

**SCIENTIFIC AND ORGANIZATIONAL REPORT**  
**of the "Fluid Mechanics" department**  
**for the first half of 2024**

**Theme: Development of theoretical and applied bases of non-stationary, non-equilibrium processes arising in the co-flow of heterogeneous systems.**

In the reporting period, the following research works were carried out in accordance with the subject research plan.

Within the research framework, it was established that at the molecular level, depending on thermobaric conditions, there is always a chaotic or non-equilibrium flow of mixtures. Thus, regulation of input and output parameters of the process at unsteady and non-equilibrium flow of liquids and gases is one of the important problems of mechanics of liquids and gases. In this connection, in the framework of the current research the issues of evaluation of the instability criteria arising in heterogeneous systems with different density parameters, creation of various structural forms to expand the field of their application in displacement in porous media and evaluation of the influence of physicochemical characteristics of liquid mixtures on the flow parameters are considered, practical bases of flow and filtration processes are developed.

**Work 1. Modelling of transient processes under in-situ gas formation.**

**Project researchers:** corresponding member of Azerbaijan NAS, doctor of technical sciences, professor Panahov G.M., candidate of technical sciences, associate professor Abbasov E.M., junior researcher Mammadov I.D.

In the work the process of gas formation and gassing in the porous medium was evaluated. In the process of research, the effects arising from gas diffusion in porous medium and heat and mass transfer were studied. Heat and mass exchange processes are characterized by gas diffusion in a gas-liquid medium and are described by a linear relationship. The correlation of the solubility coefficient and molecular diffusion coefficient with temperature leads to instantaneous diffusion fluxes of the generated gas into a porous medium saturated with liquid. The studied

research can be applied as an effective method of hydrocarbon recovery from oil-saturated formations.

**Work 2. Study of Liesegang structural forms arising in porous media as a result of interaction of heterogeneous solutions.**

**Project researchers:** corresponding member of ANAS, professor Panahov G.M., candidate of technical sciences Abbasov E.M., PhD Yuzbashieva A.O.

Investigating mutual diffusion in systems forming a precipitate as a result of reaction of two substances, R. Liesegang (R. Liesegang, 1896) it was found that in some cases the precipitate is distributed not continuously depending on pores, but through layers of non-sediment forming solution (in separate separated layers).

A preliminary explanation of this phenomenon is based on the assumption of the critical existence of solution supersaturation. So without it, precipitation is impossible.

Taking the sedimentation reaction rate as a basis, a refined mathematical model of the Liesegang phenomenon is considered. This is an important condition for the possibility of applying the effect in the management of oil field development processes.

**Work 3. Investigation of the influence of periodic gas formation on the displacement process in porous media.**

**Project researchers:** corresponding member of NAS of Azerbaijan, professor Panahov G.M., PhD Agayeva G.R., PhD Museibli P.T.

In this work the mechanism of stoichiometric chemical reaction is considered using the system of differential equations expressing the rate of change of concentration of components. It is found that the concentrations of initial and final products of gas-forming reaction are not subject to oscillations, their periodic change is accompanied only by intermediates. The periodic behavior, independent of the initial conditions, can be described by differential equations of nonlinear time dependence of the corresponding system variables. In addition, the process of

adsorption of reaction products at some stages of gas formation is due to fluctuation. The differential equations of the rheo-gaschemical reaction in gas formation under reservoir conditions can be written as:

$$\frac{dX}{dt} = A - (Y + 1)X + X^2Z; \quad \frac{dZ}{dt} = YX - X^2Z;$$

Solving this system of equations under the boundary conditions defined by the initial values of  $X$  and  $Z$  will help to fully determine the concentrations that can be obtained in the reaction zone.

1. During the reporting period, 3 articles were prepared, of which 1 was published and 2 were accepted for publication: Geylani Panahov, Eldar Abbasov, Azer Ehmedov, Ibrahim Mamedov Modelling of internal transformations of gas phase in porous media *Advanced Mathematical Models & Applications*, Vol. 9, No.1, 2024, pp.54-67. <https://doi.org/10.62476/amma9154> (**Scopus**).

2. Ibrahim Mamedov, Geylani Panahov, Sayavur Bakhtiyarov Investigation of the Effect of Mutual Diffusion on Hydrodynamic Parameters under Fluid Displacement // *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences* (**Scopus**).

3. Панахов Г.М., Аббасов Э.М., Мусейбли П.Т., Мамедов И.Д. Периодическое пенообразование в процессе селективной изоляции высокопроницаемых каналов пористой среды // Сетевое издание Ogbus «Нефтегазовое дело», г. Уфа, 2024 (принята к печати).

Corresponding Member of ANAS Geylani Panahov was elected a member of the Organising Committee of the International Scientific and Practical Conference "Development of Hydrocarbon Potential - Green Technologies" held in Ufa on 21-23 May 2024. At the plenary session of the conference, Professor Geylani Panahov made a report on "Achievements and prospects of scientific and practical cooperation between Azerbaijani and Bashkir researchers in the development of energy-efficient hydrocarbon technologies".

On 23-25 April 2024, employees of the department made presentations at the international scientific conference "Information Technologies and their Applications-ITTA - 2024" (2nd International Conference on Information Technologies and their Applications). Associate Professor Eldar Abbasov was the leading moderator of the scientific session "Information Technologies in Modelling".

On 03-06 July 2024 the scientific staff of the department participated in the XI International Scientific Conference "Modern Problems of Mathematics and Mechanics" at the Institute of Mathematics and Mechanics, 2 theses were presented.

The 44th volume, 7th issue of ANAS Transactions (Mechanics edition) for 2024 was prepared for printing. Corresponding Member of ANAS Prof. Geylani Panahov supervised 4 thesis students and 1 master's student.

Corresponding Member of ANAS, Professor Geylani Panahov led a course of lectures on various disciplines of fluid and gas mechanics at BSU; Candidate of Technical Sciences, Associate Professor Eldar Abbasov participated in the management of scientific and industrial practice of student groups (bachelor's degree) of the department "Theoretical mechanics and continuum mechanics" BSU in the scientific departments of the Institute of Mathematics and Mechanics and the Institute of Oil and Gas.

During the reporting period the employees of the department carried out field operations on application of new methods of oil production stimulation in "Binagadi Oil Company" (production wells Nos. 223102 and 232926).

Department head,

corresponding member of Azerbaijan NAS

Geylani Panahov