

Fluid Mechanics Department
SCIENTIFIC AND SCIENTIFIC-INSTITUTIONAL REPORT
for 2017

SUBJECT: Investigation of the influence of the boundary layer under the heterogeneous systems flow on nonstationary processes.

According to the research plan, during the reporting period, the department of "Fluid Mechanics" carried out studies of the influence of the boundary layer on the rheological parameters of non-Newtonian oils, the role of heat transfer in nonstationary processes, the study of discrepancies in the values of the initial shear stress and fluid viscosity under the action of external thermal source, the simulation of the gas evolution process during the fluid flow, study of the effect of electrokinetic processes on gas evolution in gas-liquids systems, the perturbations in bubbly liquids.

Work 1. Study of the boundary layer on the rheological parameters of non-Newtonian systems. Executors: Corresponding Member of Azerbaijan NAS, Dr. Geylani Panahov, Associate Professor Eldar Abbasov, PhD Sevinj Rasulova

The effect of the boundary layer on the rheological parameters of non-Newtonian oils was studied. The manifestation of these effects leads to changes in the rheological parameters of the oils and changes in the quantitative and qualitative parameters of the applied processes. The influence of the applied "open" area of the pipes on the rheological properties of non-Newtonian oils was studied. To assess the rheological parameters, pipes of different diameters were selected, with the criterion $1 / d > 100$ being observed and the effect of the "end" effects.

As a result of experiments, the identity of the effect of the boundary layer in the pipes on the rheological properties of oil at the reduced and constant temperatures was revealed.

Results obtained may provide determining condition for evaluating the rheological parameters of hydrocarbons during production and transportation (eg, the Baku-Ceyhan pipeline).

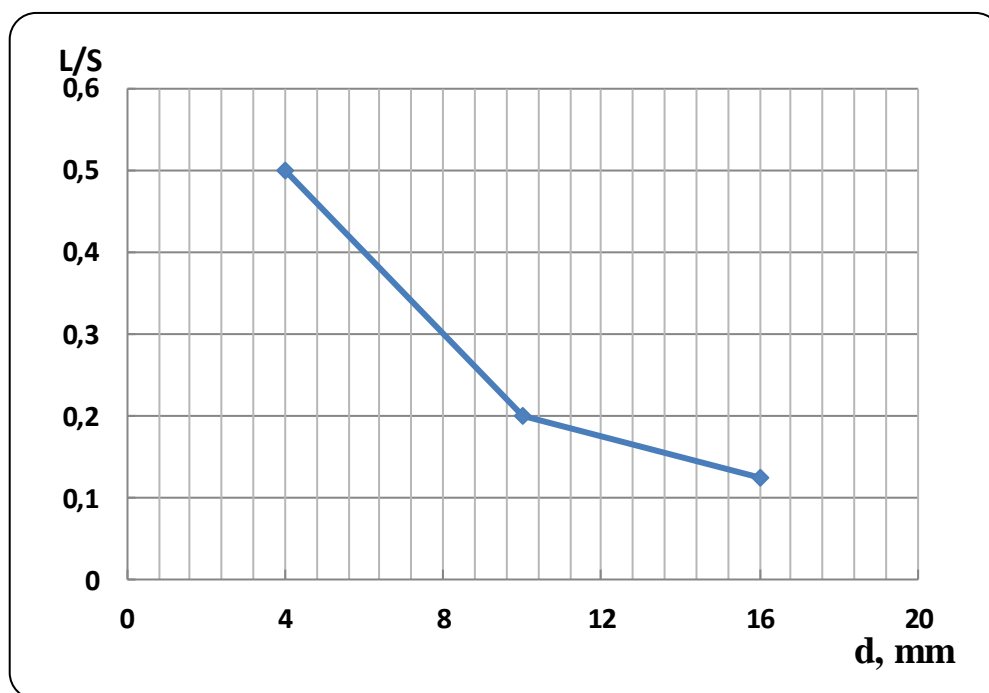


Fig. 1 Dependence of the reduced index L/S vs. pipe diameter

Articles published in the framework of research:

1. Панахов Г.М., Исмаилов Ш.З., Юзбашиева А.О., Расулова С.Р. Влияние пристенных эффектов на реологические параметры неньютоновских нефтей // Азербайджанское нефтяное хозяйство, №2, 2017. - С.45 – 49.

Work 2. Simulation of gas formation process during heterogeneous liquids flow. Executors: corresponding member of Azerbaijan NAS, Geylani Panakhov, PhD Gulshan Agaeva, PhD Afet Yuzbashieva.

The work is devoted to the study of the influence of temperature and structure-destroying additives on the rheological parameters of non-Newtonian systems.

In hydrocarbon systems containing resin-asphaltene components, thermal effects occur during the pipeline transportation. A number of experiments have shown that in the process of temperature effect on oils, change in rheological

characteristics largely depends on the heating rate. The effect of temperature under such conditions leads to a discrepancy in the change in the initial shear stress and viscosity of the liquid.

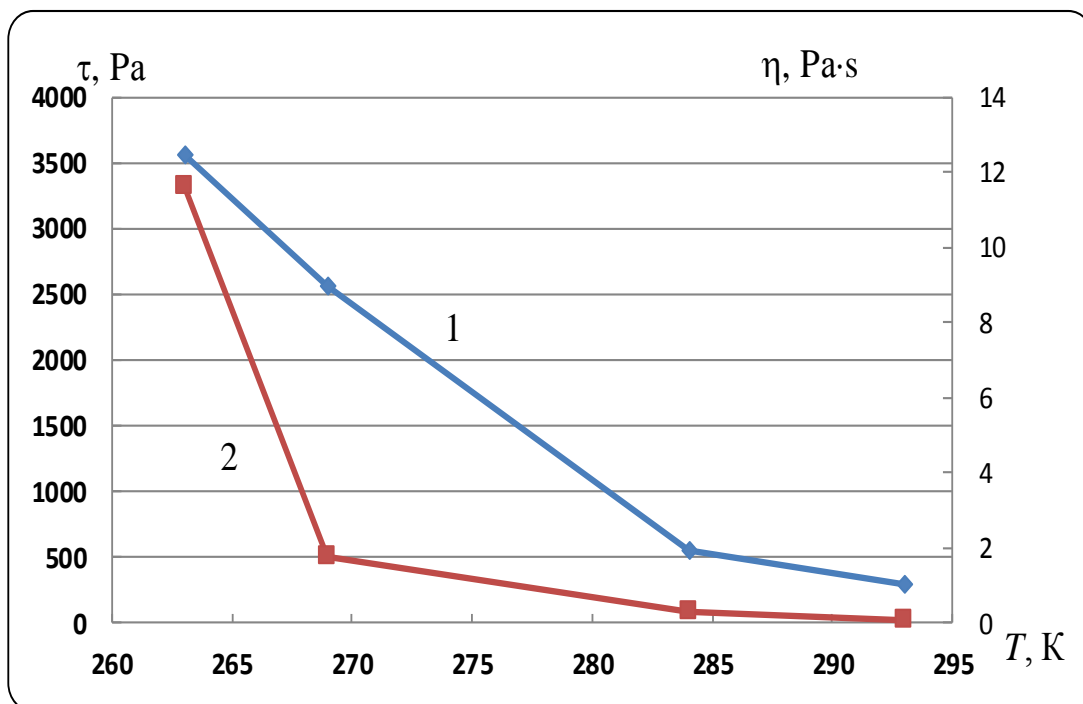


Fig. 2. Effect of temperature T on the initial shear stress and viscosity (diameter of the pipe $d = 4$ mm)

It was also determined that with the addition of structurally degrading polymeric additives to oil under different temperatures, a non-equilibrium change in rheological parameters.

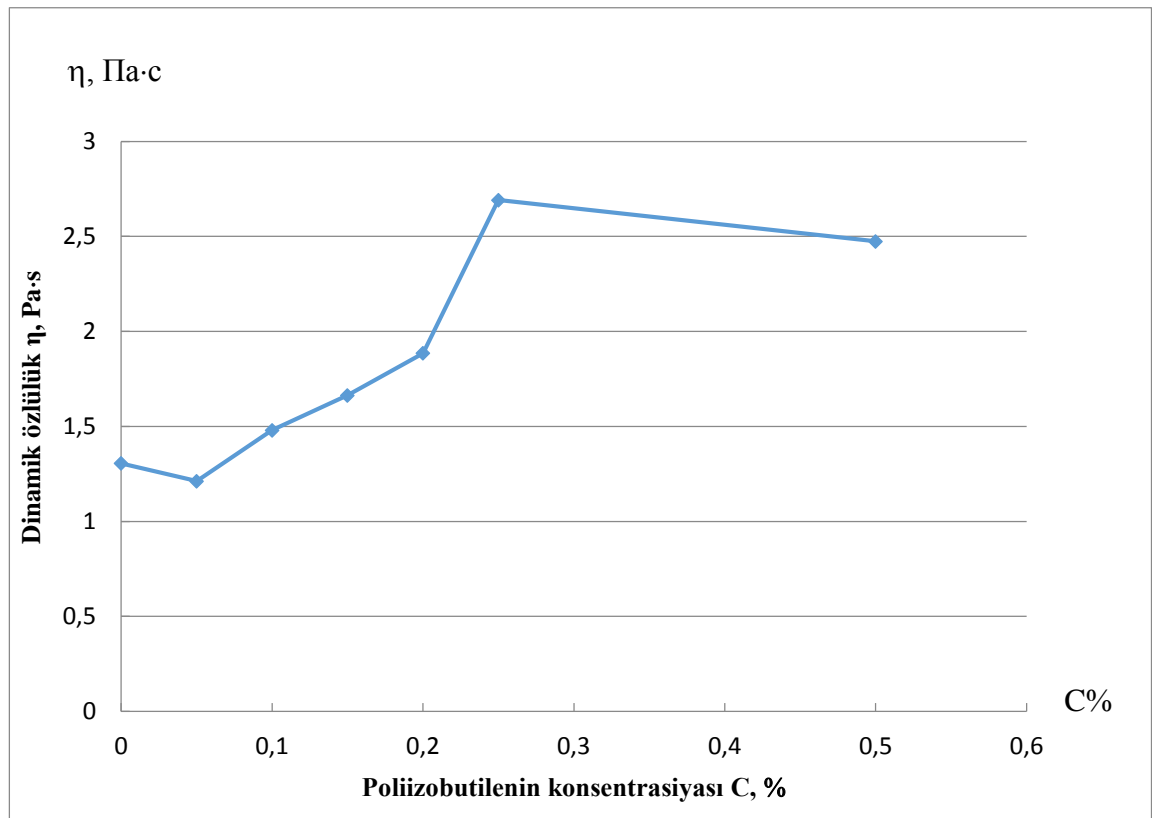


Fig. 3. The dependence of the dynamic viscosity η on the polyisobutylene concentration (C)

On the topic of the work two articles are published:

1. Панахов Г. М., Аббасов Э. М., Юзбашиева А.О., Расулова С. Р., Мусеибли П.Т. Тепловое и химическое воздействие на реофизические свойства неньютоновских нефтей // Азербайджанское нефтяное хозяйство, №5, 2017.

2. Gadjiev T., Aliev S., Panahov G., Abbasov E. Placement of wells as a method of oil field development control // Visnyk of the Lviv Univ. Series Mech. Math., 2016, Issue 82, pp. 94-97.

Work 3. Investigation of the of electrokinetic processes effect on gas formation under of gas-liquid systems flow. Executors: corresponding member of ANAS, Geylani Panahov KM, associate professor Dr. Eldar Abbasov, researcher Parviz Museibli.

The effect of the electrostatic potential on the formation dynamics and the expansion radius of gas bubbles in gas-liquid systems is investigated.

In general, this process is described by a system of equations:

$$\operatorname{div} v_1 = 0 \quad (1)$$

$$\rho \frac{dv}{dt} = -\operatorname{grad} P + j \times E \quad (2)$$

$$\rho c \left(\frac{\partial T_1}{\partial t} + (v_1 \nabla) T_1 \right) = -\operatorname{div} q_1 + \Phi + q_v \quad (3)$$

$$\frac{\partial \rho_2^0}{\partial t} + \operatorname{div}(\rho_2^0 v_2) = 0 \quad (4)$$

$$\rho_2^0 \left(\frac{\partial v_2}{\partial t} + (v_2 \nabla) v_2 \right) = -\operatorname{grad} P_2 \quad (5)$$

$$\rho_2^0 \frac{d}{dt} \left(u_2 + \frac{v_2^2}{2} \right) = -\operatorname{div} q_2 + \operatorname{div}(P_2 n v_2) \quad (6)$$

$$P_2 = \rho_2^0 R_2 T_2 \quad (7)$$

$$j = \sigma E, \quad q_v = j^2 / \sigma \quad (8)$$

taking into account the equation of motion (2) and condition of mechanical equilibrium, the dynamics of the development of gas bubbles takes the form:

$$a \frac{d^2 a}{dt^2} + \frac{3}{2} \left(\frac{da}{dt} \right)^2 + \frac{\sigma E^2}{\rho} a \frac{da}{dt} + 2 \frac{\Sigma}{a} = \frac{P_2 a(t) - P_\infty}{\rho}$$

here, Σ is the surface tension coefficient, P_∞ is the fluid pressure at infinity, and $a(t)$ is the bubble radius. In this equation, $P_2 a(t)$ and $a(t)$ are unknown quantities.

Having made certain transformations in the system of equations (1) - (8), one can determine the effect of the electric field strength E on the bubble radius, solving together a system of new equations with the equation of bubble dynamics. The bubble radius is estimated by solving the obtained system of equations by a numerical method.

The effect of electrokinetic processes on gas formation under the gas-liquid fluids flow is studied, which can be used in pipeline transport processes, chemical processes and hemodynamics.

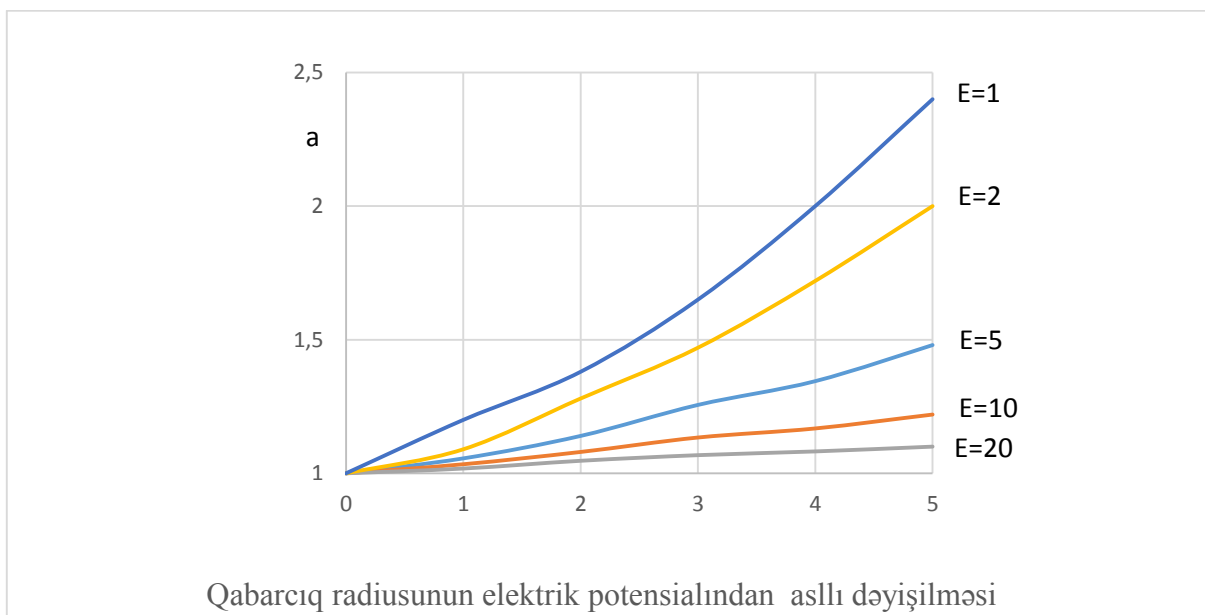


Fig. 4. Change in the radius of gas bubbles for different values of the electric potential in time

The following articles are published on the topic of the work:

1. Panahov G.M., Abbasov E.M., Guseynov V.G., Museibli P.T. Regulation of pipeline transport of heterogeneous systems in condition of uncertainty of initial parameters // XXIX International Conference "Problems of decision making under uncertainties", Ukraine, 2017, p. 97-98.
2. Panahov G.M., Museibli P.T. Influence of the electrostatic potential on the dynamic of gas evolution // Sumqayıt Dövlət Universitetinin yaradılmasının 55 illiyinə həsr edilmiş "Riyaziyyatın nəzəri və tətbiqi problemləri" Beynəlxəq Elmi Konfransın materialları, Sumqayıt Dövlət Universiteti, Sumqayıt, 2017, s.122.

Two works are prepared for printing.

SCIENTIFIC- INSTITUTIONAL REPORT

Employees of the department are Candidate of Technical Sciences, Associate Professor Eldar Abbasov, PhD Afet Yuzbashieva, PhD Sevinj Rasulova made reports on the results of the research at the weekly scientific seminars of the department.

The staff of the department presented 3 projects for grant supporting by the Science Development Foundation under the President of the Azerbaijan Republic:

1. Mathematical simulation of processes of environmental contamination by hydrocarbon products and development of ways of consequences elimination;
2. Theoretical and practical bases of influence of non-stationary effects on the pipelines functioning;
3. Investigation of the internal effect of gas evolution in binary systems and the construction of appropriate mathematical models.

Employees of the department participate in the contest of projects announced by the SOCAR Science Foundation with the aim of financing scientific research and innovative projects:

4. The project "Development of a new hydrodynamic method for optimizing of production of residual oil reserves" was presented.

During the reporting period, corresponding member of ANAS, Dr. Geilani Panahov and associate professor Eldar Abbasov prepared the next issue of the Journal of Transactions (Mechanics issue) of Azerbaijan NAS.

Corresponding member of ANAS, Dr. Geilani Panahov visited the Ufa State Oil Technical University (Ufa, Russia). During the meeting with the rector of the University prof. Ramil Bakhtizin and members of the Academic Council of the University discussed the prospects of scientific and technical cooperation in the development and implementation of new innovative technologies developed in the Department of "Fluid Mechanics" at the oil and gas fields of Bashkortostan, and a number of promising works were included in the plan for scientific research of the University at next year:

1. Development and application of an address method of influence on oil-saturated reservoirs with the aim of extracting residual hydrocarbon reserves;
2. Methods of intensification of oil production through the implementation of isolation and gas-generating treatments of the bottomhole zone of oil wells;

3. Development of technology for gas-dynamic desorption of natural gas through in-situ generation of carbon dioxide;

4. Development of technology for cleaning gas pipelines with composite viscoelastic compounds.

Corresponding member of ANAS, Dr. Geilani Panahov and associate professor Eldar Abbasov, in cooperation with the scientists of the Institute of Oil and Gas of the National Academy of Sciences of Azerbaijan, was the winner of the international ecological prize "EcoWorld", conducted under the auspices of the State Duma of the Russian Federation at the Russian Academy of Natural Sciences. The results of project studies on the theme "Prevention of evaporation, reduction burning and dispersing hydrocarbon gases from natural and man-made sources to reduce the greenhouse effect".

The competition is aimed at solving environmental problems, preserving biodiversity, environmental education and public awareness, restoring ecological balance.

During the reporting period, corresponding member of ANAS, Dr. Geilani Panahov supervised the work of the scientific seminar at the Specialized Dissertation Council of the Institute of Mathematics and Mechanics. He is a member of dissertational councils of IMM NAS of Azerbaijan and Azerbaijan State University of Oil and Industry.

Corresponding member of ANAS, Dr. Geilani Panahov is chairman of the State Examination Commission at the Department of Theoretical Mechanics and Continuum Mechanics at the Baku State University and a professor at the same department.

Corresponding member of ANAS, Dr. Geilani Panahov is a member of the editorial board of the journals "Azerbaijan Oil Industry" and "Oil and Gas Business".

Corresponding member of ANAS, Dr. Geilani Panahov is a member of the Scientific Council of the Institute of Oil and Gas of ANAS.

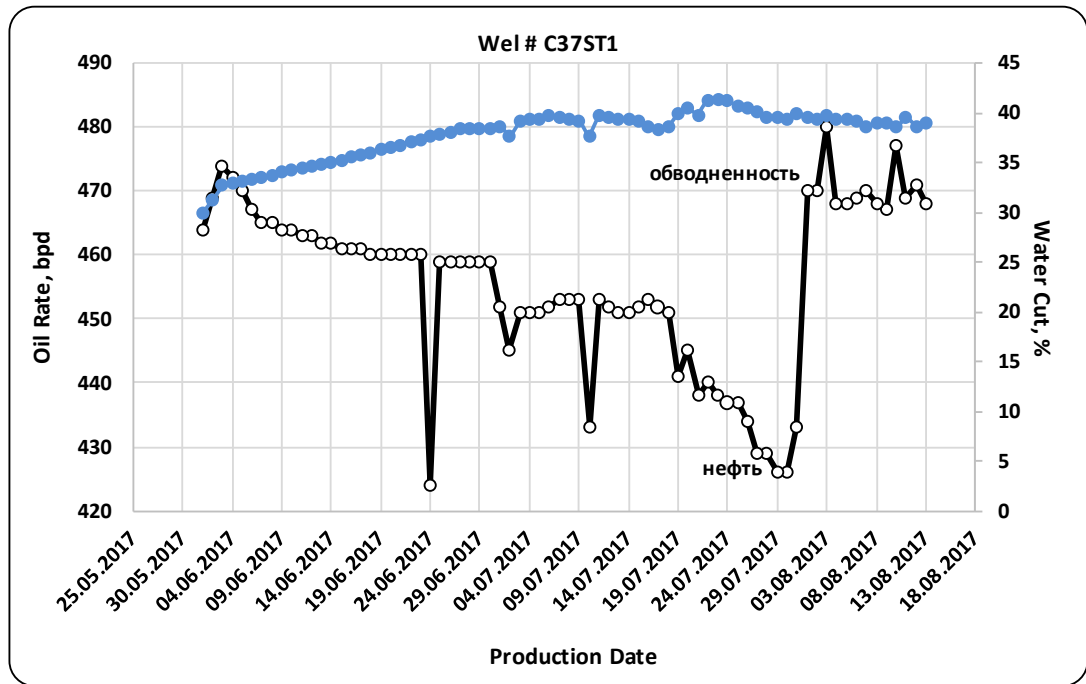
Associate Professor Eldar Abbasov is a member of scientific seminars at the Specialized Councils D2.02.141 in the Azerbaijan State University of Oil and Industry and D 01.081 at the Institute of Geology and Geophysics.

During the reporting period, PhD Afet Yuzbashieva taught at the Department of Applied Mathematics and Informatics at the Baku State University.

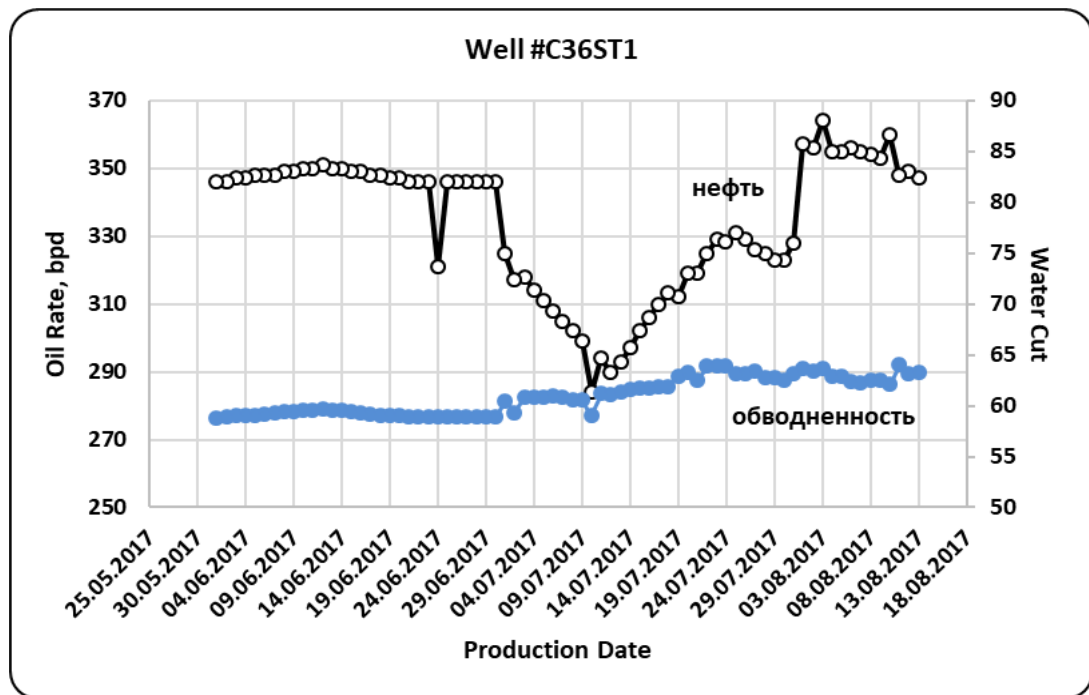
APPLIED RESEARCH

In June, 2017 the staff of the department, corresponding member of ANAS, Dr. Geilani Panahov and the leading researcher Eldar Abbasov visited Beijing and Tianjin cities at the invitation of the Chinese company “New Horizon”, discussed technologies related to enhanced oil recovery. Within the framework of the visit, the sides discussed the directions of cooperation between IMM and Chinese companies, implementation of innovative developments of the department at Chinese fields and geophysical software created by Chinese companies at oil refineries in Azerbaijan.

In July, 2017 corresponding member of ANAS, Dr. Geilani Panahov and leading researcher Eldar Abbasov participated in the commercialization of technology on the offshore field Bohai Bay of the oil company CNOOC (Petrochina). Within 10 days, a fishing operation was carried out to generate carbon dioxide CO₂ and create a gas-liquid rim to displace oil in difficult marine conditions. As a result of the application of the technology, 3,700 tons of oil from the surrounding production wells was additionally mined.



a)



b)

Fig. 5. Indicators of exploitation of production wells C08 (a) and C37 (b) before and after the implementation of the bed stimulation technology

During the reporting period, the department staff published 5 articles and 3 theses of the conference, 2 articles were accepted for publication.

1. Панахов Г.М., Исмаилов Ш.З., Юзбашиева А.О., Расулова С.Р. Влияние пристенных эффектов на реологические параметры неньютоновских нефтей // Азербайджанское нефтяное хозяйство, № 2, 2017. Баку, стр.45-49
2. Панахов Г.М., Аббасов Э.М., Юзбашиева А.О., Расулова С.Р., Мусеибли П.Т. Тепловое и химическое воздействие на реофизические свойства неньютоновских нефтей // Азербайджанское нефтяное хозяйство, № 5, 2017. Баку.
3. Шахвердиев А.Х., Панахов Г.М., Аббасова Э.М. Влияние физико-химических свойств и обводненности пластового флюида на эффективность газлифта // Нефтяное хозяйство, № 6. 2017. – С. 72 – 76.
4. Gadjiev T., Aliev S., Panahov G., Abbasov E. Placement of wells as a method of oil field development control // Visnyk of the Lviv Univ. Series Mech. Math. 2016. Issue 82. P. 94-97.
5. Panakhov, G.M., Abbasov, E.M., Gadjiev, T.S., and Bakhtiyarov, S.I. (2017). Rheological Features of Structural-Forming Disperse Systems. I-manager's Journal on Mechanical Engineering, 7(3), 1-9. <https://doi.org/10.26634/jme.7.3.13576>
6. Panahov G.M., Abbasov E.M., Guseynov V.G., Museibli P.T. Regulation of pipeline transport of heterogeneous systems in condition of uncertainty of initial parameters // XXIX International Conference Problems of Decision Making under Uncertainties, Ukraine, 2017, p. 97-98.
7. Panahov G.M., Museibli P.T. Influence of the electrostatic potential on the dynamic of gas evolution // Sumqayıt Dövlət Universitetinin yaradılmasının 55 illiyinə həsr edilmiş "Riyaziyyatın nəzəri və tətbiqi problemləri" Beynəlxalq Elmi Konfransın materialları, Sumqayıt Dövlət Universiteti, Sumqayıt, 2017, s. 122.
8. Panakhov G.M., Abbasov E.M., Yuzbashieva A.O., Guseynov V.G. Control of the disturbances development in the boundary layer under the flow of heterogeneous fluids in pipes // Proceedings of the International Conference

“Modern problems of mathematics and mechanics” devoted to the 80th anniversary of academician Akif Gadjiyev, Baku, 6 – 8 December, 2017. – pp. 170.

9. Panahov G.M. and Museibli P.T. The study of internal exposure on the fluid hydrodynamics // Proceedings of the International Conference “Modern problems of mathematics and mechanics” devoted to the 80th anniversary of academician Akif Gadjiyev, Baku, 6 – 8 December, 2017. – pp. 171.

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Corresponding Member of the

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