SCİENTİFİC REPORT

of the «Fluid Mechanics» Department

for 2022

Research Topic: Development of theoretical and applied bases of non-stationary, non-equilibrium processes occurring at joint flow of heterogeneous systems.

According to the thematic plan during the reporting time the following researches were carried out:

Research 1: Investigation of the effects of changing saturation pressure in porous media on the flow of non-stationary processes in mixtures and fluid displacement (corresponding member of ANAS, Dr. Panakhov G.M., Associate Professor Abbasov E.M., PhD in Mechanics Museibli P.T.)

During the reporting period, nonequilibrium cases of systems exposed to various influences with certain energy were investigated in researches-related studies, and substantiations were made for the characteristics of interaction, which is one of the important conditions by displacement control of such cases in porous media.

In this direction, the results of studies of physico-chemical and phase transformations occurring in gas-liquid mixtures due to changes in saturation pressure depending on the size of gas bubbles formed in certain areas of the porous medium, the free path length and the diffusion coefficient were also evaluated.

Research 2: **Evaluation of the role of electrokinetic processes in heterogeneous fluid flow, development of mathematical models and applications** (Corresponding member of ANAS, Dr.Sc. Panahov G.M., Associate Professor Abbasov E.M., Doctor of philosophy in mechanics Museibli P.T.).

By theoretically substantiating non-stationary processes occurring at joint flow of different liquid mixtures it was shown that slip effect is appeared as the result of electrokinetic layer formation between liquid and capillary wall.

By introducing charge density at stationary state and assuming that in Navier-Stokes equation fluid is assumed to be incompressible, presence of slip as boundary condition at the capillary wall and potential difference constant with pressure in the flow, the equation was solved numerically, velocity profile v was estimated.

A constant pressure gradient in the circular cross section capillary ($r = x = y$) at different values of parameters ρ_e and $\nabla\phi$ with and without considering the electrokinetic factor is taken, the equation is solved numerically using MATLAB software package, the graph of velocity profile changes is plotted.

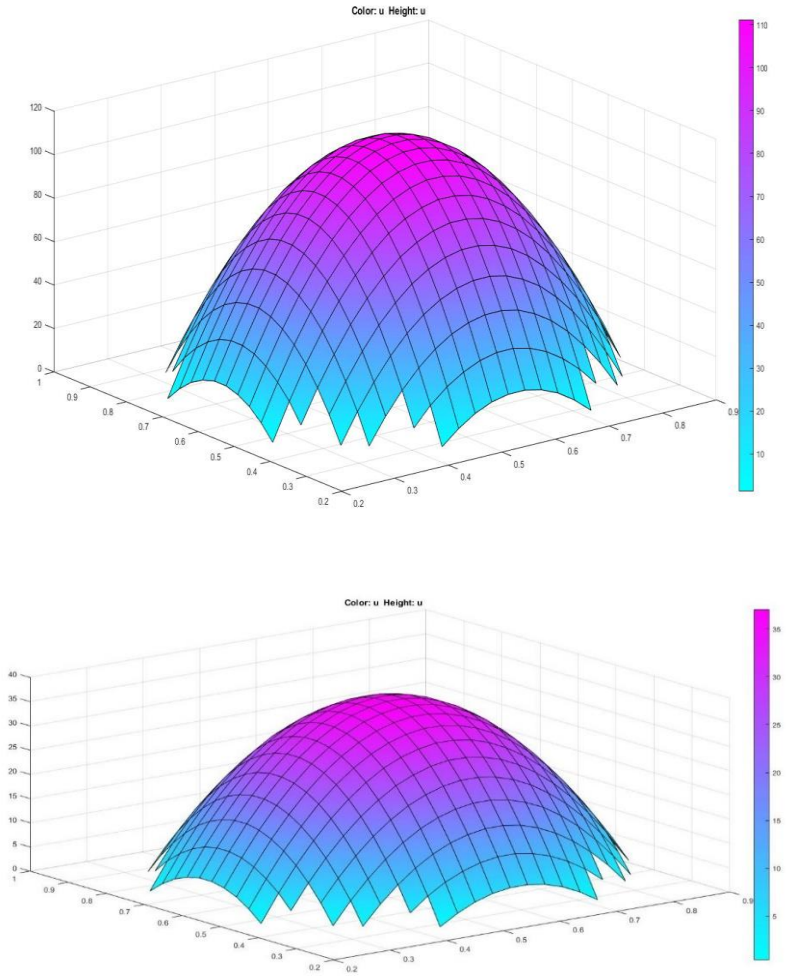

Fig. 1 Velocity profile change as a function of potential

difference in liquid flow in the capillary

As can be seen from the diagram, the velocity distribution diagrams in the boundary layer near the capillary wall are different. At constant pressure the velocity at the capillary wall is different from zero depending on the gradient of the flow potential (electric charge density).

The study also substantiated the variation of the viscosity as a function of the electric potential and revealed the non-linearity of the ratio $\frac{\mu}{\mu_e}$.

Research 3: **Evaluation of the effect of physical and chemical characteristics of liquid mixtures on flow properties** (Corresponding Member of ANAS, Dr. Panahov G.M., PhD in Mechanics, Associate Professor Agaeva G.R., Mammadov I.S.).

The dependence of the problems arising at the flow of liquid mixtures on the physical and chemical properties of the mixtures and the level of the technical means by which they are controlled has been noted.

In this work the significant variants of solving the problems of boundary stability of phases in operational processes are investigated, theoretical and practical

substantiation and evaluation of effective indicators of the indicated direction at various variants of the solution are carried out.

Publications.

During the reporting period, nine articles were published, two - accepted for publication, one article was prepared and submitted for publication, and nine abstracts and conference proceedings were published.

Articles:

1. Panahov, G. M., Abbasov, E. M., & Salmanova, G. M. (2022). Evaluation and control of gas-dynamic parameters of gas pipelines transporting heterophase mixtures. AIP Conference Proceedings, 2637(1), 040004. https://doi.org/10.1063/5.0120346 (**Scopus, Web of Science**).

2. Qeylani Pənahov, Babek Sultanov Ground consolidation under the fractal filtration law // ANAS Transactions (issue Mechanics), Vol. 42, № 7, 2022. – pp. 22-29.

3. Панахов Г.М., Аббасов Э.М., Юзбашиева А.О., Мусеибли П.Т., Мамедов И.М. Исследование физико-химических и газовых методов воздействия при вытеснении углеводородов // «Azərbaycan Neft Təsərrüfatı» August 2022, pp. 22 – 29. https://doi.org/10.37474/0365-8554/2022-08-22-29 (is accredited by the AR Higher Attestation Commission).

4. Eldar M. Abbasov, Vusal G. Huseynov, Ulfet F. Jafarova, Sevinj Nasibova In situ gas generation in dispersed systems to control structure formation // Transactions of ANAS, Vol. 42, № 8, 2022.

5. Панахов Г.М., Аббасов Э.М., Балакчи В.Д. Регулирование приемистости нагнетательных скважин набухающими композициями // Материалы II Международной научно-практической конференции, посвященной 10-летию Северо-Кавказского федерального университета “Инновационные технологии в нефтегазовой отрасли. Проблемы устойчивого развития территорий”, Ставрополь, 2021. – С. 259 - 266. (**RISC**).

6. Шахвердиев А.Х., Панахов Г.М., Аббасов Э.М., Балакчи В.Д. Регулирование фронта вытеснения в неоднородных пластах путем блокирования высокопроницаемых каналов коллектора набухающей композицией // Актуальные проблемы нефтегазовой отрасли. Сборник докладов научно-практической конференции журнала «Нефтяное хозяйство». г. Москва, 2022. – С. 268-281. (**RISC).**

7. Аббасов Э.М., Агаева Г.Р. и др. Simulation of the inference of filter operation process on oil and gas production indicators // Journal of Contemporary Applied Mathematics. Vol.10, № 1, 2022.

8. Pənahov Q.M., Əhmədov A.D., Məmmədov İ.C. Müxtəlif reofiziki xassələrə malik sıxışdıran və sıxışdırılan sistemlərdə dayanıqlığın müəyyən edilməsi üçün təqribi üsulların işlənməsi // Proceedings of the II International Science and Engineering Conference, Baku Engineering University, Baku, Azerbaijan. - 2022. - Səh. 63 – 65.

9. Məmmədov İ.C. Müxtəlif reofiziki xassələrə malik sıxışdıran və sıxışdırılan sistemlərdə dayanıqlığın müəyyən edilməsi üçün təqribi üsulların işlənməsi // BDU Xəbərləri Jurnalı, Bakı Dövlət Universiteti http://static.bsu.az/w1/29%2003%202022%20j/riyaziyyat-4-2021.pdf

10. Azizaga Kh. Shakhverdiev, Geylani M. Panahov, Renqi Jiang, Eldar M. Abbasov *In-situ CO_2 generation technology as the method for residual oil recovery* // Journal of Petroleum Science and Technology, Taylor and Francis (JCR Impact Factor – 1.325) – **accepted for publication.**

11. Panahov G.M., Abbasov E.M., Sultanov B.N. Capillary instability control under hydrodynamic impact on the reservoir // Int. J. of Applied Mechanics and Engineering (Scopus) – **accepted for publication.**

12. Qeylani Pənahov, Perviz Museibli, Babek Sultanov Effect of soil consolidation on the fractality of the filtration law // International Journal of Applied Mechanics (IJAME), University of Zielona Góra, Department of Mechanics - (Scopus) – **submitted to the journal.**

Researchers have spoken at the following international conferences:

1. Akademik İ.İ. İbrahimovun 110-illik yubileyinə həsr olunmuş Beynəlxalq Konfrans. **AMEA, Riyaziyyat və Mexanika İnstitutu**:

– G.M. Panahov, B.N. Sultanov Fractal Modeling of Consolidation under Filtration in Water Saturated Soils;

– Geylani M. Panahov, Zuleykha S. Sadigova Flow of heterophase mixtures in gas pipes and methods to control gas dynamic parameters;

– E.M. Abbasov, P.T. Museibli, I.J. Mamedov Diffusion transport of in-situ generated gas in fluid-saturated porous media;

– E.M. Abbasov, S.I. Nasibova Study of the flow of heterogeneous fluids with variable component content and external environment.

2. Geylani M. Panahov, Eldar M. Abbasov, Babek N. Sultanov Capillary instability control under hydrodynamic impact on the reservoir // International Conference Mathematical Analysis and its Applications in Modern Mathematical Physics, September 23-24, 2022; Samarkand, Uzbekistan / Ministry of Higher and Secondary Special Education of the Republic of Uzbekistan Samarkand State University - **Mathematics Institute of The Academy of Science of Uzbekistan**.

3. Geylani Panahov, Babek Sultanov, Zuleykha Sadigova 2nd International Conference on Engineering and Applied Natural Sciences, October 15-18, **Konya, Türkiye.**

4. İbrahim Mamedov, Sevinj Nasibova 2nd International Conference on Engineering and Applied Natural Sciences, October 15-18, **Konya, Türkiye.**

5. G.M. Panahov, Ş.Z. İsmayılov, E.M. Abbasov, V.D. Balakchi V International Workshop «Thermal Methods for Enhanced Oil Recovery: Laboratory Testing**, Simulation and Oilfields Applications» ThEOR2022, Baku, Azerbaijan, November** 3-5, 2022.

6. Аббасов Э.М., Агаева Г.Р. и др. Моделирование влияния процесса работы фильтров на показатели добычи нефти и газа // The 8th International **Conference on Control and Optimization with Industrial Applications, Avgust 24-26, 2022, Baku, Azerbaijan.**

Scientific grants.

In the reporting period, the staff of the department successfully implemented a grant project funded by SOCAR "Development of fundamentals for application of enhanced oil recovery through in-situ generation of surfactant compositions, gas and foam of different structures", implemented under the leadership of Corresponding Member of ANAS Geylani Panakhov.

A new device, the IKA Rothowisk Rheoviscosimeter, was purchased for the laboratory of the Fluid Mechanics Department as part of the project to measure the viscosity of liquids in various measurement ranges.

Fig. 2 Rheoviscosimetr – IKA Rhotovisc

Scientific and organizational activities.

In the reporting period the department plans to take part in implementation of the "Road map" on development of scientific cooperation between the Azerbaijan

National Academy of Sciences and the Academy of Sciences of the Republic of Uzbekistan for 2022-2024, with participation of Prof. Bakhtiyar Khujayorov, head of the department "Mathematical Modelling" of Samarkand State University has presented the research topic of the joint project – “Implementation of joint research into mathematical modelling of the flow of heterogenous systems in pipes and porous media”.

This year Corresponding Member of ANAS Geylani Panahov was elected member of editorial boards of journals "Bulletin of the Academy of Sciences of the Republic of Bashkortostan" and "Bulletin of the Academy of Sciences of the Republic of Bashkortostan". Academy of Sciences of the Republic of Bashkortostan, Problems of Mechanics, Academy of Sciences of Uzbekistan and Baku Mathematical Journal.

Scientific researcher Parviz Museibli is a member of the editorial board of the journal "Young Researcher" of ANAS.

Employees of the department "Fluid and gas mechanics" participated in the exhibition organized within the framework of "Festival of aviation, space and technology - Technofest Azerbaijan" on May 26-29. It was stated that the presented technologies are of great importance for increasing the efficiency of works carried out in oil and gas industry, and that they have been tested in many countries of the world.

Dr Geylani Panahov, corresponding member of ANAS, made a presentation at the Academic Council of the Faculty of Mechanics and Mathematics of Baku State University.

Fig. 3

The Journal of ANAS Transactions (Mechanics issue) - Volume 42, Issue 7 of 2022 was published.

ANAS Corresponding Member Geylani Panahov supervised the work of 4 dissertation and 2 master's students.

Thesis advisor of the department, researcher Perviz Museibli VAK awarded the degree of Doctor of Philosophy in mechanics.

Master student of the department Ibrahim Mammadov successfully passed exams in connection with entering doctoral studies.

Corresponding member of ANAS, Dr. Geylani Panahov, associate professor Eldar Abbasov and associate professor Afat Yuzbashiyeva conducted lectures on different disciplines for masters and bachelors in IMM and BSU.

During the reporting period one student defended his master's degree at the Institute of Mathematics and Mechanics, and a bachelor's degree at Baku State University under the supervision of corresponding member of ANAS Geylani Panahov.

Applied researches.

During the reporting period the department employees conducted field operations at Binagady Oil Company on oil production enhancement and injectivity increase at injection wells No.222710, 222802, 222811 and 232907.

In response to a technological problem encountered on a pipeline between stationary platforms in Vietsovpetro's (Socialist Republic of Vietnam) White Tiger field, PV-Chem ('PetroVietnam') Socialist Republic of Vietnam invited RMI staff Geylani Panahov and Eldar Abbasov to Vung Tau to conduct pilot tests of the new technology.

Azerbaijani scientists visited the Vung Tau city at Vietsovpetro, discussed the difficulties encountered and their solutions, and worked out a research plan with deputy director of the Research Institute, Dr. Alexey Ivanov and head of production and technical department of Vietsovpetro, Le Dan Tam. First of all, experimental researches related to the proposed solution were carried out on the basis of PV-Chem. Upon confirmation of positive results, the new viscoelastic composition and technological development were implemented. On July 8 - 13, 2022 the composition was successfully tested on the offshore oil and gas production platform DSP-7 and DSP-5 with the joint participation of Vietsovpetro specialists, IMM researchers and representatives of PV-Chem on the gas pipeline extending for 1500 m between two platforms and the complex route. The operation ensured that the pipeline was cleaned and the process was completed by removing 8 m^3 of water and condensate at a maximum pressure of 5 atm.

Fig. 4

Fig. 5

Corresponding member of NANA Panakhov G.M. and associated professor Abbasov E.M. attended operational meeting in "Gas export department" of SOCAR on May 27, 2022 where technological solutions on viscous-elastic systems application created in the department for solving problems arising in "Hajigabul-Gazy-Mohammed" trunk pipeline were presented.

“Fluid Mechanics” Department Head
Corresponding member of ANAS
Dr. Geylani Panahov