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ABSTRACT

Dissertation submitted to receive the scientific degree of Doctor of Sciences

INCREASING THE EFFICIENCY OF TRANSPORTATION OF CRUDE OIL AND PETROLEUM PRODUCTS WITH THE APPLICATION OF NANOCHEMICAL AND CAVITATION TECHNOLOGY

Specialty: 3354.01- "Construction and exploitation of oil and gas pipelines, base and storage»

Field of science: Technical sciences

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Baku-2024

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GENERAL CHARACTERISTICS OF THE WORK

The actuality of the subject: In oil field practice, during the transportation of oil through technological pipelines, the movement of liquids with different rheophysical properties, as well as their mixtures (including watery, sandy, clayey, etc.) in complex relief and thermobaric conditions, the structure of which is unknown, is often encountered. In the process of transportation of multi-component, multi-phase heterogeneous systems, starting from production wells to oil processing stations, the product constantly changes its physico-chemical and rheological properties, as well as the quality of the commodity, depending on time. It is for this reason that the number of technical-technological issues and complications occurring in the system of technological pipelines is even greater, and their solution is difficult. On the other hand, technological difficulties increase with the dilution of these systems, which greatly increases energy costs.

During the transportation of well products with different types and rheophysical-chemical properties, their quality indicators are not taken into account, and even in some oils, they are almost never studied. During the movement of two-component (oil-gas, gas-condensate, etc.) and three-component (oil-gas-water, gas-condensate-water) mixtures in mining conditions, phase transformations (separation of oil from gas, fall of condensate from gas, due to structural change 3- formation of solid phase and precipitation of asphaltene-resin paraffin (ARP) and formation of water-oil emulsions with anomalous rheophysical properties. Heterogeneous gas-liquid mixtures are non-additively different from the primary components due to their rheological and physico-chemical properties and have a very serious effect on the work of the well-gathering system. Thus, the accumulation of ARP sediments in pump-compressor pipes and technological mining pipelines and the formation of anomalous high-viscosity emulsions greatly increase the excess losses of formation energy, surface energy costs, and the probability of accidents and complications.

It is known that in oil and gas extraction, blockages occur frequently due to the deposition of the macroscopic solid phase in the pipelines that carry out the collection and transportation of oil mixtures. The "incompatibility" of mixing different oils leads to the formation of deposits, as well as anomalous changes in the quality indicators of the mixture and practically important parameters (density, viscosity, freezing temperature, volume, etc.). Even when mixing two good fuels, a "problem" mixture can be formed due to the precipitation of heavy particles. Although the formation of solid deposits during the mixing of individual petroleum products (fuels) is mentioned as the principle of "immiscibility", what is mentioned for crude oils has hardly been studied. Therefore, this issue is one of the most important issues in the process of transportation of mixed oils and is of great theoretical and practical importance.

Supramolecular compounds in oil are formed under external influence based on the principle of "self-construction and self-formation", which depends on the structure of individual components involved in it. The formation of spontaneous supramolecules in oils mainly occurs during the interaction of asphaltenes and resins, which is related to their solubility properties. When mixing different oils and oil products, disregarding the structural characteristics of the components that make them up causes great economic losses and technical problems. From this point of view, the study of the heavy components included in its composition during oil mixing is one of the urgent issues and is very important in terms of reducing the cost of transportation, increasing the pipeline's transportation capacity and production capacity. Considering that parameters such as viscosity and freezing temperature are important parameters during oil pipeline transportation, this problem becomes more urgent. Recently, the trend of extracting and transporting anomalous "non-Newtonian" oils with high paraffin, resin, asphaltene content is increasing. As such oils have high viscosity, freezing temperature and abnormal rheological properties, during their transportation by highway and technological oil pipelines and tankers, a number of complications arise depending on the ambient temperature, which mainly occurs in the zones where ARP deposits are formed. The development of new nanostructured chemical reagents and technologies is of great importance in order to eliminate the mentioned complications and increase the efficiency of transportation.

Purpose of work:

1. Diagnosing optimal and reliable working conditions of pipelines based on relevant standards while maintaining their quality indicators during transportation, taking into account the rheophysical-chemical properties and compounding laws of oil and oil products.
2. Elimination of technical difficulties caused by the formation of paraffin, resin and asphaltene deposits in pipelines and tanks, improving the rheological properties of high-viscosity oils by applying nanostructured reagents.
3. Analytical and experimental determination of out-of-state cavitation zones formed in oil pipelines during transportation and substantiating the feasibility of increasing the efficiency of transportation of high-viscosity oils and oil products using cavitation technology.

The main issues of the study:

1. Study of the scientific bases, regulation and management of the main factors influencing their rheophysical-chemical properties in the process of transportation of oil and oil products.
2. Necessity of compliance of quality indicators of exported oil and oil products with international ASTM, EN, ISO, DİN and ГОСТ standards.
3. Determining the density of oil-condensate-water mixtures taking into account dilution and modeling according to the obtained results.
4. Study of the causes of specific problems caused by the mixing of oils and oil products.
5. Studying the anomaly of rheophysical-chemical properties of oil mixtures and scientific analysis of the formation of self-complex structures in oil extraction, transportation, and storage.
6. Study of rheophysical-chemical regularities for reducing energy costs in the process of fuel-oil, fuel-water mixture transportation.
7. Necessity of studying the laws of oil product compounding and determining the economic efficiency of increasing fuel resources.
8. Study of the effects of nanostructured and chemical additives such as SNPX-2005 on the rheological parameters of oils with high viscosity.
9. Studying the effect of nanostructured Baf-1 and Baf-2 porous,

layered coordination polymers on the transportation, storage, and rheological parameters of high-viscosity oils and their use in cleaning ARP sediments formed in pipelines and tanks during oil transportation.

10. Justification of the possibility of the cavitation process in the obliteration zones formed by the ARP settled on the inner surface of the pipelines in the free flow areas of the oil pipelines.

11. Development of a grapho-analytical method for determining free flow areas in oil pipelines in a steady state.

12. Study of the effect of the cavitation process with the presence of chemical solvents on the rheology of oils.

13. Development of methods of elimination of cavitation zones formed as a result of ARP deposition in underwater pipelines and study of the effect of hydrostatic pressure on the reliability of the pipeline.

14. Based on the perspective of applying cavitation technologies to the oil and oil products transportation process.

Methods of solving the issues: The issues raised in the work are solved theoretically and experimentally, based on the rheophysical-chemical properties of oil and oil products transported through the oil pipeline system, the analysis, systematization and processing of actual data, using laboratory equipment that meets international ISO standards (ASTM, EN, ISO, DİN and ГОСТ standards) and using mathematical methods (grapho-analytical method, three-dimensional dependence model for the existing system). Determination of the density of oil-condensate-water mixtures, modeling according to experimental results, was solved using modern computer models and software tools. The perspective of improving the rheological parameters of high-viscosity oils and their products by applying nanostructured chemical reagents and cavitation technologies has been confirmed by relevant practical tests.

Scientific innovations:

1. The rheophysical-chemical basis of continuous transport was developed based on the laws of compounding of oil and oil products.

2. Based on the results of laboratory tests, the possibility of identifying the anomalies observed during the mixing of oils and

their elimination was shown.
3. The rheophysical and chemical regularities of reducing energy costs during transportation of fuel oil-oil, fuel oil-water mixture through pipelines have been determined.
4. A grapho-analytical method was developed to determine the out-of-state cavitation areas that occur in the free flow areas of main oil pipelines.
5. The possibility of the cavitation process occurring in the free flow areas of oil pipelines and in the obliteration zones formed by ARP sediments on the inner surface of the pipeline is determined according to ГОСТ 2070-82 for iodine number and ASTM D1159/1160 for bromine number.
6. Anomalies that can appear due to the formation of supramolecular compounds in the mixture of Azerbaijani oils and oil products were determined by mathematical and experimental methods.
7. For the first time, the rheological properties of the composite based on Baf-1 and Baf-2 nanostructured coordination polymers were studied, and the scientific basis of the cavitation zones formed in the pipelines and the washing of bottom sediments formed in the collection tanks as a result of the ARP deposition were shown and the technologies were developed.

Main clauses protected:

- continuous transportation of oil and oil products in pipelines by adapting the buffer traffic jam formed during the sequential transportation of oil and oil products to their genetic components regulation;
- justification and determination of specific problems arising during the mixing of oil and oil products in terms of rheophysical-chemical properties of the mixtures;
- scientific analysis and optimization of the formation of self-complex nanostructured compounds during oil extraction, transportation and storage;
- determination of out-of-state cavitation areas that occur in the free flow areas of oil pipelines in the steady state;
- the possibility and determination of the cavitation process in the free flow areas of oil pipelines and in the obliteration zones formed

by ARP sediments on the inner surface of the pipeline;
- Improvement of their rheophysical-chemical properties by affecting ARP sediments in oils with Baf-1 and Baf-2 nanostructured coordination polymer-based chemical reagents;
- during the transportation of oil and oil products, justification of the perspective of applying cavitation technologies;

Practical significance of the work and application of the results:

1. Taking into account the dependence of the rheophysical-chemical properties of oil and oil products on their component composition, their determination should be carried out on the basis of various standards (ASTM, EN, ISO, DİN and ГОСТ), and the errors between the results of the analyzes should be within acceptable limits (ГОСТ Р ISO 5725 -2-2002) allows timely resolution of anomalies in transportation and preventive measures arising in orbital issues.
2. The results obtained from the modeling of the density of oil-condensate mixtures according to the experimental results, taking into account dilution, are more accurate than the results calculated according to the additivity rule, and are in agreement with the experimental results, in which case the average value of the errors determined for the mixture is more than 0.2% doesn't happen.
3. The issue of regulation of physico-chemical properties of oil products during continuous transportation was practically analyzed on the example of fractions of aviation and gasoline fuels obtained from Azerbaijani oils. Application of the proposed buffer plug for sequential transport of aviation and gasoline fuel fractions allows to increase the efficiency of sequential transport, as an original, new method confirmed in experimental and laboratory conditions.
4. The analysis of the formation of self-nanostructured complex compounds during the transportation and storage of oil and oil products showed that the application of the rule of additivity to mixing is inadmissible, and conducting preliminary laboratory tests for the purpose of obtaining rational mixtures allows for the timely solution of problems that may arise.
5. The grapho-analytical method of determining out-of-state cavitation zones in highway and technological pipelines allows to

determine the location and volume of free flow zones in oil pipelines in fixed traffic modes and to prevent possible accidents (tested in the Oil Pipeline Department of SOCAR).
6. Timely application of the method of determining the possibility of the cavitation process with the Iodine (Bromine) number in the free flow areas and the obliteration zones formed by ARP sediments on the inner surface of the pipeline during transportation by oil pipelines allows the elimination of accidents in pipelines during transportation.
7. BAF-1, BAF-2 brand nanostructured coordination polymer-based chemical regents, production tests were conducted to check the application of high-viscosity oils in improving the rheological parameters, cavitation zones formed in pipelines during transportation, and bottom sediments settled in tanks, and they were tested in Muradkhanli, Garasu, Salyan , Shirvan, Neftchala, Gobustan, Petro-HongKong-Pirsaat Siyazan oils, it was found that they have a clear advantage in comparison with SNPX-2005 chemical additive.
8. Taking into account the improvement of the rheological parameters of oils in the cavitation process, it is possible to increase the efficiency of transportation by applying cavitation technologies to the transportation of highly viscous oil and petroleum products.

Approval of work. The main results of the dissertation work**:**

- "XVIII International Specialized Exhibition" International Oil and Gas Forum. Gas. Oil. Technologies, Ufa, 2010;
- "New technologies in oil and gas extraction" II International scientific-practical conference, Baku, 2012;
- "Problems of ecology and safety of life" Materials of international scientific and practical conference, Atyrau, 2012;
- "Problems of innovative development of the oil and gas industry" Proceedings of the fifth international scientific and practical conference, Almaty, 2013;
- "Innovative development of the oil and gas complex of Kazakhstan" International scientific and practical conference, Aktau, 2013;
- "Ecology and oil and gas complex" international scientific and practical conference, Atyrau, 2013;

- "Oil and Gas" 69-th International Scientific Conference, Moscow, 2015;
- "Actual problems of the development of oil and gas complex of Russia" XI All-Russian scientific and technical conference, Moscow, 2016;
- "International scientific and technical conference, devoted to the memory of Academician Azad Khalilovich Mirzadzhanzade", Ufa, 2016;
- ""Caspian oil and gas field"" conference, Baku 2018;

reported and discussed.

Job posting: 71 scientific works, including 48 articles, 5 patents, 12 conference materials and 5 theses, and 1 monograph were published in Germany.

Structure and scope of work:

The dissertation consists of 312 pages with 333195 markers, including an introduction, 5 chapters, conclusions, 325 references, 113 figures, 53 tables and appendices.

CONTENTS OF THE WORK

In the introduction, the relevance of the work is theoretically and practically substantiated, the purpose and the main issues solved are given, the scientific novelty, practical importance and defended provisions are shown, and the content of individual chapters of the dissertation is briefly explained.

The first chapter of the dissertation is devoted to the analysis of the rheophysical-chemical basis of oil and oil products transportation. The factors affecting the rheophysical-chemical properties of oils and the effect of their influence in terms of composition and structure are explained. An analysis of the problems arising during the transportation of various oil and oil products was carried out. In modern times, the increase in the demand for hydrocarbons has determined the importance of expanding the exploitation of high-viscosity oils and natural bitumen resources and developing new technologies for this.

During the study of rheological, mechanical and structural properties of oils, the amount and structure of asphaltenes in their composition should be the main research object. The analysis of the composition of high-viscosity oils shows that, although their density indicators are close, their rheological and physico-chemical properties differ significantly from each other.

Analyzing the physico-chemical characteristics of highly viscous and bituminized oils produced from the oil fields of Azerbaijan, the Russian Federation, and the United States, it was found that they are completely different from each other. Azerbaijani oils differ from other oils in that they have a low bitumen saturation limit, high water solubility, low penetration into rocks, and high rheophysical-chemical properties. It is concluded that in order to use high viscosity oils extracted from Azerbaijan, Russian Federation, Canada, Venezuela and other fields with the application of new technologies, their phase composition must be taken into account.

Many problems that arise in the process of transporting heavy oils (HO) and bituminous oils (BO) are related to their low stability and the formation of asphaltene deposits. Solvents - gas condensates, light oils, gasoline, kerosene fractions are mainly used to reduce the viscosity of AN and BN, which can create conditions for "incompatibility" of component mixtures. Deterioration of the solubility of dispersed systems leads to a decrease in consistency, the formation of asphaltene deposits, a decrease in density and viscosity (the hydrodynamic factor of continuous dispersed systems), which leads to a decrease in the quality of oil. As a result of the phase transformation during the process, the transition of solid particles to solidified asphaltene colloids takes place according to the following scheme: nanocolloids-locculated nanocolloids-flocculated asphaltene particles. In this case, a decrease in the sedimentation resistance of the system can be observed at the phase boundaries. Asphaltenes play a key role in the formation of high viscosity in low-paraffin oils, because in cases where the amount of asphaltene and resin is high, the aggregation process of particles is accelerated, which causes a sudden increase in viscosity. As it is known, synthetic surfactants (SS) - polyisobutylenesuccinimides, alkylphenols, ethoxylated nonylphenols, alkylbenzene sulfoacids, fatty acids, amines, etc., are used to improve the rheological properties of HO and BO and prevent delamination. It is used. According to the acid-base interaction mechanism between the polar molecular group of SS and the molecular groups of asphaltenes, due to the formation of hydrogen bonds, the non-polar molecules of SS form a spherical cloud around the aggregates of asphaltenes, and as a result, the change of aggregate states is prevented, which weakens the deposition process. and causes the oil viscosity to decrease. It is shown in the work that the prevention of aggregation of asphaltene fractions should be considered as the main condition for reducing the viscosity of oils. Studies on phase transformation of resins and asphaltenes, the effect of aggregate sizes and structures on the rheology of oils are rarely found in the literature. Therefore, the scientific research conducted in the direction of studying the rheology of HO and BO can contribute to the solution of many unresolved issues in the oil industry. Based on the analysis, it is necessary to change the mechanical strength and durability at the molecular level and in the solvate layer to adjust the ratio of components in the oil-dispersed systems under existing complex conditions.

It was determined that the information about the chemical reagents used to adjust the rheological properties of oils according to the amount of resin-asphaltene-parfin is absent in scientific research. The improvement of the rheological properties of oils by chemical reagents, although the effect of various functional groups in the reagents is theoretically justified, has not been proven in this production. Although chemical reagents such as R-140, GY-3, Danox-501, DMN-2005, SNPX, PK and AP-174 are used to regulate the rheological properties during oil production, transportation and storage in a number of foreign countries, they create undesirable conditions when mixing oils. is considered economically inefficient due to In Azerbaijan and the CIS countries, the research works carried out in the direction of eliminating the difficulties arising in the production, transportation and storage processes of highly viscous and heavy oils are almost non-existent. Undesirability caused by resin-asphaltene-paraffin compounds during the transportation of oil and petroleum products depends on their fractional composition and the causes of cavitation in the cavitation zones where they meet have been found to be unsolved issues. Also, the relevance of applying new laboratory and technological methods to monitoring the continuous transportation of oil and oil products has been determined.

In the second chapter of the work, the rules of the compounding of oil products and the development of the rheological physico-chemical basis of their sequential transport were considered. The analysis shows that oil with a high TAN (total acid number) costs an additional 1,15-10,73 dol. per barrel for transportation, and the economic return is in the range of 43,5-63,7 dol./barrel. Producers are able to purchase valuable oil distillates in oil refineries by improving the physical and chemical properties of oil by purchasing synthetic oil at low cost.

It is known that quality parameters determine the market price of oils. Density, total acid number, and sulfur content vary between API specific gravity light oils (high API, low density) and heavy oils (low API, high density). Standards and methods of analysis used in order to adapt the main quality indicators of oil and oil products to modern requirements. Although most oil refineries are designed to effectively meet the demand for raw materials, their production capacity has decreased significantly. The main reason for this is the tightening of the demand for fuel and the fact that the production parameters of the factories do not meet the environmental requirements. Most of them are designed for the production of low-sulfur, light oils. There are a limited number of plants designed to produce sulphurous, heavy oils. In order to provide them with raw materials properly, monitoring of their quality bank during the mixing of oils in accordance with the existing standards is one of the important conditions, and it is of great importance in the purchase of targeted oil products in the oil industry and in the protection of the environment.

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During the study of the rheophysical-chemical properties of nets and oil products, one of the main conditions is that their quality indicators meet the relevant standards. In this regard, in this chapter of the dissertation, the quality indicators of nets and oil products were studied using modern methods. As a rule, oil rich in valuable, clear oil products is mixed with heavy non-standard and low-quality oil and sent to production. The goal here is to deliver low-quality oils to the user at minimum cost and to reduce the cost. Maintaining and transporting a quality bank of modern commercial and military aviation jet engine fuels is of great importance. So, the fuel should be pumped into the tanks once it is out of production, so that the environment does not have a big impact on the quality of the fuel.

In accordance with the requirements of ГОСТ 10227-82, analyzes of TC-1 fuel (kerosene) fraction obtained from Azerbaijani oils were carried out, and the results of the analysis show that such fuel fractions must undergo appropriate technological processes to be used as fuel. On its own, the TC-1 fuel fraction is irreplaceable in the transportation of difficult-to-solve oil products and increasing their resources as a strong solvent. Bitumen is one of the products that cause difficulties in the transportation process in the oil industry. Since transportation and storage of bitumen is regulated by international standards ISO 9001, ISO 14001, EN 12591, EN 14023, EN 13108-21, EN 1426, EN ISO 4259, ГОСТ 22245-90, ГОСТ 11955-82, EN 12697-1 and OHSAS 18001 in this chapter, the analysis of the physico-chemical characteristics of bitumen was carried out in accordance with ГОСТ 11955-82 (40/70) and EN 12591-2009 (50/70), and it was shown that the application of this type of bitumen in the industry can bring great economic benefits. The mixture of such bitumen with TC-1 brand kerosene fraction according to relevant standards will give a great impetus to the development of fuel resus. Taking this into account, the rheophysi-calchemical properties of the compound obtained from a mixture of TC-1 grade kerosene fraction obtained from Azerbaijani oils and 50/70 grade bitumen were studied.

The compounds were obtained in two stages, in the first stage, they were added to the 50/70 brand bitumen, TC-1 brand kerosene fraction, in the second stage, 50/70 brand bitumen was heated to 90 ^{0}C and added to the TC-1 brand kerosene fraction, and laboratory studies were conducted (tables 1, 2). The results of the experiments showed that in the first stage, the formation of sediment is gradual, and in the second case, the formation of small colloid particles at the border of resin-asphaltene nanophases is observed in the first added layer. Based on the obtained results, it is possible to give preliminary recommendations about the results obtained when different oil products are mixed. Changes of many parameters in bitumen kerosene mixture are observed with anomalies. The observation of such an anomaly in the density parameter is explained by the fact that the mass remains stable and the structure changes.

The good solubility of bitumen in kerosene can be attributed to the fact that the amount of aromatic hydrocarbons in the TC-1 fuel fraction is high, and the amount of solid paraffin hydrocarbons is negligible, that is, to the good solubility of similar liquids in each other (solution theory).

Such processes often occur during the transportation of oil products, especially during sequential transportation, which results in the emergence of major technical problems. The advantage of sequential transportation is that different oil products are transported through the same pipeline, and the disadvantage is the formation of a mixture in the contact zone of the two products.

Table 1

Results of physico-chemical analyzes of different mixtures of TC-1 brand kerosene and 50/70 brand Bitumen

1st stage Indicators	Mass amount of 50/70-brand bitumen								
	0,01	0,02	0,04	0,05	0,10	0,15	0,20	0,25	0,30
At 150 ^{0}C Sta. evil Thermo. St. 100 cm^3 side. Fall. Layer. with mg. GOST 11802	39	73	131	162	207	298	586	775	963

Table 2

Results of physico-chemical analyzes of different mixtures of TC-1 brand kerosene and 50/70 brand Bitumen

2nd stage Indicators	Mass amount of TC-1 brand kerosene								
	0,01	0,02	0,04	0,05	0,10	0,15	0,20	0,25	0,30
Static evil at 150 ^{0}C. term. stable. 100 cm^3 side. collapse fold, mg. GOST 11802	1618	1596	1577	1567	1509	1457	1413	1364	1326

Experiments show that the amount of mixture is less in the turbulent flow regime than in the laminar flow regime. Transportation of kerosene fraction after bitumen with technological belts in oil refineries is observed with the purification of bitumen and vice versa, technological problems appear during the transportation of bitumen with the belt where kerosene fraction is transported.

Determining the amount of the mixture formed during successive transportation, receiving it at the final destination and using it are the main issues.

The results of physico-chemical analyzes of mixtures of TC-1 brand kerosene and 50/70 brand bitumen in different proportions showed that it is possible to increase their resources by using such mixtures as fuel within the existing standards. In this chapter, the issue of studying the rheophysical-chemical regularities of the effectiveness of fuel oil-water mixture transport was also considered. It was determined that the transportation of fuel oil along with a low-viscosity liquid (water) through a pipeline occurs due to a continuous circular liquid ring formed by a low-viscosity liquid on the surface of the pipe wall. At this time, the fuel oil is supplied to the pipeline in such a way that the formed low-viscosity liquid ring ensures the movement of the high-viscosity liquid.

The increase in the discharge capacity (flow rate) of the pipe occurs due to the increase in the thickness of the circular ring formed on the wall surface, and the decrease in the amount of fuel oil in the total flow. Therefore, it is not recommended to increase the volume of low-viscosity liquid by 40-45 %, and the amount of sludge formed on the wall surface should not exceed 10 %, which ensures the economic efficiency of transportation.

A sudden decrease in viscosity was observed with the increase in temperature. At all temperatures where the experiment was conducted, an increase in the viscosity of fuel oil is observed at 5%-10% dilution. At temperatures of 30 and 40 ^{0}C, the viscosity begins to decrease when the amount of water and dilution is 15%, and increases again at 60 and 80 ^{0}C. Only, at 20 % dilution and at temperatures of 60, 80 ^{0}C, the viscosity starts to decrease again. At 20-25 % dilution, the viscosity practically did not change at all temperatures. From what has been said, it can be concluded that the rheological properties of fuel oil change in the interval of 10-15% dilution and the efficiency of fuel oil transportation increases. Thus, based on the results of all analyses, it can be said that to increase the efficiency of fuel oil transportation by pipeline, it is appropriate to choose water as a low-viscosity liquid.

It should be noted that the physico-chemical and rheological parameters of the fuel oil selected for transportation were initially conducted in laboratory conditions according to the relevant ГОСТ and ASTM standards. In this work, the possibility of obtaining mathematical models by taking into account parameters such as density, kinematic viscosity, amount of resin and asphaltenes during the transportation of fuel oil is shown.

One of the economically efficient ways to transport fuel oils with anomalous viscosity is to mix them with low-viscosity oils. This technology, which is used to transport fuel oil mixed with low-viscosity oils from one point to another point, does not create any technical danger for the transportation of both oil and fuel oil-oil mixture. As a result, low-viscosity oil improves the redophysical-chemical properties of fuel oil and lowers its main indicator, viscosity. Correct determination of viscosity is possible only in laboratory conditions. The most accurate result for determining the value of viscosity is the results determined by the kinematic method, which can provide accurate diagnostic information for the correct adjustment of fuel oil transportation through pipelines. For experimental studies, oil-diesel mixtures in different proportions were obtained at different temperatures for 30 minutes in the Ultra-Tyrrax T 25 device and their viscosities were determined.

The amount of fuel oil taken to prepare the mixture was 5, 10, 20, 25, 30, 40 and 90 % (mass). The temperature dependence curves of the viscosity of fuel-oil mixture are given in figure 1.

As can be seen from the graph, the viscosity decreases as a result of mixing fuel oil with low viscosity oil. Despite the change in viscosity, the rheological parameters improve when the optimal mixing limit of fuel oil is up to 20 %. Although the viscosity of oil decreases in the range of 20-50 %, it is not excluded that technical problems arise during transportation.

The results calculated by the additivity method do not agree with the experimental results. All this shows that their rheophysical-chemical properties should be studied in the laboratory before the fuel-oil mixture is transported through the pipeline.

When preparing fuel-oil mixtures, the selection of brands of fuel oil to be mixed according to the quality bank of oils is indicated as the main condition.

The change of the physico-chemical properties of oil products during sequential transportation depending on the mixing ratio was studied, and in all cases, when choosing buffer oil products for separator plugs, it was proposed to select total hydrocarbons according to the fractions of consecutively transported batches.

In the study, taking into account that oil and oil products consist of a mixture of complex organic compounds, mainly paraffin, resin, asphaltene, naphthenic acids and aromatic hydrocarbons, each of them was analyzed with appropriate standards. It has been shown that fuels with high viscosity are rich in secondary processing products.

Those fractions should be characterized by a high amount of polyaromatic hydrocarbons, resins and asphaltenes. Thus, the amount of resin-asphaltene mixture in diesel and gas turbine fuels is small, and their amount in DY motor fuel and F5 and F12 fuel oil should be up to 50%. Based on the chemical composition of the fuel, it includes methane C_nH2_{n+2}, naphthen CnH2n and aromatic C_nH_{2n-6} hydrocarbons.

The properties of these hydrocarbons, as in all chemical compounds, depend on the structure and density of the molecules that make them up, and their density, viscosity, and boiling point increase proportionally to these factors. Taking into account that the molecules of light distillates are composed of 13-17 carbon atoms, those of heavy distillates are 18-27, and those of residual products are composed of 28-70 carbon atoms.

Taking into account that oils are divided into methane-naphthene, naphthene-aromatic and aromatic types depending on the amount of the three main hydrocarbon classes, consideration of the chemical composition of the fuel from its purchase to the appearance of the used oil during transportation is reflected in the work.

Due to the large amount of high-molecular compounds in the local raw materials, the amount of tar in the oil products obtained from it reaches 25%.

In this work, the chemical composition of motor fuels in a group form, determination of their properties is shown. It has been determined that the presence of paraffins in the fuel improves their combustion ability, increases their viscosity, has a high combustion temperature, produces little smoke, and causes filter clogging at low temperatures.

Fuels containing large amounts of oxidized aromatic hydrocarbon compounds have been shown to have extremely low combustion temperatures, smoke, and low combustion temperatures. It has been shown that the quality of the fuel deteriorates because the amount of paraffin hydrocarbons in their content is low, the amount of aromatic-naphthenic hydrocarbons with carbon and hydrogen ratio and the amount of solid hydrocarbons is high.

Physico-chemical indicators of A-76 gasoline according to ГОСТ 2084-77, TC-1 kerosene fuel according to ГОСТ 10227-86, and the main indicators of the mixture of petroleum products were studied according to the requirements of ГОСТ and the results are given in table 3.

All results obtained under laboratory conditions were within the margin of error. The dependence curves of the amount of gasoline (% by mass) in the mixture of TC-1 and A-76 oil products on density, viscosity and fraction composition were constructed.

It was determined that if the report made by the rule of additivity is justified in terms of density and fraction composition, deviations are observed in the viscosity parameter in some cases.

If such deviations are large, the structure of the studied system may collapse. Taking into account that their quality composition does not change completely when adding up to 5 % to TC-1 aviation kerosene and up to 3 % to kerosene, a common buffer plug for the fractions was determined.

The buffer plug used during the sequential transportation of oil products is composed of common hydrocarbons with an average position for both products.

In this way, the production difficulties caused by the continuous transportation of oil products are reduced to a minimum and there is no need to use additional equipment.

To carry out the transportation process, after calculating the volume of the transported oil product, it is enough to have one or two empty tanks to supply the buffer solution to the contact zone.

The proposed method does not harm the quality of various oil products during sequential transportation. It has been determined that the buffer plug product is genetically similar to the transported oil products.

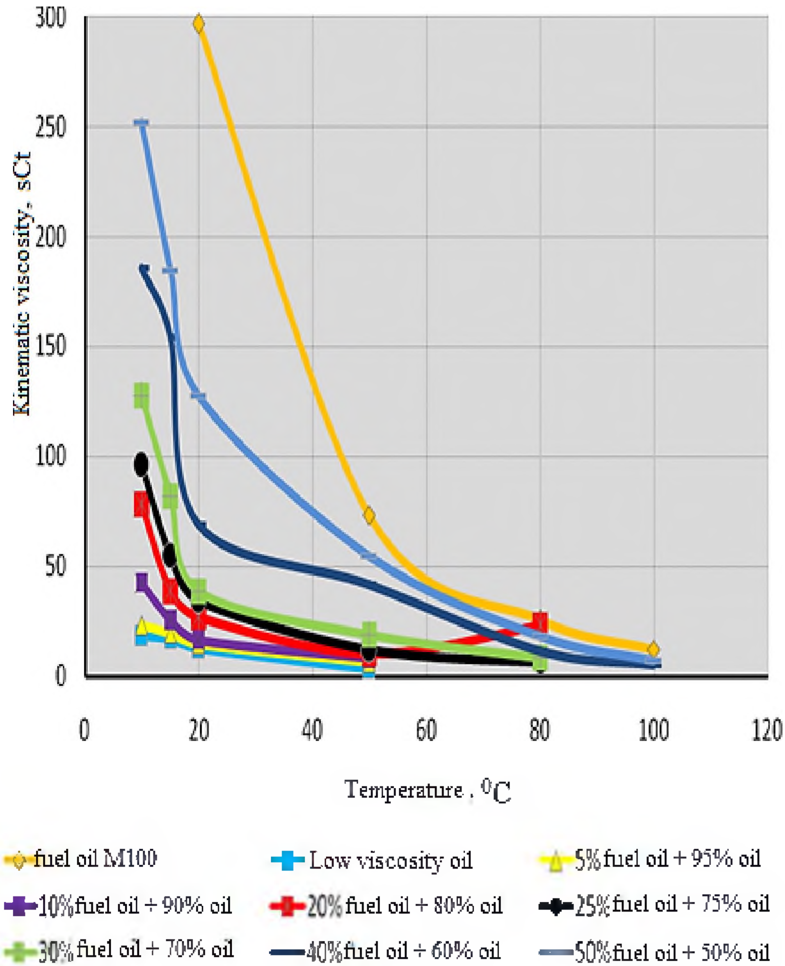


Figure 1. Variation of kinematic viscosity of various mixtures as a function of temperature

Table 3

Results of physico-chemical analyzes of various mixtures of oil products TC-1 and A-76

Indicators		Mass amount of A-76 gasoline												
		0,01	0,02	0,03	0,04	0,05	0,06	0,1	0,4	0,6	0,8	0,9	0,95	0,99
Boiling tempera-ture, °C	beginning	147	145	144	142	140	132	101	79	79	57	48	43	39
	10 %-distillation	161	159	156	155	154	145	114	98	98	84	77	73	69
	50 %-distillation	183	181	179	177	175	163	152	148	148	121	117	115	111
	90 %-distillation	223	223	222	221	220	215	195	191	191	180	178	176	173
Ignit. tem. in a clos. pot. °C		35	33	30	29	26	22	Analysis is dangerous						
Density, 20 °C, kq/m³		789,5	789,1	788,7	788,2	787,6	786,9	785,1	774,3	785,5	785,1	756,4	755,8	754,7
Kinem. viscosity 20 °C, sSt		1,501	1,484	1,467	1,451	1,442	1,434	1,401	1,114	1,411	1,401	0,629	0,590	0,559
Acidity, mq KOH, 100 sm³ in fuel		0,42	0,43	0,45	0,47	0,50	0,52	0,56	0,59	0,65	0,78	0,82	0,91	0,96
Amount of actual resins, mq 100 sm³ in fuel		0,384	0,383	0,381	0,379	0,376	0,371	0,369	0,344	0,325	0,301	0,258	0,243	0,235
Test on copper plate at 100 °C		Resis-tant	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.	Resis.
The starting temperature of crystallization, °C		- 68	- 68	- 68	- 68	- 68	- 68	- 68	- 68	- 68	- 68	- 68	- 68	- 68
Total amount of sulfur, %		0,068	0,068	0,067	0,066	0,066	0,065	0,060	0,045	0,038	0,035	0,034	0,033	0,032
Mercaptan sulfur content, %		0,002	0,002	0,001	0,001	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.
Hidrogen sulfidin miqdarı, %		Doesn't feel	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.
Saturated vapor pressure, kPa		21,4	21,6	23,1	23,3	23,9	26,4	28,6	35,8	38,7	40,5	41,9	42,2	43,6
Dissolving acid and alkali in water		D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.	D. F.
Mass content of aromatic hydrocarbons. %-with		16,0	16,2	16,4	16,6	16,8	17,0	17,4	18,6	19,4	20,2	21,0	21,6	22,0

The third chapter of the dissertation work is devoted to the effect of oil mixing on their rheological properties and quality indicators. It was determined that the main problem-causing factors during oil transportation are mechanical mixtures, salts, resin-asphaltene-paraffin hydrocarbons included in their composition. In the process of transportation of multi-component, multi-phase heterogeneous systems, starting from production wells to oil processing stations, the product constantly changes its physico-chemical and rheological properties, as well as the quality of the commodity, depending on time. It is for this reason that the number of technical-technological issues and complications occurring in the system of technological pipelines is even greater, and their solution is difficult. On the other hand, technological difficulties increase with the dilution of these systems. For example, difficulties arise in the processes of collecting, preparing and transporting highly viscous and anomalous diluted oils in mining conditions, which significantly increases energy costs. It is known from world practice that in oil and gas extraction, cases of blockages occur frequently due to the deposition of macroscopic solid phase in the pipelines that carry out the collection and transportation of oil mixtures. The oil extracted from the sea deposits in Azerbaijan is delivered to the complex collection, processing and transportation point of oil through underwater pipelines. There, after passing through preliminary cleaning and deemulsification processes from water and mechanical mixtures, it is pumped to terminals located on the coast by means of pumps. It has been shown that the quality indicators of oil also change during the pipeline transportation process. It has been determined that in most cases this happens due to pollution of the pipelines. When oil pipelines are operated for a long time, paraffin, tar, sand, clay, etc., contained in oil. joints collapse and form "out-of-state cavitation" zones due to the formation of layers or plugs in the walls of the belts. Mechanical, chemical and other methods are used to clean the belts from the mentioned contaminations. However, in many cases it is not possible to completely clean them. In order to eliminate all of the above, it was considered appropriate to carry out an accurate analysis of the composition of the oil and the monitoring of the regulation of the transportation according to it. Azerbaijani oil is transported to the world market through pipelines. Oils transported by Azerbaijan to foreign companies are mainly analyzed in accordance with the standards set by ASTM. The error between the results of the analyzes conducted according to GOST and ASTM should not exceed the permissible limit. In order to meet these requirements, in 2002, despite the fact that analyzes were conducted with different standards such as GOST and ISO, GOST P ISO 5725-2-2002 was adopted for the uniformity of the results. In this work, the importance of conducting laboratory analyzes in accordance with GOST R ISO 5725-2-2002 standards, and using them for urgent elimination of deficiencies arising in transportation issues, is shown.

In addition to a number of difficulties that occur during pipeline transportation of various types of rheologically complex oils mixed with each other or with light oil, including solvents, it has been determined that imbalances in their storage, as well as delivery and reception processes occur due to the creation of "undesirable pairs". In this study, the rheological properties of the mixtures obtained using the crude oils produced from the "Bulla", "Siyazan", and "Garachukhur" fields, the condensate of the "Umid" field, the A-76 gasoline fraction and the DY-diesel fuel fraction were studied.

Dependencies reflecting the change of quality indicators for mixtures depending on the mass fraction of the mixed product are shown in figure. 2-5, respectively.

As can be seen from figure 2, when mixing "Bulla" and "Garachukhur" oils, the change of the quality indicators of the mixture depending on the mass share of the first one cannot be expressed by the rule of additivity (broken lines in the figure reflect the values determined by additivity). Kinem. viscosity

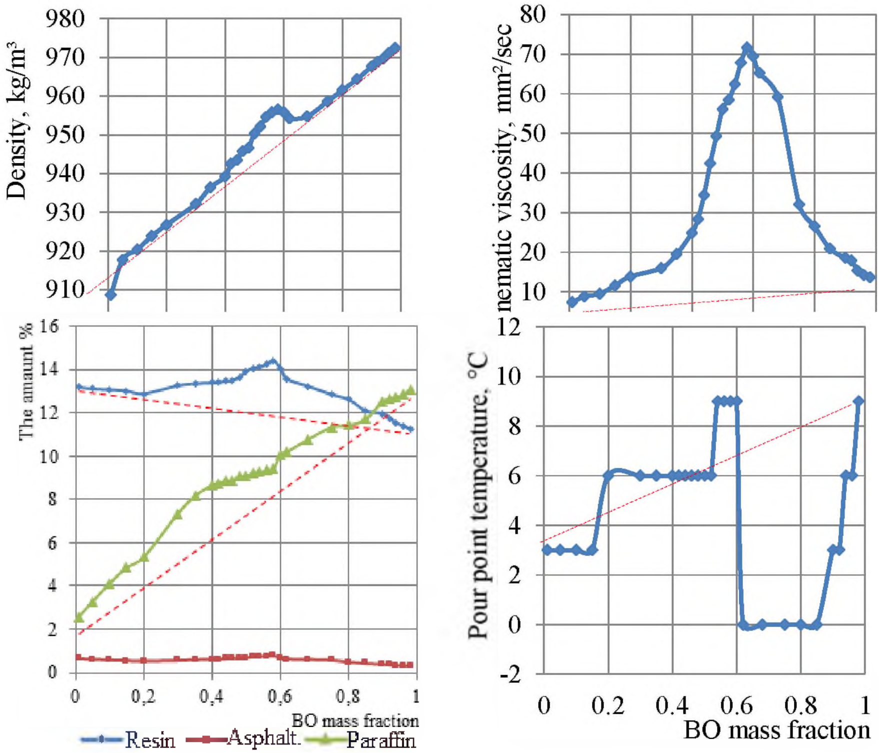


Figure 2. Mixing of "Bulla" (BO) and "Garachuxur" (GO) oils

A similar change in quality indicators was found to occur during mixing of "Bulla" and "Siyazan" oils, depending on the mass share of the first one (figure-3). In this case, in the ratio of 50:50 % = "SO-BO", anomalous changes occur in the values of almost all indicators.

In this study, the mixtures obtained during the mixing of petroleum products (A-76 gasoline) with diesel fuel (DY) in different proportions were studied and the effect of the mixing factor on the quality indicators of the product was studied (figure-4).

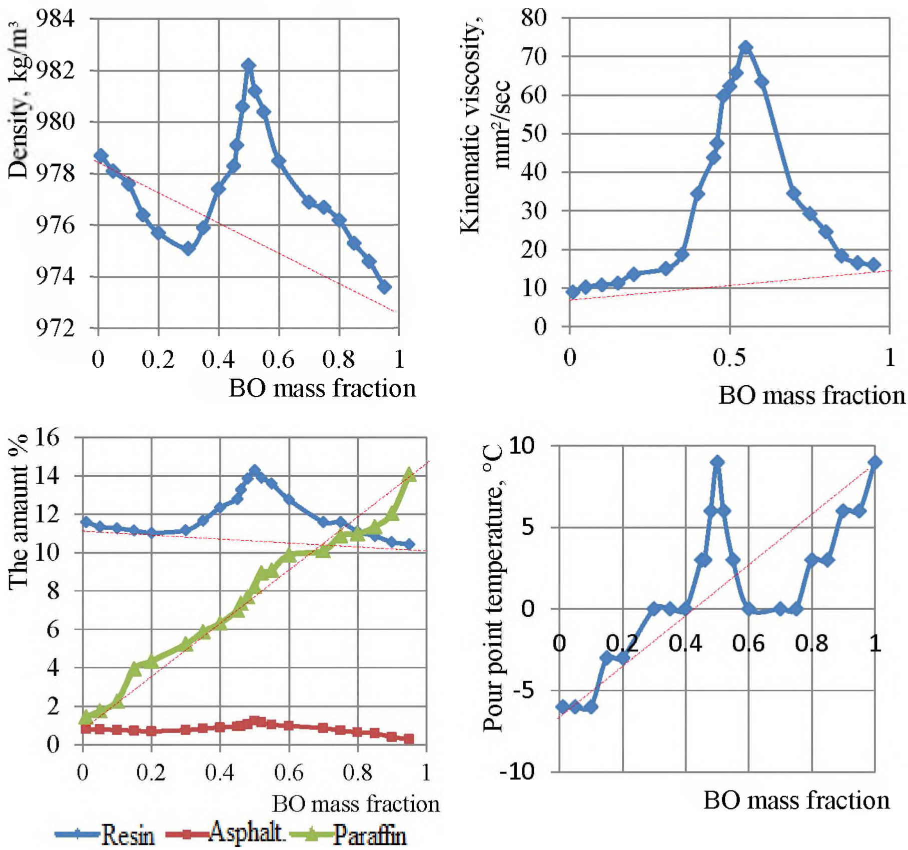
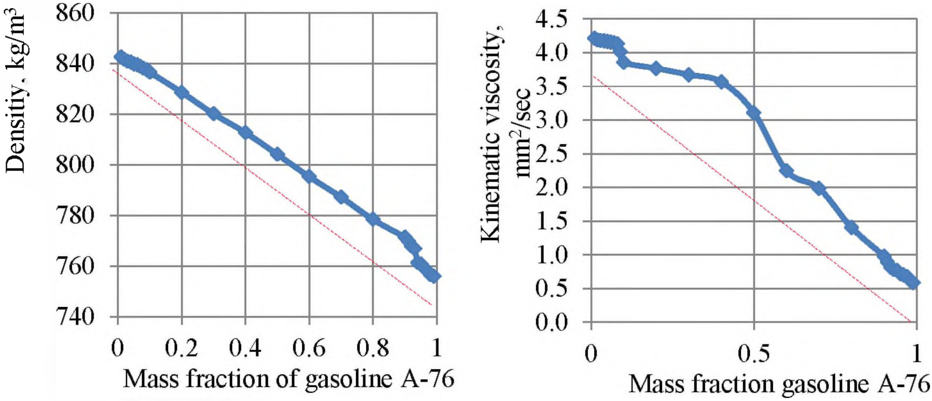
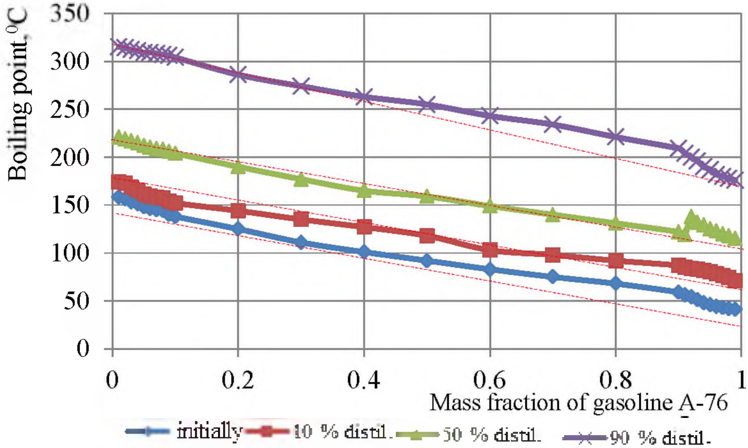


Figure 3. Mixing of "Bulla" (BO) and "Siyazan" (SO) oils

As can be seen from the figure, although the values of the experimentally determined parameters (density, viscosity and fraction composition) for the mixtures are not abnormal in all cases, these values are significantly different from the values calculated according to the additivity rule. In this case, the biggest difference for density occurs in the ratio of "DF-(A-76)" mixture 10:90 %, and for viscosity 60:40 %. The change in the fractional composition of the gasoline-diesel fuel mixture was also observed in the same proportions. In this work, the analysis of the quality indicators of the mixture of "Bulla" oil (well No. 89) and "Umid" condensate in





different mass fractions was carried out and it was shown that the determination of parameters such as density, viscosity and freezing temperature according to the rule of additivity is not allowed.

Figure 4. Mixing of A-76 and DF (summer) oil products boiling point

Although the process of mixing oil and condensate and transporting it through the pipeline is considered efficient due to a significant reduction in viscosity, the anomalous increase in the freezing temperature of the mixture at densities below 10 % of the condensate indicates that mixtures at these densities are undesirable. Because at this time, it was determined that the possibility of the belt's work becoming complicated, or even stopping, increased significantly. As can be seen from Figure 5, depending on the degree of dilution, the freezing temperature of the oil-condensate mixture can be determined without error based on additivity in cases of more than 20 % density of the condensate, and it is shown that these mixtures are considered as additive mixtures.

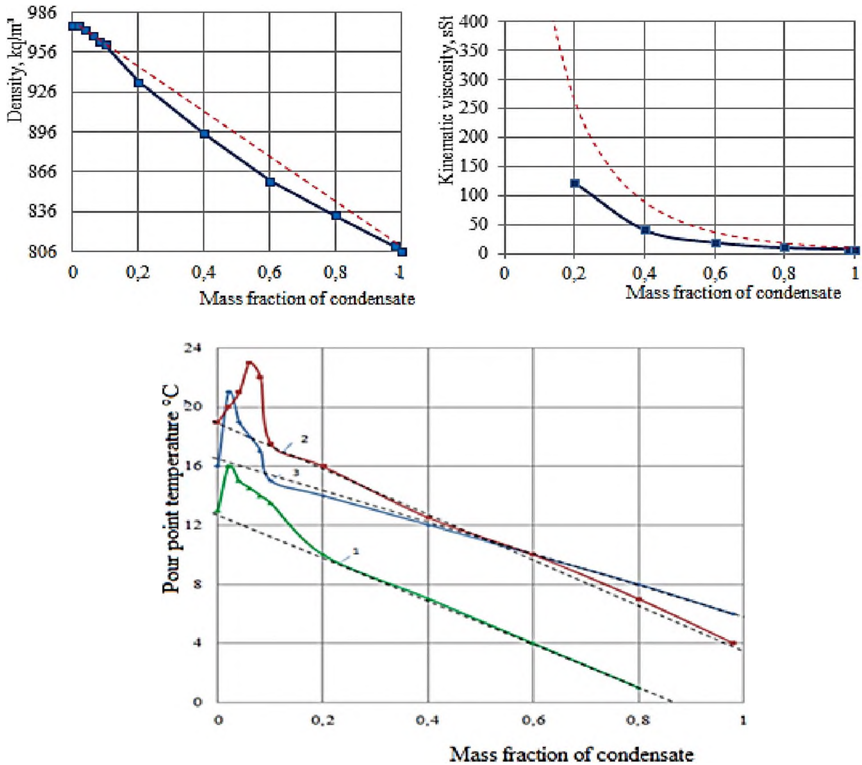


Figure 5. Dependence of the physico-chemical properties of the mixture of oil ("Bulla" field, well No. 82, well 89) and condensate ("Umid field") on the mass fraction of condensate

Here, on the example of Azerbaijani oils, it has been shown that the quality indicators of various oil mixtures depend on the initial properties of the oils and how they are mixed. In a number of cases, during mixing of oils, it was found that the quality indicators changed abnormally, and some mixtures caused specific problems and were generally "undesirable".

The inadmissibility of applying the rule of additivity to such mixtures should be taken into account, and the necessity of conducting preliminary laboratory tests in order to obtain rational mixtures was determined.

Anomalies occurring in their rheophysical-chemical properties during the mixing of oils were analyzed. Ways to solve problems such as the "undesirability" of some mixing, the emergence of serious problems in technological processes such as oil extraction, preparation and transportation, and the inadmissibility of applying the rule of additivity have been studied. The effect of the chemical composition of the mixed oils on the rheological and physico-chemical properties of the mixtures obtained by mixing different oils of Azerbaijan was studied. When mixing Bulla (BO), Garachukhur (GO) and Muradkhanli oils, the regularities of how the quality indicators change depending on the mass share of the mixed oils have been studied.

Here, the metals contained in Bulla (BO), (GO) and Muradkhanli mixed (MMO) oils were determined using the modern ASTM D 5708 Inductive Plasma method. It was determined that V-0.87 in BO, GO and MMO oils; 0.92; 1.57 mg/kg; Ni-1.78; 1.96; 3.51 mg/kg and Fe-4.43; 4.82; It is 8.16 mg/kg. The results and conducted scientific analyzes show that the presence of metals (V, Ni, Fe, etc.) in oils and their oxidation are one of the main reasons for the appearance of anomalous properties in oil mixtures, and the rheological effect of resin-asphaltene-paraffin depends on their mass, amount and structure it depends. Also, the scientific basis of the self-formation of compounds with complex structures in the processes of extraction, transportation and storage of oils and their influence on the rheological properties of oils were studied.

It is shown in the work that nanotechnology is designed to be applied to nanotechnologies with the most molecular structure, which is determined by mechanomolecular forces at the expense of additional energy. The mechanomolecular approach is characterized by influencing molecules through special devices due to external forces. This also shows that the application of nanostructured compounds to the oil and gas industry in the near future can significantly improve the work of specialists.

Considering the fact that supramolecular chemistry, which is the basis of nanotechnology, is based on the formation of a self-organizing system without external influence, its application to the oil industry can lead to the achievement of high levels of efficiency. The formation of compounds with a complex nanostructured structure by the particles themselves is as if programmed in advance, depending on the structural property of the molecules. Thus, in systems with a nanostructure, it is possible to achieve the formation of new structures by affecting the macroscopic parameters (an example of this is the change in the composition of the system). It was determined that. During the mixing of oils in mines, transportation and collection by technological pipelines, as a result of their interaction with each other, various blockages occur in the pipes. In such cases, density, viscosity, freezing temperature, etc. Anomalous changes are observed in important parameters such as Therefore, during the mixing of oils, as a result of their interaction, their mixing in optimal concentrations allowed should be considered as a basic condition. For this reason, before the process of mixing oil and oil products in production, it is recommended to experimentally determine the rheophysical-chemical properties of mixed oils. according to the results of laboratory studies, the possibility of obtaining exact empirical formulas for mixing different oils was shown in the work. Also, it was determined that the basis of the complications arising as a result of mixing in the process of transportation of oils and petroleum agents depends on the quality bank rather than the rheological parameters, and a solution was shown.

The fourth chapter of the dissertation is devoted to the development of new technology and innovative methods for increasing the efficiency of transportation of high viscosity oils and their mixtures. The determination of the density of oil-condensate mixtures, taking into account the dilution, was modeled according to the experimental results. The density for the oil condensate mixture obeys the law of additivity, but this cannot be applied to the diluted oil condensate mixture, it is very difficult to determine the density of the dilution in mining conditions. Therefore, taking into account the degree of density dilution and the amount of condensate in the mixture, the three-dimensional dependence $\beta_s = f(\rho_{qar}, \beta_K)$ for the existing system was studied and empirical expressions were proposed with the help of mathematical analysis.

The calculated values of the density for the mixture according to the proposed expressions are more accurate than the results calculated according to the additivity rule and are consistent with the results obtained by the experimental method. In such a case, it is shown that the average permissible error limit set for the mixture does not exceed 0.2 %.

Also, based on the rheological properties of oils, the effect of various chemical reagents on the paraffin, tar and asphaltene hydrocarbons contained in them was studied. Initially, the effect of the SNPX-2005 reagent was checked on high-viscosity Neftchala, Shirvan, Garasu, Muradkhanli, Salyan, Sangachal oils, which have similar physicochemical parameters, the amount of resin and asphaltene hydrocarbons is high, and the amount of paraffin hydrocarbons is low. The studies were carried out by checking dynamic viscosities in a rotational viscometer (Reotest-2). It was determined that the SNPX-2005 reagent has a bad effect on the rheology of Muradkhanli and Sangachal oils and their mixtures in different proportions, and the application of this reagent to commodity oils is shown to be inadmissible.

In this work, the effect of nanostructured coordination polymer-based composites on the rheological properties of oils, obtained for the first time in the "Chemical sensors and reagents laboratory" of the scientific research institute "Geotechnological problems and chemistry of oil, gas and chemistry" of the Azerbaijan State University of Petroleum and Industry, was studied. The proposed reagents are nanostructured, porous and layered coordination polymers and are used as water-non-emulsifiers with self-construction and organization, which allows to reduce the kinematic viscosity of the hydrocarbon medium. For the experiments, 200 grams of BAF-1 and BAF-2 reagents were prepared in a 1 % solution of alkalized diesel fraction waste (SADFW). 1 gram of each of BAF-1 and BAF-2 coordination polymers was dissolved in 198 grams of SADFW. This solution was applied to reduce the viscosity of Muradkhanli mixed oils. Rheophysical and chemical characteristics of crude oil taken from Muradkhanli field are given in table 4.

Table 4

Rheophysical-chemical characteristics of Muradkhanli mixed oils (commodity).

Rheophysical-chemical indicators	Prices	Methods of analysis
Density, kg/m^3	876,7	ГОСТ 3900
Kinematic viscosity, mm^2/sec.	83,32	ГОСТ 33
Amount of resin, %	18,32	Chromatography
Amount of asphaltene, %	4,86	ГОСТ 11858
Amount of paraffin, %,	6,21	ГОСТ 11851
Saturated vapor pressure, kPa	23,4	ГОСТ 1756
Pour point temperature, °C	+9	ГОСТ 20287
Mechanical mixtures, %	0,0234	ГОСТ 6370
The amount of salts, mq/l	47,3	ГОСТ 21553
Amount of water, %	0,15	ГОСТТ 2477

It was found that (table 5) after adding 20 ml of 1 % composite to the oil sample, its kinematic viscosity decreases by 50,43 mm^2/sec. After the composite addition of 25, 30, 40 mm^2/sec, the value of kinematic viscosity gradually decreases to the value of 43,37 mm^2/sec, after which the formation of a new phase is observed. With the formation of a new phase, the kinematic viscosity of the oil sample gradually increases and rises to 51,42 mm^2/s after the addition of 50 ml of composite. After the separation of the intermediate phase by extraction, the kinematic viscosity of the oil sample suddenly drops to 31,36 mm^2/sec, i.e., the viscosity drops by 62,3 % after the addition of 50 ml of composite (Figure 6). In this case, the consumption of nanoreagent is 0,5 g (500 mg).

Table 5

Variation of oil viscosity depending on the amount of composite

The amount of the composite in the oil sample is ml	Kinematic viscosity of oil, mm^2/sec
-	83,32
5	78,91
10	72,18
20	50,43
25	48,69
30	45,22
40	43,37
45	46,21
50	51,42

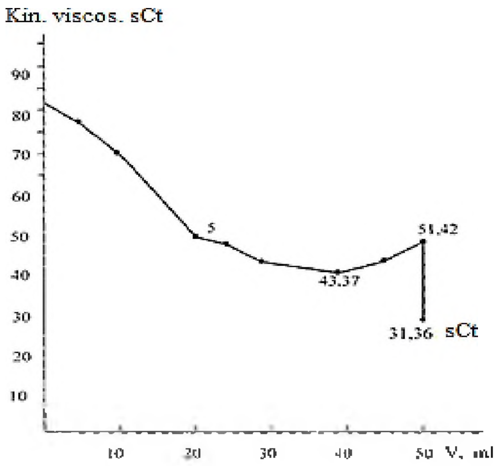
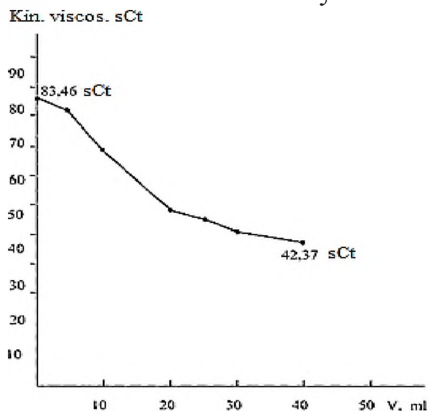
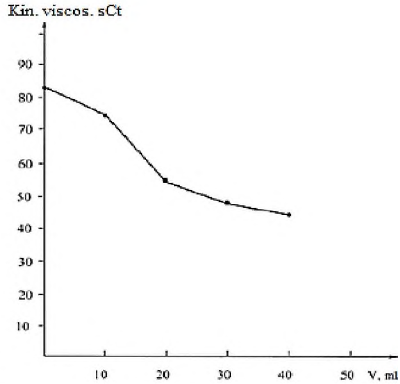


Figure 6. Viscosity graph as a function of the amount of composite

It was found that if after adding 40 ml (0.4 g of nanoreagent) composite to 100 ml of oil, the kinematic viscosity is 43.37 mm^2/sec, after adding the same amount of composite to 300 ml of oil, this value is 42.37 mm^2/sec (Fig. 7 (a)). In the latter case, a lower value of viscosity was determined by using 3 times less nanoreagent.

Sulfanol was chosen as a surfactant (CAS) because the partial replacement of SADFW with sulfanilic acid had a positive effect on the reduction of oil viscosity.



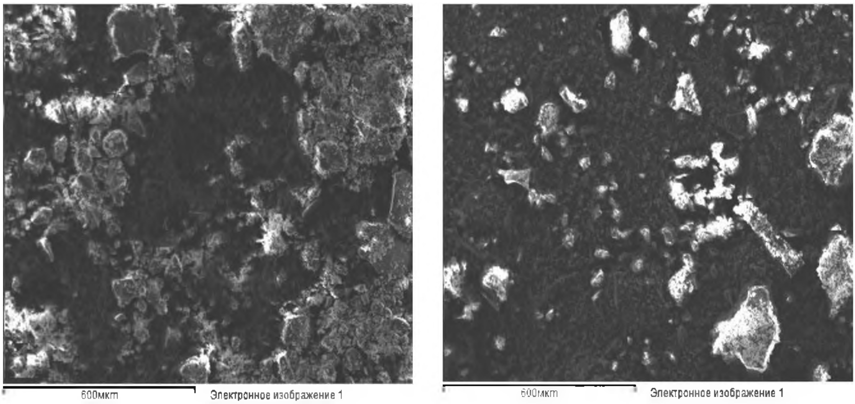


a) b)

Figure 7. a) Dependence of the kinematic viscosity of oil on the amount of composite, b) graph of the dependence of kinematic viscosity of oil on the volume of the composite at 50 °C (content of the composite: 2 grams of nanoreagent, 198 grams of purified SADFW)

Here, as a result of choosing sulfanol as SAM, it was determined that the kinematic viscosity of the oil sample at 20 °C decreased to 40,99 mm^2/sec and no intermediate phase was formed (Figure-8 (b)). Also, the dependence of the kinematic viscosity on the temperature was studied in the work, and the curves of the dependence of the kinematic viscosity on the amount of compact at a temperature of 50 ^{0}C were given. It was found that BAF-1 and BAF-2 composites reduce the kinematic viscosity of the mixed oil of the high-viscosity Muradkhanli field by approximately 51 %. It was determined that the most effective method for introducing the reagent into the oil pipeline system is the method of creating a cavitation process with a hydrodynamic cavitation.

Here, dry residues (tar) taken from oil samples were subjected to electron microscopic and X-ray studies. Electron microscope images and radiographs are shown in figure-8 and figure-9, respectively. The result obtained for the dry residue of oil without reagents of the electron microscopic study showed that asphaltene, resin and paraffin associates in the dry residue were collected in mass in the oil. In the dry residue of the reagent-treated oil, these associations are completely decomposed (figure-8 (b)). This also shows that the applied reagent improves the rheological properties of oil by directly influencing the structure of the associates. The change in the structure of the associates is also evident from the radiograph, so that the maxima observed between 5-400 angles in the dry residue of unreacted oil (fig. 9), the 2nd maximum completely disappears in the radiograph of the dry residue of reagent-injected oil, and the 1st



a) b)

Figure 8. Electron microscope images of dry residues of oil samples without reagent (a) and reagent injected (b) (well 1573)

maximum is replaced by a small varies in the direction of the angle. It is clear that a part of this association has completely collapsed, and a part has changed its structure.

Thus, the results of experimental studies have shown that the basis of the improvement of the rheological properties of oil under the influence of the reagent is the change in the structure of associates, which directly causes the deterioration of the rheological properties of oil. The fact that this completely coincides with the "structure-property" principle confirms the correctness of the new scientific approach once again.

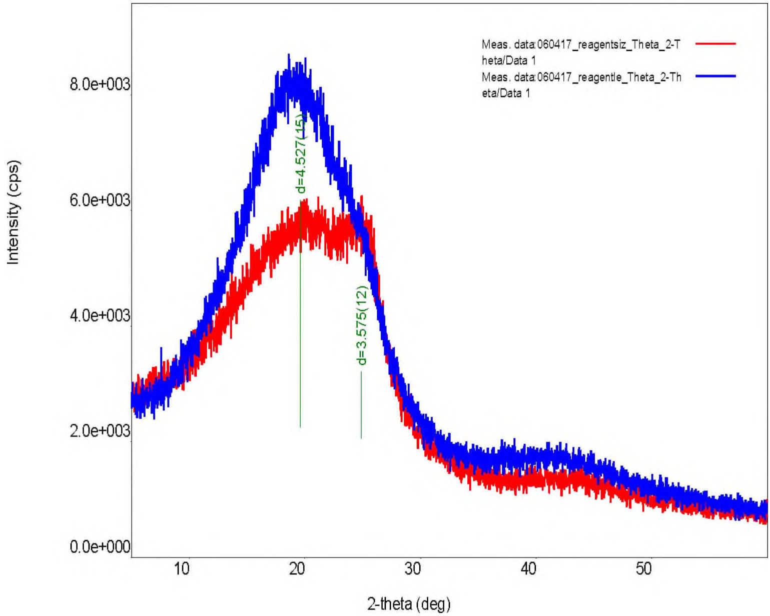


Figure 9. Comparison of radiographs of dry residues (tar fractions) of unreacted and reagent-injected oils

The best way to introduce the reagent into the system is cavitation with a hydrodynamic cavitator, which requires the optimization of the cavitation process, that is, the required length of the diffuser is calculated and a control valve with parameters (speed and pressure) close to the initial parameters is installed there. The proposed method is reflected in the work, and the general technological scheme of the hydrodynamic cavitator for injecting the reagent into the system in pipelines is shown. In order to ensure complete safety of the regime and to avoid repeated cavitation events, a locking device is included in the system. The solid (composite) system is fed through a nozzle with a plunger pump-doser. The results of the experiments have shown that the viscosity of oil decreases significantly when using this method compared to the usual method. It has been shown that these reagents can be successfully used in oil production to increase the oil production coefficient of the layers, the oil yield of the wells, to increase the efficiency of their transportation by lowering the viscosity of the oils, and to wash the conventional cavitation zones formed inside the bottom sediments and pipelines.

It has been determined that all of these are fed from the same source, that is, their composition and the causes of their formation are the same.

It was also determined that the reagent has an effect on heavy oil products, heavy oil (commodity), reducing the viscosity of crude oil, as well as increasing oil quality indicators (mainly viscosity) from refineries and oil storage facilities by affecting oil in mining conditions, increasing their production.

The results showed that the proposed reagent can be successfully applied in the cleaning of sludge formed in oil and oil products tanks, it is ecologically safe and economically very efficient.

During long-term operation, sediment accumulates at the bottom of the tanks, which reduces the useful volume and complicates the operation of the tanks. Sediment is unevenly distributed over the area, its greatest height occurs in areas outside the intake-distribution branch pipes, which does not allow accurate measurement of the actual amount of oil in the tank.

Over time, the sediment becomes denser and in separate zones it is either difficult to wash away or not washed away at all.

To ensure the useful operation of tanks, it is necessary to periodically clean them of accumulated sediment. Cleaning of tanks with the help of chemical-mechanical methods using solutions of detergents is one of the widespread cleaning methods. Here, the use of manual labor to a certain extent makes it possible to increase the intensity and quality of the cleaning process. The main drawback of this technology is the use of a special reagent, which limits its practical application, and the process of cleaning detergents from oil residues. In addition, the method of using oil as a detergent for cleaning tanks is also known.

It has been known that the danger of explosion and fire of the cleaned tanks depends on the properties of the detergent, its solution, as well as the properties of the oil residues that significantly change the composition of the gas environment by becoming active during the cleaning process, which can lead to dangerous concentrations of gases released into the atmosphere. The main drawback that limits the practical application of this technology is that the oil used as a detergent evaporates in the air during the cleaning process and forms a dangerous solid, which can cause an explosion and a fire hazard in the tank being cleaned. On the other hand, in order to minimize the risk of fire and explosion, it is necessary to ensure the saturation of hydrocarbons at the upper limit of safety and to eliminate the violation of solidity due to air absorption, which leads to the consumption of additional electricity and the use of additional equipment.

Currently, steam washing of tanks and cleaning of the tank area by applying internal ventilation, as well as removal of solid sediment (oil sludge) are used. In recent years, large volume tanks with floating lids have been widely used in Azerbaijan. The diameter of the tanks is over 40 meters, and the height is located at the bottom of the support column during cleaning, and the distance between the bottom and the roof is 1000-1500 mm. A large number of the following structures are located in the space between the cover and the bottom: support beams, a system for removing atmospheric precipitation from the cover, a system for reporting precipitation falling on oil, a heating system and other equipment. All these make cleaning the tank difficult. One of the options for solving the problem of cleaning tanks from sediment is to prevent their sedimentation as an effective method.

The most rational of the current methods applied to combat the accumulation of deposits in tanks is the hydraulic washing system. The system consists of a group of spray nozzles. Through these nozzles, the oil slurry collects at the bottom of the tank and washes the sediment, and then the suspended sediment particles are removed from the tank together with the oil. This system eliminates the difficult task of periodic cleaning of tanks, prevents sedimentation and accumulation of valuable fuel oil, increases the useful volume of the tank and prevents environmental pollution.

A compact flow system created by slow-rotating nozzles can also be applied in combination with the top circular nozzle system, which can ensure highly efficient mixing of sediment with oil. The lack of such systems is as follows: 1) As the service life increases, the coating of the pipelines breaks down, the moving parts of the nozzles are seized, and the effectiveness of washing bottom sediments decreases. 2) Accumulation of bottom sediments is related not only to the efficiency of mixing, but also to the concentrations of resins, asphaltenes and mechanical mixtures mainly contained in the oil. It is known that mechanical mixtures are mainly collected in resins and asphaltenes. Therefore, over time, the specific gravity of resins and asphaltenes exceeds the specific gravity of oil, and as a result, sedimentation occurs. Agitation prevents the accumulation of temporary sediments. This is also dangerous from the point of view that the sediment hangers pumped from the tank together with oil fall into the pipeline and settle there in a stationary state, which impairs the efficiency of the pipeline. 3) In order to ensure the long-term and accident-free operation of the stationary hydraulic system of washing, it is shown in the work that it is important to find the optimal conditions of their operation.

In this work, in order to minimize the above-mentioned deficiencies related to tank cleaning, the efficiency of washing and removal of bottom sediments from vertical tanks storing oil and (or) petroleum products (ГОСТ Р 52910-2008) using composite based on nanostructured coordination polymers was developed.

To solve the problem posed by us, a method for washing and removing bottom sediments from vertical tanks storing oil and (or) oil products (ГОСТ Р 52910-2008) using a composite made on the basis of nanostructured coordination polymers containing BAF-1 and BAF-2 was proposed.

A 1 % Polymer - ADFW - SAS composite is prepared from these coordination polymers (ADFW - alkalized diesel fraction waste; SAS - surface-active substance). 5 g of a mixture of naphthenic acids and 1 drop of sulfanol were taken per 100 g of composite as SAS.

Washing and removal of bottom sediments is carried out after the tank is decommissioned.

The proposed method is implemented according to the following procedure; a certain amount is given to the composite jaw. For 15-20 minutes, the composite solution is collected at the bottom of the tank. When the composite solution passes through the bottom sediment, the reagent remains in the sediment. At this time, the viscosity of the sediment decreases by approximately 3 times, and the mechanical mixtures are washed with ADFW and SAS and move to the bottom of the tank. Thus, the specific gravity of the sediment decreases, and the specific gravity of the ADFW - SAS mixture increases, and the surface tension coefficient of the system decreases to a minimum due to the SAS. As a result, the sediment breaks off from the bottom of the tank and rises on top of the ADFW - SAS emulsion.

At this time, since the pH of the environment is alkaline, a stable resin-water emulsion is formed. Then the precipitate is treated with 1% hydrochloric acid solution. In this case, due to the formation of a weakly basic environment, the precipitate easily separates from the ADFW - SAS emulsion.

Sediment removal from the tank is carried out with a cleaning pump to the technological level possible. Removal of sediment from the tank is more effective if it is done by stirring. For better washing of bottom sediments, when the sediment level in the tank is up to 0.1 m, washing should be carried out for 2-2.5 hours, depending on its volume.

If the sediment level in the tank is up to 0.5 m, this process should be carried out in 6-8 hours, depending on the volume of the tank. When the sediment level in the tank is up to 1 m, depending on the volume of the tank, the washing process is carried out for a maximum of 10-12 hours. When the sediment level in the tank is higher than 1 m, this process lasts 12-16 hours depending on the volume of the tank. Analyzes of sediment samples taken from tanks have shown that they differ greatly in their composition. In the study, the composite solution is fed through a tank washing system, the bottom sediment is suspended and removed from the tank by a cleaning pump.

In the work, the physico-chemical study of the cavitation zones formed by salt deposits, the development of the technology for their physical-mechanical cleaning, and the issue of re-operation of the pipes were also considered.

It has been known that highly mineralized reservoir waters extracted together with oil contain a large amount of various salts. These salts settle on the walls of the pump-compressor tubes (PCT) during the operation of the wells, reducing their inner diameter and ultimately causing a decrease in the level of oil production.

Such salt deposits are regularly formed in pipelines used in oil extraction. This causes the internal diameters of the pipes to completely decrease, cavitation zones to form, oil production to drop sharply, and accidents to occur. In the research work, samples of salt deposits formed on the surface of the inner walls of the pipeline were taken and their elemental composition was determined by the method of elemental analysis. The results of the X-ray phase analysis showed that the composition of the salt deposit mainly consists of $CaCO_3$ and $MgCO_3$. From the thermographic analysis of the salt sample, it was found that after the water of crystallization is removed from the contents of the salts at 200 0C, the degree of crystallinity of the salt decreases and the adhesion forces weaken. Starting from 500 ^{0}C, the process of gradual disintegration of the crystal lattice is underway. For this reason, the thermal treatment of salt deposits is considered suitable for the purpose.

The fifth chapter of the dissertation is dedicated to the perspective of the application of cavitation technologies during the transportation of oil and oil products. When studying the effect of the cavitation process on oil, it was found that taking into account their physical and chemical properties is one of the main conditions. Conducted studies have shown that the cavitation process in oils mainly depends on the proportion of hydrocarbons that make it up. To explain this experimentally, the effect of organic solvents on oils in the hydrodynamic cavitation environment was studied. Experiments, Moscow State University of Environmental Engineers professor M.A. Based on Yershov's scientific research, it was carried out on Azerbaijani oils. For this purpose, a cylindrical cavitator (truncated cone) is placed in the pipeline. The working area of the pipe is designed to achieve high velocities where the pressure drops to the saturated vapor pressure. The general technological scheme of the device is given in the work. As is known, oil is composed of low and high molecular weight organic and inorganic compounds. In oil, organic and inorganic compounds exist in the form of molecules or associates. The most common inorganic or heteroatomic compounds in oil are manifested in resin-asphaltenic compounds. These compounds have the ability to influence technological parameters in oil extraction, oil transportation and processing processes.

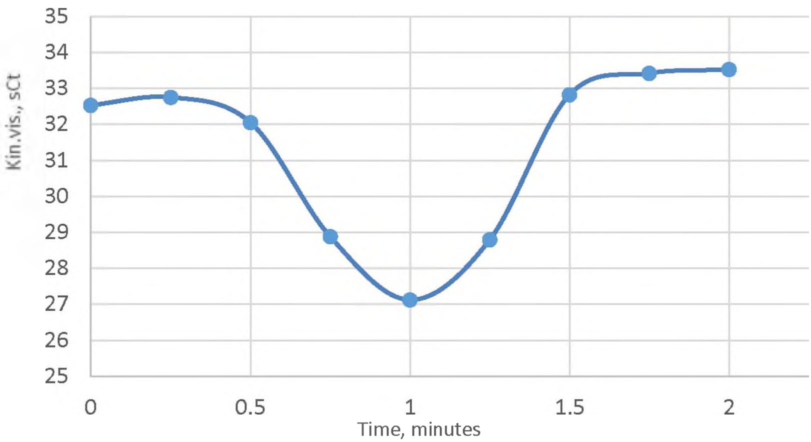
The possibility of improving the transportation of high-viscosity oils by affecting their rheological parameters by dispersing resin-asphaltene associations in oils has been shown.As oil samples, Azerbaijan's paraffinic, Shikhbagi, Bulla-deniz, and resin-asphaltenic Shirvan, Muradkhanli oil samples, which differ from each other in terms of their physical and chemical properties and composition, were used (table 6). It was determined that the kinema-tic viscosity of oils in the cavitation process is dependent on time (figure 10). Further studies were carried out in the presence of diffe-rent solvents. Thus, experiments were repeated by adding 2 % solvent to Shikhabagi, Bulla-deniz, Shirvan oil samples and reagent to Muradkhanli oil.

Table 6

Rheophysical-chemical properties of the studied oils

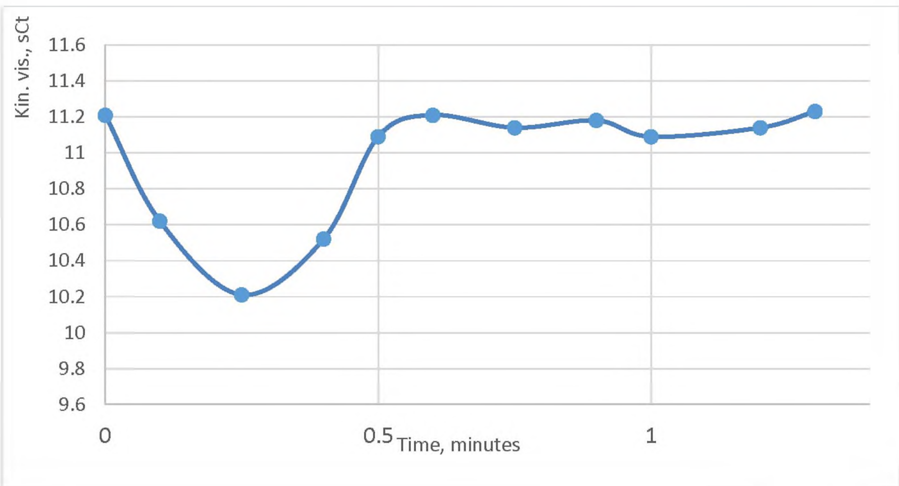
The name of the oils	Kinematic viscosity 20 °C, sCt	Quantity, mass in %		
		parafin	resin	asphaltene
Shykhbagi	32,53	12,9	15,58	2,69
Bulla-sea	11,21	9,7	5,32	0,28
Shirvan	79,86	3,88	13,27	6,24
Muradkhanli	83,42	6,21	18,32	4,86

Addition of solvent and reagent in the cavitation process changed the molecular motion of dispersed systems of oils, reduced viscosity and stability of dispersed particles. In this study, a grapho-analytical method was developed to determine free flow areas in oil pipelines in a steady state, and the possibility of cavitation in these areas was confirmed by physico-chemical methods.



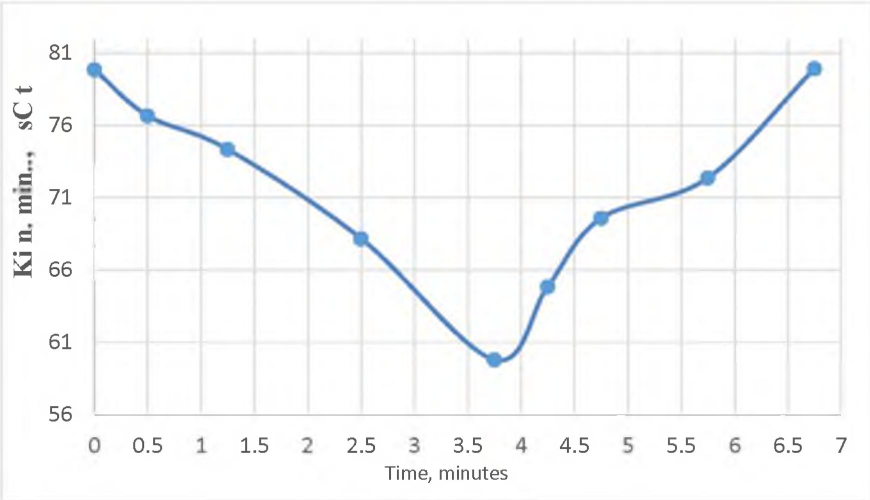
Kin.vis., sCt
35
34
33
32
31
30
29
28
27
26
25
0
0.5
1
1.5
2
Time, minutes

a)



Kin. vis., sCt
11.6
11.4
11.2
11
10.8
10.6
10.4
10.2
10
9.8
9.6
0
0.5
Time, minutes
1

b)



c)

Figure 10. Variation of kinematic viscosity of a) Shikhbagi, b) Bulla-deniz, c) Shirvan oils in the cavitation process as a function of time

It was observed that the creation of overflow or free flow zones changes the pipeline's working mode, stops the work of any pumping station, and changes the rheological and physico-chemical properties of the transported oil.

To determine the presence of an overflow zone, the hydraulic slope should be calculated and plotted (figure 11). From the end point of the belt (K) until it intersects the profile, the line of hydraulic inclination (i) is passed. The point of contact (D) with the profile of the line (3) which is parallel to that line and does not intersect the profile anywhere will be the crossing point.

If additional pressure (P_s) occurs at the end of the belt, then 2 lines are drawn from the point K′, which corresponds to the pressure height $H_s = Z_s + \frac{P_s}{\rho g}$ until it intersects the profile of the belt. In this case, the line that does not cut the profile (3) will determine that point D is the transition point. In order not to have an extreme point

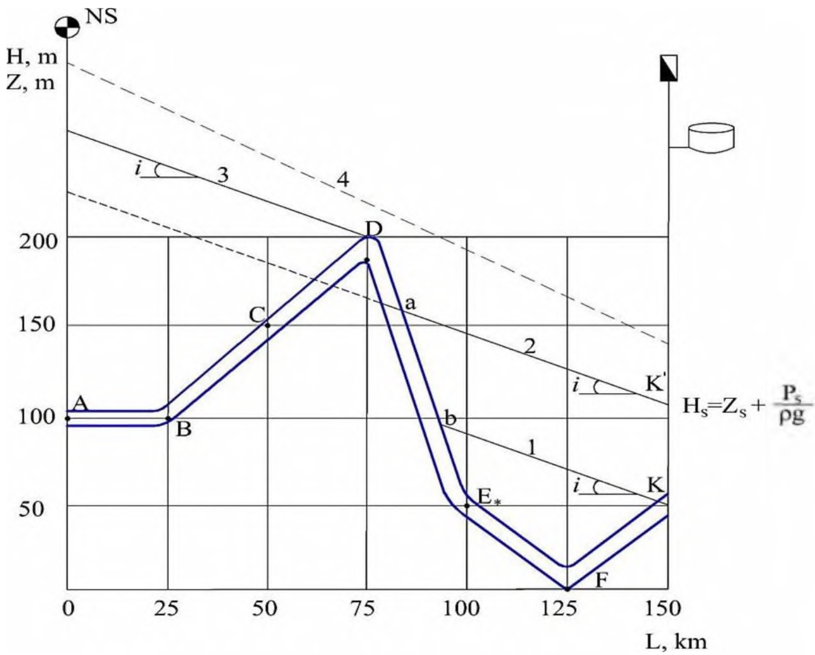


Figure 11. Determination of the free flow zone in the compacted profile of the conventional pipeline

(no free-flow areas), the hydraulic slope line (3) should not cut or touch the profile at any point (dashed line 4). In all cases where an extreme point exists, free (unstressed) flow fields will develop starting from that point (or points).

The beginning of the free flow areas will be the corresponding crossing points, and the end will be the corresponding intersection point of the hydraulic slope line drawn from the end of the belt with the profile. For example, in Figure 10, points a and b, corresponding to hydraulic slope lines 1 and 2, indicate the endpoints of the resulting free flow fields. In order not to create voids, the piezometric pressure (height – H) at any point of the oil pipeline should not be less than the geodetic height (Z), taking into account the vacuumometric height (h_v):

$$H > Z + h_v\,, h_v = \frac{P_{v.e}}{\rho g}$$

here, $P_{v.e.}$ is the oil vapor elasticity pressure, Pa. Although the consumption of oil in the free-flow areas of the pipeline is the same in the steady-state operation, the flow rates are different. Since the speed in the pressurized movement zone is lower than the speed in the free flow zone, according to the law of discontinuity (constancy of consumption), the movement of liquid in the latter zones will not occur along the full cross-section of the pipe, that is, in free flow areas, the cross-sectional area of the pipe filled with liquid will be smaller than the full cross-section of the pipe. The filling factor of the free flow areas is determined based on the consumption module corresponding to the diameter of the pipeline. The change of consumption module according to the given diameter according to different filling coefficients was explained in detail and as a result of the conducted research works, approximation-empirical formulas were proposed to determine the degree of filling of free flow areas.

Based on the hydraulic slope line and the pressure balance in the established movement mode on the example of a conventional oil pipeline, depending on the terrain, the location, volume and cavitation process of the cavitation process in the pipeline were determined. In this work, the possibility of cavitation flows in the free flow areas of oil pipelines has been proven by physico-chemical methods (table 10). During the cavitation process, molecular microcracking and ionization of oil components take place. The progress of microcracking and ionization process was determined according to GOST-2070-82, based on the change of iodine number and bromine number according to international ASTM D 11599 standards. As can be seen from Table 7, the quality indicators of oil change during the cavitation process.

During the transportation of oil, the formation of zones called out-of-state cavitation zones in some areas of pipelines has been found to cause changes in the rheological properties of oil in a positive direction. In addition to the positive aspects of the creation of such zones, there are also negative aspects, for example, even if the creation of such zones is under technical control, since it is impossible to regulate it, the consequences caused by it are very severe and their elimination is very expensive. The losses caused by it are measured in millions and resulted in accidents.

Table 7

Analysis of physical and chemical properties of low-paraffin Azerbaijani oils at the transition boundaries of cavitation

Taken for oil names of analyses.	Results prior to cavitation probable zone	Results after cavitation probable zone	Test conducted methods
Density, (20°C) kg/m^3.	863,4	862,2	GOST 3900
Saturated vapor pressure, kPa.	31,6	34,7	GOST 1756
The amount of water in % mass.	0,24	0,24	GOST 2477
Freeze temperature °C	-24	-27	GOST 20287
The amount of chlorine salts in % by mass.	0,0068	0,0068	GOST 21534
Paraffins in % by mass.	4,21	3,53	GOST 11851
Kinematic viscosity (20°C), mm^2/sec.	15,8	13,6	GOST 33
Mechanical mixtures in % by mass.	0,0096	0,0096	GOST 6370
Sulfur content in mass %.	0,213	0,213	GOST 1437
Distillation:	68	59	
Boiling point °C	5.0	6.5	
100 °C volume in %	9.5	11.0	
120 °C volume in %	15.0	17.5	
150 °C volume in %	18.5	20.0	
160 °C volume in %	22.0	24.5	
180 °C volume in %	25.5	27.0	
200 °C volume in %	28.5	30.0	GOST 2177
220 °C volume in %	33.0	34.5	
240 °C volume in %	37.5	39.0	
260 °C volume in %	43.0	44.5	
280 °C volume in %	47.5	49.0	
300 °C volume in %	52.0	53.5	

Continuation Table 7

Analysis of physical and chemical properties of low-paraffin Azerbaijani oils at the transition boundaries of cavitation

Taken for oil names of analyses.	Results prior to cavitation probable zone	Results after cavitation probable zone	Test conducted methods
320 °C volume in %	54.5	55.5	
340 °C volume in %	59.5	63.0	
350 °C volume in %			
B.p.68-350°C frac. iod number, 100 g. frak. - the amount of iodine in grams	0.9	1.7	GOST 2070-82

Here, along with the negative aspects of cavitation, its positive aspects were verified by rheophysical-chemical analyzes in various oil and fuel oil samples. The work also showed the possibility of resin-asphalten-paraffin sediments (RAPS) settling in oil pipelines and creating out-of-state cavitation zones (Figure 12).

Figure 12. Out-of-state receipt zone created by the RAPS formed in oil pipelines

In order to confirm the occurrence of the process, rheophysical-chemical analyzes of oil mixtures were carried out before and after the places where cavitation zones are supposed to exist at different times, and their results are given in table 8. It has been found that the change of the oil quality bank in the probable cavitation zones and the parameters of the area formed by the RAPS lead to the microcracking process in the flowing oils and the destruction of the hydrocarbons that make up the oil.

Due to the increase in the amount of unsaturated hydrocarbons in the oil, the change in the bromine or iodine number of fractions of distilled oil boiling up to 350 ^{0}C, the possibility of cavitation in such zones has been shown.

It has been determined that one of the main reasons for the formation of cavitation zone in pipelines is the direction of heat conduction on the surface of the pipe.

This type of deposition is caused by the formation of a number of conditions: the effect of high molecular compounds in oils, especially hydrocarbons of the methane series; the temperature of the flow drops to the point where the solid phase separates; with a decrease in temperature, hydrocarbons crystallize and firmly adhere to each other, settle on the pipe surface and disrupt the technological regime of the flow.

The results of our research have shown that the amount of paraffin has nothing to do with the intensity of precipitation. The uncertainty of such relations does not depend entirely on the ratio of high molecular hydrocarbons, solid paraffins, aromatic hydrocarbons to naphthenic hydrocarbons in the oil.

Our research proves that the uncertainty of the relationship can be determined by the characteristics of paraffin formation, which is formed by solid hydrocarbons in oil. The more branched aromatics, naphthenes and isoalkanes, the stronger the stability of the associations formed by paraffins, because these types of compounds have the ability to retain crystalline substances high in the liquid mass. The methane series hydrocarbons make it easier to dissolve the solid-form RAPS formed by the high molecular weight paraffins.

Studies have shown that although the soft and semi-liquid RAPS generated during pipeline operation is easy to clean, the solid PAS produced by normal alkanes requires special methods for cleaning, which requires a large amount of resources. It was found that during the transportation of Azeri Laight oils (200 m^3/h) in main pipelines, the formation of RAPS begins to be felt after 200 days. This period can change with the decrease in the density of solid particles.

Table 8

Results obtained before and after the presumed cavitation zone for oil mixtures

№	Names of analyzes carried out for oil	Results obtained before cavitation	Results obtained after cavitation Day 1	Results obtained after cavitation Day 5	Results obtained after cavitation on day 10
1	Density: 20 °C – da, kg/m³	863.2	862.6	862.2	861.8
2	Kinematic viscosity, cCt 0 °C-da 10 °C-da 20 °C-da 30 °C-da 40 °C-da 50 °C-da	 - - 78.55 42.26 31.75 24.52	 98.43 86.75 54.53 39.97 28.46 23.39	 95.86 85.78 54.14 38.75 26.17 22.98	 94.27 85.56 53.75 38.23 24.42 22.19
3	Saturated vapor pressure, kPa	24.3	26.1	27.5	28.6
4	Puor point temperature, °C	+3	0	0	-3
5	Asphaltene. Quant. mass in %	0.27	0.26	0.26	0.25
6	Paraffin, % by mass	6.59	6.12	5.94	5.43
7	For fraction boiling up to 360 °C, Iodine number, g/100g	2.6	2.9	3.1	3.2
8	Characterizing factor	11.26	11.38	11.52	11.84
9	Distilled (101.5 kPa), °C Qaynama başlanğıcı 10 % -distillation 15 % - distillation 20 % - distillation 25 % - distillation 30 % - distillation 35 % - distillation 40 % - distillation 45 % - distillation 50 % - distillation 55 % - distillation 60 % - distillation 65 % - distillation 70 % - distillation 75 % - distillation 80 % - distillation 85 % - distillation End of boiling	 61 158 164 172 189 198 215 243 287 325 352 369 371 375 378 381 383 385	 59 141 160 169 187 195 211 233 281 321 348 368 369 375 378 381 383 385	 57 138 158 165 182 193 209 231 278 319 344 366 368 374 378 381 383 385	 55 131 155 161 180 191 207 229 275 315 341 365 367 374 378 381 383 385

External influences on pipelines, earthquakes, landslides, hydrostatic pressure loads, temperature changes, loads caused by wind, water waves, the mass of pipes and covers, etc., cause the emergence of the "out-of-state" cavitation process caused by RAPS. has been determined. The internal effects are mainly related to the pressure created in the pipeline during the transportation of liquids and gases. It is possible to determine the cavitation zones formed in the main pipelines and draw certain conclusions according to the change of the physical and chemical properties of the oils.

Flow modeling of the cavitation process; The basis of the technological process of viscous liquids that do not mix with each other during turbulent flow depends on the tracking of the components that make them up. Turbulent flows are carried out by special devices and are affected by various complex thermodynamic parameters (temperature, pressure, etc.) depending on time. By adjusting these parameters, the cavitation process in the equipment can be controlled, and on the basis of this, it is possible to create conditions for obtaining high-quality products.

The most accurate method for mathematical modeling of hydrodynamic and cavitational flow of turbulent flow was performed using the Nave-Stokes (RANS - Reynolds-averaged Navier-Stokes) equation. During highly turbulent flows, the pressure drop causes cavitation bubbles to form and separations due to explosion, which leads to multiphase flow. The proposed cavitation model assumes the existence of two phases (liquid and gas), between which mass exchange occurs. In the cavitation model, the main flow is a mixture of liquid, gas and unstable gases. For the equation of motion, the effect of flow and turbulence is considered. Based on the experimental results in the research work, the proposed model was not justified, so the average value of the Reynolds number was determined according to the Nave-Stokes equation for the dimensions of the entire range of turbulent flow. Movement during turbulent flow is divided into two principal dimensions: large-scale turbulence, which characterizes the geometric dimensions and structure of the flow, but is not universally described, and the second is small-scale turbulence, which is in equilibrium and has a universal structure.

In the method of modeling large flows (LES-Large Eddy Simulation), the calculation of the structure of large-scale flows is carried out with the help of the integrated form of the Nave-Stokes equation. The difference in the sizes of small streams is not much larger than the sizes of the pores, and they have a universal nature and are modeled on the basis of approximate rationals. In order to avoid the deviation of small-sized pulsations, short-wave operator programs are used for turbulent flows.

It was found that the results of the system are not related to the equation, the results of small-scale turbulence are in a state of non-linear dependence with the model, therefore the obtained results are not justified in practice.

The most promising method for any flow is the one-time calculation (DNS - Direct Numeric Simulation) modeling method. In highly turbulent viscous oils, they have a large spectrum of flow turbulence - from large size to small size. The value of the characteristic time for small-scale turbulence is very small, this indicator of turbulence plays a key role in the turbulent flow of viscous oils.

A graphoanalytical method was proposed to determine the occurrence of "out-of-state" cavitation process in such zones formed by RAPS, and for their elimination, the application of chemically nanostructured coordination polymer-based composites was proposed for the first time.

It has been determined that currently it is impossible to model the cavitation process due to some technical reasons.

CONCLUSION

1. Taking into account the requirements imposed on refineries and exported commodity oils, depending on their classes, appearance, types and groups, in accordance with the technical conditions of AZS 115-2004, ГОСТ 51858-2002, analyzes of the component composition of different oils of Azerbaijan were carried out, and the

rheophysical-chemical problems arising during transportation were solved.

2. Taking into account the existence of errors between the results of the analyzes conducted according to ГОСТ and ASTM, it was shown the possibility of eliminating the shortcomings that may arise in orbiting issues by analyzing the quality of Azerbaijani oils according to ГОСТ Р ISO 5725-2-2002 standards.

3. Taking into account the deterioration of the rheological properties of oil with the decrease in temperature in the process of transportation by underwater pipeline in the sea, the technology of joint transportation of oil, condensate, and water mixture was developed to increase the efficiency of transportation, and for the first time, three parameters for the oil, condensate, and water mixture - density, dilution, and condensate three-dimensional dependence on the amount in the mixture was determined and an empirical formula was given.

4. In order to maintain the quality bank of the fuel during the continuous transport process, a buffer product with an average position composed of total hydrocarbons was proposed with the addition of up to 3% of A-76 gasoline fraction to TC-1 aviation kerosene.

5. Based on the results of rheophysical-chemical analyzes of compounds of different mixtures of TC-1 brand kerosene fraction and 50/70 brand bitumen, it was determined that using these mixtures as an appropriate fuel fraction, rather than reprocessing them, can give great economic results.

6. During the collection and transportation of oil mixtures, the rheophysical-chemical basis of the deposition of the macroscopic solid phase in the pipelines and the formation of obliteration zones formed by ARP sediments have been developed, and in the example of Azerbaijani oils, it is necessary to take into account the inadmissibility of applying the rule of additivity to mixtures and to conduct preliminary laboratory tests for obtaining rational mixtures shown as.

7. It has been determined that the problems arising from the mixing of oils and oil substances during transportation are more dependent

on the quality bank than on rheological parameters, and the main ways to solve them have been shown.

8. When determining the rheophysical-chemical properties of fuel oil, it was determined that under normal conditions, when the amount of water in fuel oil reaches 10-15 %, its viscosity increases by 2 times and becomes 10 % at 30-40 ^{0}C temperature, 15 % at 60-80 ^{0}C temperature. when liquefied, its viscosity is lower than the initial viscosity of fuel oil, which gives great efficiency during continuous transportation of fuel oil through pipelines.

9. The effect of SNPX-2005 additive on the rheological-chemical properties of the mixture of Muradkhanli, Garasu, Salyan, Shirvan, Neftchala, Gobustan, Petro-Hong Kong-Pirsaat oils was studied and it was determined that in order to improve the rheological parameters of any oil, the quality bank of that oil should be determined by appropriate standards. after it is done, it should be considered as an important condition to select additives according to the structures of the RAPS.

10. The effect of nanostructured coordination polymer-based Baf-1, Baf-2 reagents on the rheophysical-chemical properties of oils was studied on the example of Muradkhanli commodity oil and it was determined that the viscosity of the oil at room temperature decreases to 51% compared to the initial viscosity, which is due to its pipeline can ensure the efficiency of transportation.

11. In order to study the mechanism of effect of nanostructured coordination polymer-based BAF-1 and BAF-2 reagents on the rheophysical-chemical properties of oil, the dry residue fractions of oil (without reagent and with reagent) were studied by X-ray and electron microscopy, and the results of the research showed that these reagents they completely destroy the asphaltene-resin-paraffin associations that are in the oil and directly worsen the rheophysical-chemical properties of the oil. Considering this feature of the reagents, an effective method was developed for washing bottom sediments consisting mainly of asphaltene-resin-paraffin and "off-state" cavitation zones formed in transport pipelines using composite solutions based on them.

12. The rheophysical and chemical properties of Azerbaijan's paraffinic, Shikhbagi, Bulla-deniz and resin-asphaltenic Shirvan oils were analyzed by chemical solvents in a cavitation environment, and it was determined that solvents change the molecular movement of substances in groups in the dispersed systems of oil, lower their viscosity and the stability of dispersed particles.
13. A grapho-analytical method was proposed to determine the location and volume of the free flow zones arising from the Oil Pipeline Administration, Sumgait-Shirvanovka line in the determined movement modes and was used to determine the "off-state" cavitation zones.
14. By applying the cavitation process to oil and oil agents, their rheophysical-chemical properties were studied and it was determined that by applying the hydrodynamic cavitation process, it is possible to increase the efficiency of transportation by taking the frequency and time parameters as the main factors.

APPENDICES

Appendices include acts of application, protocol of experimental results conducted in an international laboratory, certificate of conformity issued by the national certification system of the Republic of Azerbaijan for the application of BAF-1, BAF-2 brand nanostructured coordination polymer-based chemical reagents, patent documents issued for inventions, results obtained during the analysis of oil and oil products. international certificates confirming its integrity have been presented.

THE MAIN CONTENTS AND RESULTS OF THE DISSERTATION ARE PUBLISHED IN THE FOLLOWING WORKS

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In the works carried out with co-authors, the personal work of the author:

[12, 15, 16, 18, 19, 20, 22, 33, 37, 38, 40, 41, 46, 61] - performed independently:

[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 17, 21] - Setting the issue, analyzing and compiling production and theoretical data:

[14, 23, 24, 25, 26, 27, 28, 29, 30, 31, 34, 35, 36, 39, 42, 43, 53, 54, 57, 58] - Collection of practical and theoretical data, analysis, research, preparation of conformity certificate and book.

[32, 44, 45, 47, 48, 49, 50, 51, 52, 55, 56, 59, 60, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71] - Setting the issue, analyzing and compiling production and theoretical data.

The defense will be held on 26 april, 2024 at 11:00 at the meeting of the Dissertation council ED 2.03 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Azerbaijan State Oil and Industry University.

Address: AZ1010, Baku, D. Aliyeva str., 227

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Electronic versions of dissertation and its abstract are available on the official website of the Azerbaijan State Oil and Industry University.

Abstract sent to 15 March 2024 the appropriate addresses.
(day) (month) (year)

Signed for print: 14.03.2024
Paper format: A5
Volume: 77387
Number of hard copies: 20