR).

The lack of consistency in the rules used in trade in the national system creates many obstacles defined by protectionist measures. An important role in the regulation of foreign trade is played by the Customs Cooperation Council.

Despite its inter-country differences, the structure of the customs tariff includes:

- autonomous rates; these rates only apply when the country is not provided with a regime of very favorable conditions (FRP);

- KZR rates;

- preferential rates applied in relation to goods from developing countries.

Member countries of the Foreign Trade Organization, in the practice of regulating foreign trade, apply a block of restrictive measures, which are classified in the order below:

- administrative measures of economic content (shortage of goods, inequality of the balance of payments, damage to industrial policy), as well as measures of a non-economic nature;
- voluntary export-import restriction by mutual agreements of entities;
- restrictions or measures against unfair competition;
- restrictions imposed in order to protect the environment, preserve national security.

Foreign trade policy is defined as the targeted impact of the state on trade relations with other countries. Main goals of foreign trade policy:

- change in the degree and manner of introducing this state into the international division of Labor;
- changes in export import structure;
- providing the country with the necessary resources;
- changes in the ratio of export and import prices;

Some goals are of a long-term nature, for example, the introduction of this country into the international division of Labor, changing the order and approach, while other goals can be realized in the short term, for example, changing the volume of exports or possible imports.

There are two main directions of foreign trade policy:

- free trade policy;
- protectionism.

When pursuing a free trade policy, the state does not directly interfere with foreign trade, allowing it to develop under the influence of Free Forces of supply and demand. Only free trade allows you to maximize the volume of products produced by each country participating in it.

Pursuing a free trade policy allows developed economies to benefit the most from international economic exchange.

The implementation of the policy of protecting the national market from foreign competition by customs tariffs and non-tariff approaches to regulation is called protectionism. In comparison with free trade policy, protectionism denies the free effects of market forces after it is explained that individual countries have different economic potential and competitiveness in the world market and, therefore, the free effects of market forces may be ineffective for less developed countries.

Now in the history of international trade, where the question of which is better free trade and protectionism is not resolved, there are periods when the two turn to one.

Modern protectionism is multifaceted and closed. Instead of customs tariffs, non-tariff approaches are widely used, protectionist actions are often selective, that is, they can be applied against specific goods and products of certain industries, as well as against a number of countries. The position of protectionism prevails over developing countries and industrialized countries [5].

The economic instrument regulating foreign trade includes customs tariffs, due to the nature of its action, it belongs to the classic tool for regulating foreign economic relations.

Customs tariffs are a systematic chain of rates of customs duties. Customs duty is interpreted as a tax on imports and exports when crossing the border of the state.

Until now, tariffs have been an active form of state regulation of international trade and an important item of budget revenue.

The main goal of the International Trade Organization is the commercial and economic direction of raising the standard of living of members of the state, which is carried out in the following ways:

- full employment;
- production of goods and services and the growth of Commodity Exchange.

Today, the country is entering a new stage of socio – economic modernization and democratization.

The economic development of society is a multifaceted process that includes economic growth, economic structural changes, improving the condition and quality of life of the population. The economic life of society is constantly in motion, it is characterized by uniform quantitative and qualitative changes. These changes relate not only to productive forces and production relations, but also to the growing productivity of labor, its ability to create large volumes of goods [6].

CONCLUSION

The leading role in the foreign trade turnover of the Republic of Kazakhstan is played by trade with the Russian Federation, which, thanks to the historically established processes, is the main trading partner of Kazakhstan and the main consumer of Kazakhstan's products.

Kazakhstan can and should actively participate in multilateral international economic projects, as they contribute to our entry into the global economy and thereby rely on our favorable economic and geographical conditions and resources at our disposal.

For its part, the state is obliged to remove legislative, administrative and bureaucratic barriers to Business Initiative, and to provide direct support to promising and promising private capital initiatives.

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IRSTI 44.31.35

ANALYSIS OF THE EFFICIENCY OF A CLOSED LOOP GAS TURBINE INSTALLATION CONSIDERING THE SURFACE AREA OF HEAT EXCHANGERS

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ABSTRACT

The research object is the heat exchanger of a modular helium gas turbine installation. The problem of developing a reliable high-temperature plate heat exchanger with a long service life plays a significant practical role in the application of closed gas turbine installations for advanced nuclear power plants, as well as in gas turbine installations where heat exchangers operating at temperatures above 700°C are required. The aim of the work: analysis of technical requirements for high-temperature heat exchangers. Substantiation of using a plate-fin heat exchanger as a high-temperature heat exchanger; exploration of new ways to increase the thermal efficiency of the heat exchanger by modifying cycle characteristics such as the pressure ratio in the turbine and compressor. In other words, by varying the pressures and temperatures at the stages to obtain optimal area and dimensional characteristics and reduce the cost of the installation; comparison of theoretical and calculated parameters for the selected prototype installation; development of an engineering calculation methodology for the heat exchanger using the example of a modular helium gas turbine installation with a capacity of 200 MW. The scientific novelty of the work lies in the following: a detailed theoretical study of the influence of the heat exchanger surface area on the efficiency of the gas turbine installation has been conducted; an original methodology has been developed for calculating the heat exchanger based on known values for the turbine inlet temperature, coolant temperature in the coolers, heat exchange surface area of the recuperator, and pressure losses.

Keywords: Recuperator, pressure ratio, turbine, compressor, efficiency, pressure losses, Closed Gas Turbine, heat exchange area.

INTRODUCTION

MGR-GT (Modular Gas-Cooled Reactor-Gas Turbine) is a conceptual project for a Brayton direct cycle power plant based on a modular high-temperature gas-cooled active zone reactor. The installation is intended for electricity production, although it can be used for other purposes such as desalination. The project concept is based on a 200 MW reactor with an outlet temperature of 850 degrees Celsius. The energy system provides passive safety and high performance using currently available materials and technologies within established design standards. Thanks to the use of a high-efficiency cycle, an efficiency range of 25-40%

is possible. Operating at high pressure allows for compact component sizes, resulting in a cost-effective, fully modular nuclear power system.

The following tasks were carried out in this work:

- theoretical description of the solution to the problem, which is presented as follows: Given the turbine inlet temperature, coolant temperature in the coolers, and total specific heat exchange surface area of all heat exchangers, as well as pressure losses at the ends of the heat exchanger. The task is to determine the heat exchanger parameters (mass flow rate, dimensional characteristics, etc.) that would result in the maximum efficiency of the gas turbine system;
- analysis of the influence of surface area, heat transfer coefficients on the efficiency of the GTS, and search for additional measures.

MATERIALS AND METHODS

The thermal and geometric characteristics of the installation described in the literature [1] were chosen as initial data.

Table 1 – Temperature and Pressure in the MGR-GT System

System Components	Temperature (°C)	Pressure (MPa)
Compressor Inlet	30	3.99
Compressor Outlet	138.6	8.18
Reactor Inlet	583.1	8.01
Turbine Inlet	850	7.8
Turbine Outlet	606.5	4.05
Regenerator Outle	165	4

Table 2 – Parameters of the MGR-GT Turbomachinery, Equipment Dimensions, and System Performance

	Turbine	Compressor
Stages	6	15
RPM	10000	10000
Maximum Impeller Diameter	66.2	73.3
Blade Length	63.0	130
Efficiency (Expected)	0.931	0.937
Efficiency (Minimum)	0.91	0.91

Table 3 – Dimensions of the Prototype Heat Exchanger

	Cooler (Crossflow)	Recuperator
Volume	5.3 m^3	3.96 m^3 x 4 modules
Length	56.5 sm	1.22 m
Frontal Area	3.6 m x 2.6 m	3.25 m x 1 m

Table 4 – Relative Pressure Losses in the MGR-GT Components

Component	$\frac{\Delta P}{P}$
Reactor	0.02560
Recuperator	0.01162
Pre-Cooler	0.00096
Turbine Outlet	0.00614
Compressor Outlet	0.00623
Ducts/Collectors	0.00707
Overall	0.05962

Table 5 - MGR-GT Efficiency

	Minimum	Expected
Cycle Thermal Efficiency	46.19%	50.53%
Environmental Losses	1.22%	1.22%
Power Plant Efficiency	92%	95%
Overall System Efficiency	43.11%	46.74%
Output Electric Power	66.22 MW	93.49 MW

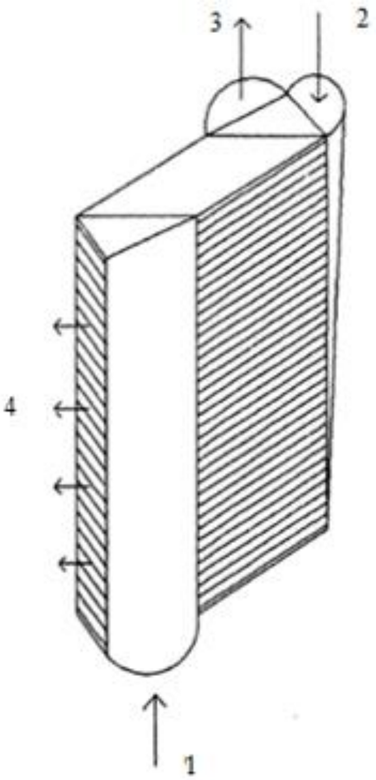


Fig. 1. Layout of the MGR-GT Recuperator [2]
1 - from the compressor; 2 - from the turbine; 3 - to the reactor;
4 - to the cooler.

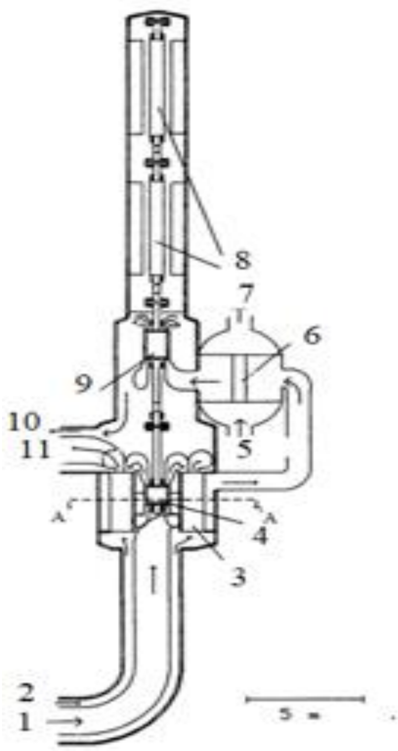


Fig. 2. MGR-GT Machinery Module [2].
1 - From the reactor; 2 - From the reactor vessel; 3 - Recuperator; 4 - Turbine; 5 - Water inlet; 6 - Cooler; 7 - Water outlet; 8 - Generator; 9 - Compressor; 10 - To the reactor vessel; 11 - To the reactor

To obtain the dependence of the cycle efficiency on the heat exchange area (A) and the pressure ratio in the compressor (π_k), we consider several cases for the value of A. In each case, A is kept constant, and we consider multiple sub-cases for the value of π_k. The calculation algorithm is the same for each sub-case. For each case, we obtain the values of the cycle efficiency and then, using interpolation, derive the dependence of $\eta_{th}(\pi_k)$. We then combine the results and obtain the dependence of $\eta_{th}(\pi_k)$. In particular, we calculate the cycle parameter values for prototype cases where $A_1 = A_2 = 17933\ m^2$, $\pi_k = 2.05$. We compare the obtained values with the cycle parameters of the prototype. The next task is to determine the optimal values of A and π_k that achieve the target efficiency value, $\eta_{th,prot}$. It is worth noting that the case with $A = idem$ and $\pi_k = idem$ is solved using a combination of iteration method and the "Function" method. In each iteration, the mass flow rate (G) is treated as the variable, and the pressure losses at both ends are refined. The "Function" method involves determining two variable parameters (in this case, t_1'' and π_T) that are treated as varying variables in all parameters. At each step of the algorithm, these variables are considered functions of the varying variables. In the end, they are determined through a system of equations based on two parameters (U_1 and U_2 – the heat transfer coefficients for the cold and hot fluids), which are determined using two methods.

$$U_1\left(\pi_T, t_1''\right) = \frac{NTU\left(\pi_T, t_1''\right) \cdot C_1\left(\pi_T, t_1''\right)_1}{A_1} \tag{1}$$

$$U_2\left(\pi_T, t_1''\right) = \frac{NTU\left(\pi_T, t_1''\right) \cdot C_2\left(\pi_T, t_1''\right)_1}{A_2} \tag{2}$$

$$U_2\left(\pi_T, t_1''\right) = \frac{1}{\dfrac{1}{\eta_{02}\left(\pi_T, t_1''\right) \cdot h_2\left(\pi_T, t_1''\right)} + \dfrac{1}{\dfrac{A_{W1} \cdot k}{A_1}} + \dfrac{1}{\eta_{01}\left(\pi_T, t_1''\right) \cdot h_1\left(\pi_T, t_1''\right) \cdot \dfrac{A_1}{A_2}}} \tag{3}$$

$$U_1\left(\pi_T, t_1''\right) = \frac{1}{\dfrac{1}{\eta_{01}\left(\pi_T, t_1''\right) \cdot h_1\left(\pi_T, t_1''\right)} + \dfrac{1}{\dfrac{A_{w2} \cdot k}{A_2}} + \dfrac{1}{\eta_{02}\left(\pi_T, t_1''\right) \cdot h_2\left(\pi_T, t_1''\right) \cdot \dfrac{A_1}{A_2}}} \tag{4}$$

Table 6 – Variations of the cases under consideration

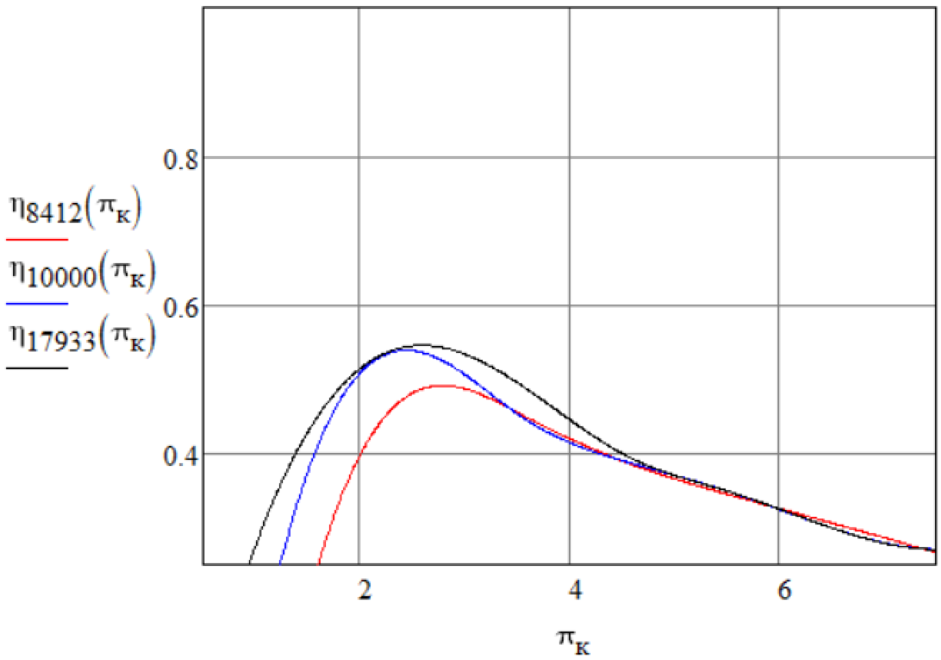
$A = 8412\ m^2$	$A = 10000\ m^2$	$A = 17933\ m^2$
$\pi_k = 1.55$	$\pi_k = 1.55$	$\pi_k = 1.25$
$\pi_k = 1.95$	$\pi_k = 2$	$\pi_k = 1.55$

Table 6 continuation

$\pi_k = 2.05$	$\pi_k = 3.55$	$\pi_k = 2.05$
$\pi_k = 2.55$	$\pi_k = 4.55$	$\pi_k = 2.451$
$\pi_k = 2.95$	$\pi_k = 6.55$	$\pi_k = 2.754$
$\pi_k = 3.55$	$\pi_k = 7.55$	$\pi_k = 4.55$
$\pi_k = 3.95$	–	$\pi_k = 5.55$
$\pi_k = 4.55$	–	$\pi_k = 6.55$
$\pi_k = 5.55$	–	$\pi_k = 7.55$
$\pi_k = 6.55$	–	–
$\pi_k = 7.55$	–	–

RESULTS AND DISCUSSION

A plate finned surface was chosen as the form of the design heat exchanger. All advantages and disadvantages of the shape of plate finned and shell-and-tube heat exchangers are listed. Stainless steel 334 was chosen as the material. Helium was chosen as the coolant. A number of advanced properties of helium among all heat carriers are indicated. As a form of finning, fins of the type 1/9-24.12 from [3] are assigned. All the necessary conditions for the calculation were specified, and the calculation algorithm was determined. All the initial data are given. In total, calculations were carried out for 26 cases with varying heat exchange area and the coefficient of pressure increase in the compressor, including one case is the same with the conditions of the prototype $\left(A = 17933\ m^2, \pi_k = 2.05\right)$. The characteristics of the MGR-GT cycle were determined and the heat exchanger of this installation was calculated. In total, calculations were considered at $A = 8412\ m^2$, $A = 10000\ m^2$ and $A = 17933\ m^2$. For all cases, the calculation results are given in the form of a table. Optima and maximum efficiency are found for each case. The heat exchange area of the prototype heat exchanger was reduced from 17933 m^2 till 8382 m^2 by increasing the coefficient of increase in the pressure in the prototype compressor from 2.05 to 3.445 with unchanged efficiency values $\eta_{th} = 0.4674$. This efficiency is the maximum for an installation with a new heat exchange area [4].



$\eta_{8412}(\pi_k)$ - is the efficiency of the installation at $A = 8412\ m^2$

$\eta_{10000}(\pi_k)$ - the efficiency of the installation at $A = 10000\ m^2$

$\eta_{17933}(\pi_k)$ - the efficiency of the installation at $A = 17933\ m^2$

Fig. 3. Dependence of the cycle efficiency $\eta_e = f(\pi_k)$ on the degree of pressure increase in the compressor at A~ idem

CONCLUSION

This technique allows you to significantly improve the apparatus and reduce the heat exchange area while maintaining the same efficiency, this allows you to take a fresh look at the problem of optimizing the thermodynamic parameters of the cycle [5-7].

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IRSTI 61.13.17

THERMODYNAMICS OF ADSORPTION OF COPPER IONS ON AMINED BENTONITES

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ABSTRACT

The article studies the adsorption of Cu^{2+} ions from aqueous solutions on aminated bentonites of the Kongyrtog mine (Uzbekistan). Experimental experiments were carried out at a concentration of Cu^{2+} ions (30-350 mg/l), medium pH 7,0 amount of adsorbents (1g/l) and temperature 293 K (20°C), 313 K (40°C), 323 K (50°C), 333 K (60°C). Maximum Langmuir adsorption capacity (q_{max}), KB=4,728; GDB=4,490; EDB =5,986 mg/g. The enthalpy values (ΔH°) of adsorption of Cu^{2+} ions on adsorbents are 1,722 in KB; 3,807 kJ/mol in GDB and 3,441 kJ/mol in EDB, which indicated the endothermic nature of adsorption. The values of ΔG° Gibbs energy at temperatures of 293, 313 and 323 K, respectively, will be equal at KB -5,539, -6,017 and -6,288; at GDB -2,987, -3,406 and -3,696 and at EDB - 4,814, -5,357 and -5,665 kJ/mol. This was explained by the spontaneous physical adsorption of copper ions on aminated adsorbents.

Keywords: Aminated adsorbents, copper ions, adsorption isotherm, adsorption enthalpy, adsorption entropy, Gibbs energy.

INTRODUCTION

Currently, there is increasing interest in the world in studying the adsorption and textural properties of bentonites. In recent years, along with the development of industry, environmental problems have become acute. One of the pollutants of the hydrosphere are heavy metals, which include more than 40 chemical elements (copper, chromium, cobalt, zinc, cadmium, manganese, iron, nickel, etc.) [1]. Copper is one such heavy metal. Sources of copper pollution in nature are metallurgy, agriculture, chemistry and other industries. Several methods are used to purify water from heavy metal ions. One of these is the adsorption cleaning method, the efficiency of which is 80-95% [2]. So, with the help of adsorbents, these problems can be solved to a certain extent. In this regard, a number of studies are being carried out to obtain cheap and effective organophilic adsorbents based on natural sorbents [3]. Bentonites have different sorption capacities depending on modification conditions [4]. In this regard, scientific and practical work to resolve such issues is of great importance today. This work is devoted to the analysis of the kinetics and thermodynamic parameters of the adsorption of Cu^{2+} ions on aminated adsorbents.

MATERIALS AND METHODS

Bentonites from the Kongyrtog mine (Kashkadarya, Uzbekistan) were used as the object of study. Its chemical composition is as follows: SiO_2 -58.2; Al_2O_3-18.82; TiO_2-0.81; Fe_2O_3-6.68; Na_2O -2.52; K_2O-2.56; CaO-0.80; MgO-1.20; P_2O_5-0.12; SO_2-0.35; SO_3-0.28 (wt.%): and weight loss upon heating -7.17. The chemical composition of bentonite was analyzed in the central laboratory of "Uzbekgeology-Kidiruv" JSC (atomic emission spectrometer ICPE-9820, Shimadzu, Japan). Lignite bentonite was first crushed into a fine powder, then soaked in distilled water for 24 hours and purified from additional impurities (fragments of sand, quartz, sedimentary rocks, etc.). Aminated bentonites were prepared by continuous stirring of 0.02n solutions of ethylenediammonium dihydrochloride and hexamethylenediammonium dihydrochloride salts in a 3% bentonite suspension in a 1:3 ratio in a water bath at 60°C for 4 hours. The dispersed phase was separated from the dispersion medium using a centrifuge. Then, after air drying for 2 hours, it was oven dried at 105°C for another 2 hours. A sample of coarse-grained bentonite (KB) with ethylenediammonium - EDB, hexamethylenediammonium - GDB [5-6].

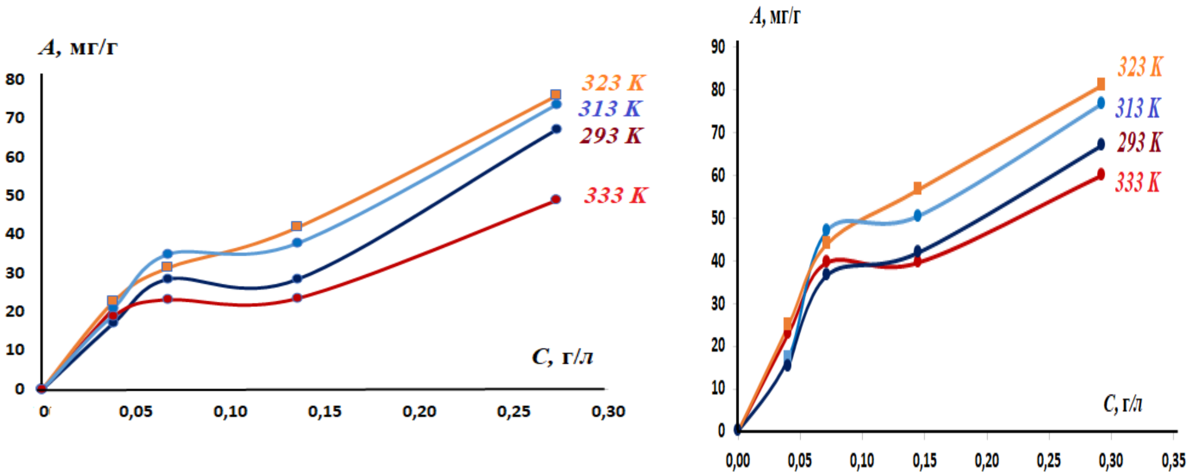
RESULTS AND DISCUSSION

Samples of solutions of Cu^{2+} ions were used, prepared by dissolving the salt $CuSO_4 \cdot 5H_2O$ in distilled water. Adsorption processes were carried out at a concentration of Cu^{2+} ions (30-350 mg/l), medium pH 7.0, amount of adsorbents (1 g/l) and temperature 293 K (20°C), 313 K (40°C) , 323 K (50°C), 333 K (60°C).

Experimental data The amount of Cu^{2+} ions after adsorption was determined by the spectrophotometric (Shimadzu 1900i) method. [7]. The amount of adsorption of Cu^{2+} ions on aminated adsorbents was calculated using the formula [8]:

$$G = \frac{\left(C_0 - C_p\right) \cdot V}{m} \quad (1)$$

Here C_0 and C_p are the initial and equilibrium concentrations of Cu^{2+} ions in solution, mol/l; m is the mass of the adsorbent, g; V - volume of solution, ml.



(A) (B)

Fig.1. Adsorption isotherms of Cu^{2+} ions on EDB (A) and GDB (B) adsorbents at different temperatures (293 K, 313 K, 323 K and 333 K)

When studying adsorption isotherms at different temperatures 293 K, 313 K, 323 K and 333 K, the shape of the adsorption isotherms was characterized by similarity to each other. Thus, in adsorption processes in the range of these temperatures, the adsorption mechanisms do not change, however, in all studied systems, an increase in the adsorption value from 293 K to 323 K was observed, and at 333 K a sharp decrease in the adsorption value of CB Cu^{2+} ions was observed. It was found that the maximum degree of adsorption on EDB and GDB adsorbents occurs at a temperature of 323 K. Therefore, all adsorption calculations were performed for adsorption isotherms at 293K, 313K and 323K.

According to the classification of Gil's adsorption isotherms, it was established that the adsorption of Cu^{2+} ions corresponds to L3 type isotherms. Such adsorption isotherms are usually associated with the sorption of the adsorbate onto the active sites of adsorbents at low concentrations [9]. According to the results of Cu^{2+} adsorption on aminated adsorbents, modification of the adsorbents led to an increase in adsorption active centers. The adsorbents were located in the series of adsorption activity according to the magnitude of Cu^{2+} adsorption as follows: EDB>GDB>KB. Based on the experiments performed, the largest adsorption capacity belongs to EDB. This led to the conclusion that ethylenediammonium cations are located perpendicularly between the bentonite layers, and hexamethylenediammonium cations are located in parallel due to their larger size.

The results of the study were analyzed using the Langmuir, Freundlich, Temkin and Dubinin-Radushkevich models [10]. Tab. 1 presents the results of the analysis of the Langmuir, Freundlich, Temkin and Dubinin-Radushkevich models of adsorption of Cu^{2+} ions on aminated adsorbents at 323 K.

Table 1. Equations of Langmuir, Freundlich, Temkin and Dubinin-Radushkevich models

№	Models	Formula	Explanation
1.	Langmuir	$\frac{1}{q_e} = \frac{1}{K_L \cdot q_{\max}} \cdot \frac{1}{C_e} + \frac{1}{q_{\max}}$	q_e – maximum adsorption capacity (mg/g), K_L – Langmuir constant.
2.	Freundlich	$log\ q_e = \log K_F + \frac{1}{n} \log C_e$	K_F – Freundlich constant, n - adsorption intensity.
3.	Temkin	$q_e = \frac{RT}{b_T} \ln A_T + \left(\frac{RT}{b_T}\right) \ln C_e$	A_T and b_T – Temkin constant related to the heat of adsorption (J/mol), R - universal gas constant (8.314), T - temperature (K).
4.	Dubinin-Radushkevich	$\ln q_e = \ln q_m - \beta \varepsilon^2$ $\varepsilon = R \cdot T \cdot \ln(1 + 1/C_e)$ $E = 1/\sqrt{2\beta}$	β – adsorption energy activity coefficient, ε - adsorption potential of the adsorbent

Indicators of the results of adsorption of Cu^{2+} ions by aminated adsorbents according to the Langmuir, Freundlich, Temkin and Dubinin-Radushkevich models (Tab.2).

Table 2. Indicators of the results of adsorption of Cu^{2+} ions by aminated adsorbents according to the Langmuir, Freundlich, Temkin and Dubinin-Radushkevich models

Isothermal models	Indicators	KB	GDB	EDB
Langmuir	q_{max} (mg/g)	4.728	4.490	5.986
	K_L (l/mg)	2.267	0.888	0.447
	R_L	3.528	9.009	1.059
	R^2	0.972	0.993	0.986
Freundlich	K_F	3.720	2.659	5.748
	1/n	0.641	0.868	0.936
	R^2	0.874	0.977	0.963
Temkin	B_T (J/mol)	0.676	0.496	0.917
	K_T (l/mg)	42.185	24.46	25.75
	R^2	0.952	0.954	0.975
Dubinin-Radushkevich	β(моль^2/K^2 J^2)	$3.08 \cdot 10^{-6}$	$4.06 \cdot 10^{-6}$	$4.27 \cdot 10^{-6}$
	E (kJ/mol)	402.59	350.732	342.14
	R^2	0.970	0.961	0.982

Here we see that the correlation coefficients of the Langmuir isotherm model (KB=0,972; GDB=0,993; EDB=0,986) are higher than those of the Freundlich, Temkin and Dubinin-Radushkevich models. Therefore, the values of the adsorption correlation coefficients in the Langmuir model described the experimental data better than in the Freundlich, Temkin and Dubinin-Radushkevich models. Maximum adsorption capacity (q_{max}), according to Langmuir, KB = 4,728; GDB=4,490; EDB =5,986 mg/g.

Based on adsorption isotherms at different temperatures, the thermodynamic parameters of adsorption were calculated: enthalpy (ΔH°), entropy (ΔS°) and Gibbs energy (ΔG°). The Gibbs adsorption energy (ΔG°) and entropy values were determined using the following formulas:

$$\Delta G = -RT \ln K \qquad (2)$$

$$\Delta G = \Delta H - T\Delta S\left[11\right], \qquad (3)$$

here ΔG° is the Gibbs energy, J/mol; R - molar gas constant, J/mol·K; T - temperature, K; $\ln K_L$ is the adsorption equilibrium constant.

The results of calculating the thermodynamic parameters of the adsorption process are given in Tab. 3.

Table 3.Thermodynamic parameters of adsorption of Cu^{2+} ions on aminated adsorbents

Adsorbents	Temperature, K	K_L	ΔG°, kJ/mole	ΔH°, kJ/mole	ΔS°, kJ/mole ·K
KB	293	9.72	-5.539	1.722	24.771
	313	10.11	-6.017		
	323	10.42	-6.288		

Table 3 continuation

GDB	293	3.40	-2.987	3.807	23.156
	313	3.70	-3.406		
	323	3.96	-3.696		
EDB	293	7.21	-4.814	3.441	28.162
	313	7.83	-5.357		
	323	8.24	-5.665		

For adsorption, the change in Gibbs free energy ΔG° has a negative value. In all systems studied, it was observed that this value increases to a negative value with increasing temperature. The values of ΔG° Gibbs energy at temperatures of 293, 313 and 323 K, respectively, will be equal at KB -5.539, -6.017 and -6.288; at GDB -2.987, -3.406 and -3.696, and at EDB -4.814, -5357 and -5.665 kJ/mol. This explains the spontaneous physical adsorption of copper ions on aminated adsorbents. It has been shown that the process of adsorption of copper ions on aminated adsorbents proceeds more favorably at higher temperatures. In such cases, the mobility of copper ions in solution increases with increasing temperature. This is also explained by the fact that the penetration of Cu^{2+} ions into the pores of aminated adsorbents, i.e., their diffusion, is greater at high temperatures. Positive values of adsorption enthalpy (ΔH°) showed that the temperature of aminated adsorbents is endothermic up to 323 K. The enthalpy values (ΔH°) of adsorption of Cu^{2+} ions on aminated adsorbents are 1.722 in KB; it turned out to be equal to 3.807 kJ/mol in GDB and 3.441 kJ/mol in EDB. In adsorption systems, ΔS° has positive values, which is associated with the adsorption of Cu^{2+} ions on the active adsorption centers of adsorbents. According to the experimental results, modification of bentonites with cationic active substances led to a significant increase in adsorption capacity.

CONCLUSION

Negative Gibbs energy values indicated spontaneous physical adsorption of copper ions on adsorbents. The enthalpy values (ΔH°) of adsorption of Cu^{2+} ions on adsorbents are 1.722 in KB. It turned out to be equal to 3.807 kJ/mol in GDB and 3.441 kJ/mol in EDB. This is due to the fact that adsorption is endothermic. According to the magnitude of Cu^{2+} adsorption, adsorbents are distributed as follows: EDB > GDB > KB is in the range of adsorption activity. The processes of adsorption of Cu^{2+} ions on aminated adsorbents occur through two main mechanisms. The first is the ion exchange mechanism. The second is the formation of chelate complexes of Cu^{2+} ions with hydroxyl groups on the surface of cations of organic modifiers and adsorbents. Thermodynamic parameters obtained from the study of Cu^{2+} ions on aminated adsorbents are important in the processes of adsorption technological calculations.

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IRSTI 61.13.15

DEVELOPMENT OF AN EXTRACTOR FOR THE SOLID BODY–LIQUID SYSTEM

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ABSTRACT

In the present paper, a brief analysis of existing extractors is given in terms of their efficiency in the extraction process. The design of the extractor and the principle of its operation are described. An extractor circuit is presented. The positive features in relation to designs developed earlier by other authors and recommendations for their use are indicated. The design of the extractor for the solid body-liquid system is proposed, which allows to intensify the extraction process by combining fractionation and extraction processes in such areas as the food and chemical industry, metallurgy, medicine, perfumery. The use of rotary pulsating devices makes it possible to exclude the grinding stage from the technological cycle. The use of active hydrodynamic extraction modes is mainly associated with the improvement of apparatus designs. In the proposed extractor design, fractionation and extraction processes are carried out simultaneously. This allows the separation of solid material and the extraction process to be carried out selectively with each fraction, rather than with the entire mass at the same time. Thus, it becomes possible to adjust the required residence time of each fraction in the extractor. The efficiency of the work is achieved by the fact that already when the solid material is supplied, its liquid is irrigated, which allows the extraction process to be carried out even at the fractionation stage. At the same time, by carrying out the fractionation process and accumulating solid material separately by fractions, the time for its extraction is minimized. Thus, a large fraction of the material is processed by the extractant separately from the small fraction, which reduces the extraction time as a whole, i.e. to intensify the process while maintaining the high quality of the resulting extract.

Keywords: extractor, extraction process, solid body-liquid, intensification, apparatus, mass transfer, hydrodynamics.

INTRODUCTION

Currently, extraction is one of the main processes used in many industries (pharmaceutical, cosmetic, chemical, etc.). Extraction plays a special role in the food industry: in sugar, oil extraction, essential oil, liquor, fermentation, brewing, canning, in the manufacture of coffee and tea concentrates, wine, soft drinks and many other products [1]. Therefore, it is necessary that the extraction process be carried out in a highly efficient and economically feasible manner. Extraction in the solid body-liquid system in the food industry is the main process that determines the further stages of processing raw materials and obtaining final products. The chemical composition of raw materials determines the method of its processing and ways of further use in various fields of life and industries [1-4]. Taking into account the increasing demand for dispersed plant materials, it can be argued that the introduction of even minor improvements in the organization of the stage of industrial processing of plant raw materials will lead to tangible economic benefits for producers. Solving the problems of increasing the efficiency of processing enterprises of the agro-industrial complex specializing in the production of plant products, in particular, conducting comprehensive studies to select rational methods and modes, type and design features of the extraction apparatus, providing appropriate technical and economic indicators, is relevant and requires a scientific approach taking into account the specifics of technology and properties of raw materials and requirements for final products[15]. The aim of the work was to develop a rational extractor design for the implementation of the extraction process from solids from crushed vegetable raw materials. Therefore, it is necessary that the extraction process be carried out in a highly efficient and economically feasible manner. The existing solutions for the design and hardware of extractors acceptable for the implementation of this extraction method in practice are either expensive or extensive extraction. Industrial-type extraction devices are divided into two types - periodic and continuously operating. Periodic devices have found application in setting up production with a small mass flow, and continuous devices with a large flow. At the same time, both types of devices must ensure the flow of the process in conditions closest to the counterflow with minimal hydrodynamic resistance to the relative movement of phases, the ratio of the mass consumption of the extractant and solid particles and the total internal and external diffusion resistances [14]. Figure 1 suggests a general classification of the main types of extractors [13].

The speed of the process, data on heat and mass transfer and information on the hydrodynamic situation or flow structure in the extractor are necessary data for calculating the extractor. The main factors affecting the operation of the extractor [13]:

1) thermodynamic - phase equilibrium constants; this group of factors determines the direction of the process, the technological parameters of the process and affects the speed and selectivity of the entire process;

2) kinetic - constants of the rate and energy of activation of the main and side processes;

3) mass transfer - mass transfer coefficients of initial and intermediate substances and final products of the process;

4) heat exchange - heat transfer coefficients between phases and heat transfer coefficients between the medium and heat exchange devices;

the size of the external heat transfer surface;

5) hydrodynamic - characteristics of the interfacial surface and mixing in solid and dispersed phases.

The constructed extractor designs should accurately reflect the physical essence of the process and have a fairly simple mathematical form, convenient for practical calculations and the choice of an optimization method [13] Extraction in the solid body –liquid system in the food industry is the main process determining the further stages of processing raw materials and obtaining final products. Currently, there is no scientifically sound approach both to the conduct of these processes and to the choice of its hardware design.

The development of new highly efficient equipment and the modernization of already used devices is currently an urgent task, since it allows to intensify the process, reduce production costs and improve the quality of the final product. An analysis of the extractors and methods used to increase the efficiency of the extraction process allows us to conclude about the main ways to improve the constructive design of this process.

The most significant methods of process intensification are reduced to an increase in the contact surface of the phases and the use of active hydromechanical modes of the process. An increase in the mass transfer surface is traditionally achieved by reducing the particle size of the solid phase involved in the process. It should be noted that excessive over-grinding can lead to a deterioration in mass transfer [2]. Thus, the first method is directly related to the second method of improving the efficiency of the process. The use of active hydrodynamic extraction modes is mainly associated with the improvement of apparatus designs. Traditional extractor designs ensure reliable operation, although they are not highly efficient and have a number of disadvantages, which include large dimensions, high processing time of raw materials and energy consumption, and a relatively low degree of component extraction [2].

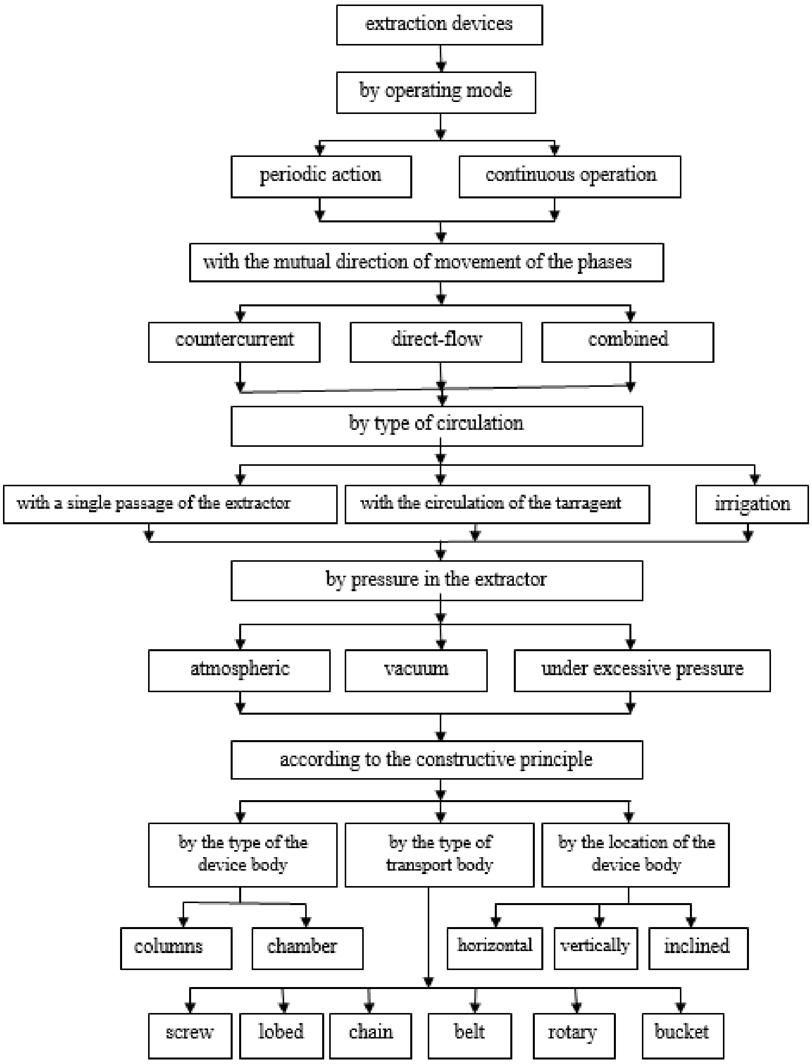

Fig. 1. General classification of the main types of extractors [15].

MATERIALS AND METHODS

The methods (methodology) of the study consists in analyzing existing extractor designs in order to create a scientifically based approach that allows you to create highly efficient mass transfer equipment.

Currently, there is no scientifically sound approach both to the conduct of these processes and to the choice of its hardware design. The development of new highly efficient equipment and the modernization of already used devices is currently an urgent task, since it allows to intensify the process, reduce production costs and improve the quality of the final product. An analysis of the extractors and methods used to increase the efficiency of the extraction process allows us to conclude about the main ways to improve the constructive design of this process. The most significant methods of process intensification are reduced to an increase in the contact surface of the phases and the use of active hydromechanical modes of the process. An increase in the mass transfer surface is traditionally achieved by reducing the particle size of the solid phase involved in the process. It should be noted that excessive over-grinding can lead to a deterioration in mass transfer [2-7]. Thus, the first method is directly related to the second method of improving the efficiency of the process. From the whole variety of devices used for the extraction process, I would like to single out rotary pulsation type (RPA) devices. Devices of this type have proven themselves well for the processes of homogenization, dispersion, etc. In these devices, there is an intense effect on the treated medium by acoustic pulsed cavitation, hydraulic shocks, and shear stresses, which leads to an increase in the efficiency of the processes being carried out. RPA extraction devices used in modern enterprises differ from those used in low specific energy and metal consumption at high the quality of the resulting finished product [3,10,11]. Extraction in RPA is based on circulation and repeated processing of the medium in the internal volume of the device. During the operation of the RPA, large velocity gradients are observed, intense mechanical action occurs on the particles of the raw material, effective turbulence and pulsation of the flow occur [3]. It should be noted that the use of rotary pulsating devices makes it possible to exclude the grinding stage from the technological cycle. The use of active hydrodynamic extraction modes is mainly associated with the improvement of apparatus designs. Traditional extractor designs ensure reliable operation, although they are not highly efficient and have a number of disadvantages, which include large dimensions, high processing time of raw materials and energy consumption, and a relatively low degree of component extraction [2].

RESULTS AND DISCUSSION

This article proposes an extractor design for the solid body -liquid system, which allows to intensify the extraction process by combining fractionation and extraction processes in such areas as the food and chemical industry, metallurgy, medicine, perfumery.

The extractor designs, which are analogues of the proposed design, additionally use a device for exciting ultrasonic vibrations in the extractant located on the side surface of the housing (Patent RU №. 2051895, cl. B01D 11/02, 1996). However, the main disadvantage of this extractor is the low speed of the solid phase dissolution process in the liquid due to ineffective mixing with blades. Closer to the proposed design is an extractor for the solid-liquid system, which contains a vertically positioned cylindrical housing with process pipes and a thermostating jacket, a drive agitator coaxially mounted in the housing, bumpers located along the periphery of the housing and an elliptical filter element coaxial to it located in the lower part of the housing, characterized in that this filter element it is rigidly fixed on the agitator (Patent RU №. 2091120 cl. B01D 11/02 dated 1997.09.27). However, the main disadvantage of this design is the low intensity of the process. In connection with these listed disadvantages, the task was set to develop an extractor design with a high intensity of mass transfer by combining solid material fractionation and extraction processes in it. The main goal is to intensify the extraction process.

The task is achieved by the fact that in the proposed extractor for the solid body -liquid system, containing a vertically arranged cylindrical body with process pipes and a thermostating jacket, a drive agitator coaxially mounted in the body and a filter element, according to the invention, the filter element is made in the form of fractional sieves with different diameters of holes in each sieve, having the shape cones and mounted under each other as the diameters of the holes in each sieve decrease. Sprinklers are installed in the upper part of the housing, and there are protrusions on the periphery of the housing - annular channels.

Fig. 2 shows a general view of the extractor.

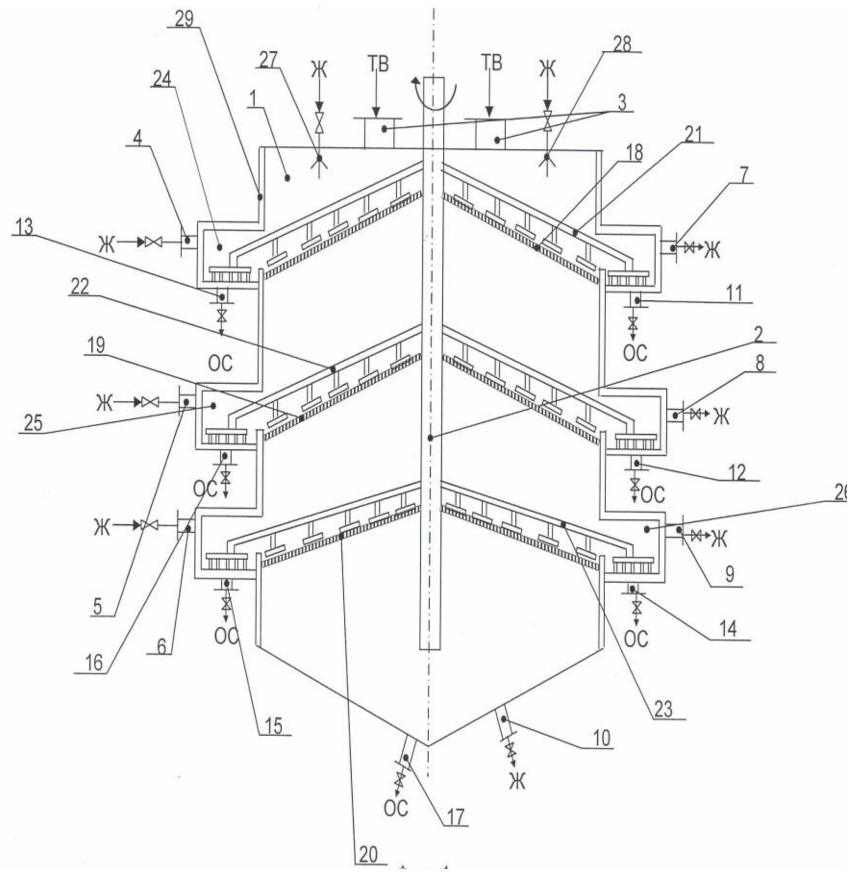

Fig. 2. Extractor [12].

The extractor for the solid-liquid system contains a vertically arranged cylindrical body 1 with a thermostating jacket 29, pipes 3 for supplying the solid phase, pipes 4, 5, 6 for supplying the liquid phase, pipes 7, 8, 9, 10 for removing the extract and pipes 11, 12, 13, 14, 15 16, 17 for sludge removal; a drive agitator 2 coaxially mounted in the housing with scrapers 21, 22, 23, fractional sieves 18, 19, 20, annular channels 24, 25, 26 and irrigation devices 27, 28. The solid material is fed through the nozzle 3 into the extractor housing 1 and, under the influence of gravity, falls on the outer surface of the conical sieve 18. At the same time, it is irrigated with the help of sprinklers 27, 28 with an extracting liquid, and the extraction process begins. Under the action of scrapers 21 mounted on a drive stirrer 2, the solid material is mixed, as a result of which it is sieved and fractionated on a sieve 18. Large fractions remain on the surface of the sieve and gradually, under the action of scrapers, roll down the conical surface of the sieve into an annular channel 24, where it is further extracted by the liquid supplied there through the nozzle 4. For more intensive interaction of liquid and solid material in the annular channel, mixing of these phases with scrapers 21 continues. The solid material of a smaller fraction, passing through the sieve 18, will fall on the conical surface of the underlying sieve 19. Mixing and fractionation processes are carried out there, similar to the processes carried out on the sieve 18. Thus, the solid material enters the downstream sieve 20 lower in fraction than on the sieve 19, which is also fractionated and the smallest fraction of solid material accumulates in the conical part of the extractor body.

The efficiency of the work is achieved by the fact that already when the solid material is supplied, its liquid is irrigated, which allows the extraction process to be carried out even at the fractionation stage. At the same time, by carrying out the fractionation process and accumulating solid material separately by fractions, the time for its extraction is minimized. Thus, a large fraction of the material is processed by the extractant separately from the small fraction, which allows to reduce the extraction time as a whole, i.e. to intensify the process while maintaining the high quality of the resulting extract. Consequently, in the proposed extractor design, fractionation and extraction processes are carried out simultaneously. This allows the separation of solid material and the extraction process to be carried out selectively with each fraction, rather than with the entire mass at the same time. Thus, it becomes possible to adjust the required residence time of each fraction in the extractor. The resulting extract in the form of a liquid is discharged through pipes 7, 8, 9, 10, and the resulting precipitate from the solid phase in the form of meal is removed through the pipes 11, 12, 13, 14, 15, 16, 17. In order to prevent heat loss, the annular channels and the housing are equipped with a thermostating jacket 29. The proposed design of the extractor allows you to obtain an extract of both different concentrations and different compositions, acting selectively in particular cases.

CONCLUSION

Thus, in the presented work: 1. The analysis of the extraction process in devices, in particular, of the rotary pulsation type from the point of view of mass transfer and hydrodynamics is given. 2. The design of the extractor for the solid body-liquid system is proposed, which allows simultaneous extraction and fractionation, thereby intensifying the process. 3. An innovative approach is proposed that allows the development of multi-purpose heat and mass transfer devices.

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INDUSTRIAL TECHNOLOGY AND ENGINEERING

Technical editor: *Nazarbek U.*

Signed for print on 12.09.2023

Format 70x100 1/16. Offset paper

Accounting-publishing list

Circulation 300 copies

CONTENTS

ISSN 2223-3911
03
9 772223 391166