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The study of internal exposure on the fluid hydrodynamics

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Abstract. *Gas separation from gas-oil mixtures containing asphalt-tar-paraffin directly influence to the hydrodynamic parameters of structure destruction process. The paper focuses on the investigation of the influence of potential difference on the formation of gas bubbles and influence of gas generation on fluid dynamics. Research has established, that the value of electrostatic potentials generated by fluid friction is increased when the radius of existing gas bubbles decreases.*

Keywords. hydrodynamcs · fluid flow · gas-liquid · conductivity · buble · pressure · perturbation · flow rate

Mathematics Subject Classification (2010): 76T10

1 Introduction

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Control of hydrodynamic parameters in fluid flows is one of the important problems in the pipelines transportation of hydrocarbons. One of the main factors affecting the efficiency of transporting liquid is the heterogeneity of transported systems.

Gas separation from gas-oil mixtures containing asphalt-tar-paraffin directly influence to the hydrodynamic parameters of structure destruction process. These subjects had been studied by many researchers and achieved some important effects [4, 7, 8, 13, 15].
As it can be seen from the research results, there is no unanimous opinion here. The authors note that gas separation may have a negative or positive effect on hydrodynamic parameters [3, 12].

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2 Objectives.

A number of authors note the essential role of the conditions for the gas bubbles formation on the hydraulic parameters of the gas-liquid flow [10]. They considered the effect of changes in the radius of the gas nuclei, as well as the dynamics of gas bubble development, depending on the thermobaric conditions of the flow.

Authors [1, 6] demonstrated the possibility of increasing the flow rate by maintaining gas bubbles' initial form at a predetermined value of temperature difference. External influence is considered as regulatory factor in all these studies. Authors considered external influences, including electric, magnetic and etc. on the dynamic of the gas bubbles formation [2, 5, 9, 11, 14, 16].

In contrast, internal processes arising during flow of gas liquid systems, especially, the influence of electrostatic potential on the hydrodynamic parameters and gas bubbles' formation dynamics are considered in the research work.

3 Experiments

At the first stage, the elektrokinetic process, which arise during fluid flow, was investigated. The influence of flow rate on the potential difference had investigated experimentally in this research work. The scheme of the experimental setup, which used for this purpose, was shown in Fig. 1.

The setup consists of high pressure cylinder (1), the capacity of mixers for the studied systems (2), tube of constant diameter (4.10^3 and 16.10^3 m) with a removable horizontal part length of 2.7 m (3) model pressure gauges (4), microreactor (5), display (8), ultrathermostat (7), taps, corresponding to the full section of the pipe (8), the shut-off valve (9) dividing the expansion joints (10).

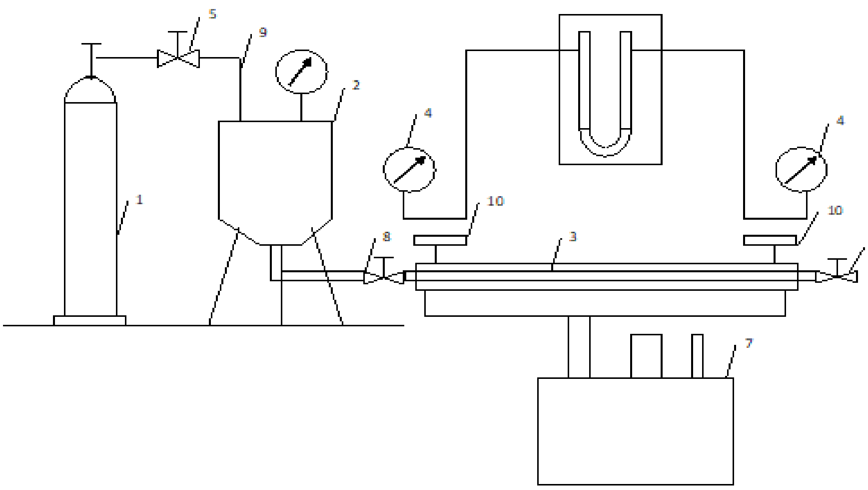

Fig.1.Experimental setup

The water and its various mixtures of water solutions was used as test fluid. Firstly, change of potential difference depending on the velocity of the flow was considered. In the research work the Shollar type water has been used (Table 1).

Table 1.

Ca^{2+} mq/l	Mg^{2+} mq/l	$Ca^{2+}+Mg^{2+}$ mq/l	Na^{+} mq/l	Cl^{-} mq/l	SO_4^{2-} mq/l	HO_3^{-} mq/l	ΣK mq/l	SiO_3^{2+} mq/l	Salinity, mq/l
3.8	2.2	6.0	0.5	0.2	1.9	4.4	6.5	18.2	345

Experiment results of the were shown in Fig. 2.

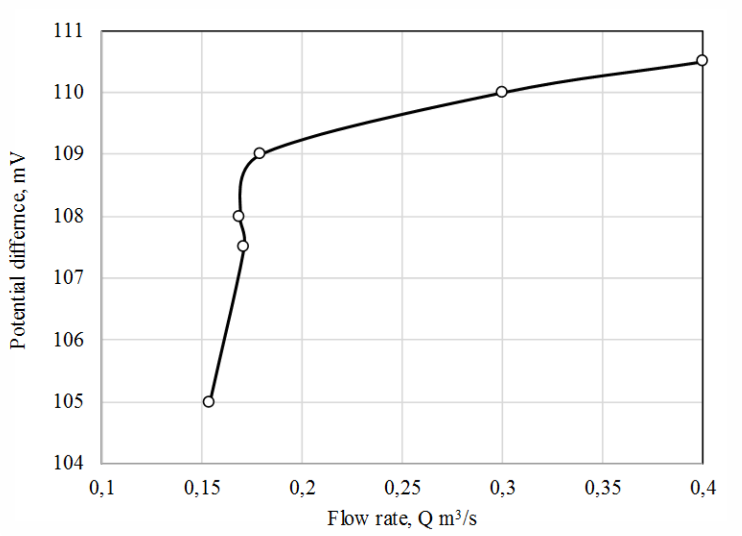

Fig.2.The potential difference dependence on flow rate

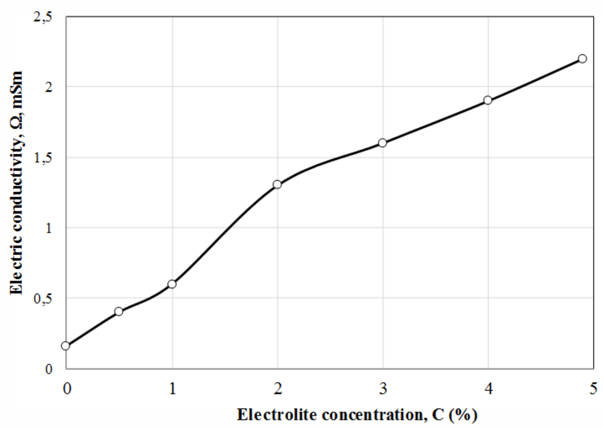

Fig. 3. The electric conductivity vs. of $NaCl$ concentration

Then, the change of the electric conductivity of tested fluid has been done at the next stage. As known, the electric conductivity of fluid varies depending on the concentration of electrolyte added to it. So, $NaCl$ as electrolyte had been added to water in the studies.

Here, conductometer was used for determination of electric conductivity. The graphics of the change of electric conductivity depending on $NaCl$ concentration was shown in Fig. 3.

On the other hand, the authors [2, 6] demonstrated that if adjusted the radius of gas bubbles, then it will influence to flow rate at the fixed value of temperatures difference of and pressure drop.

In contrast to the other studies, it was investigated the influence of potential difference on the formation of gas bubbles and fluid dynamics in this studies.

Theoretically, this study had been investigated in the following sequence. The electrostatic friction potential is determined from the following expression:

$$\vec{E} = -\vec{\nabla}$$

$$\int_l Edl = \varphi(l_1) - \varphi(l_2)$$

In general, the process is described by the following system of equations:

$$divv_1 = 0 \tag{3.1}$$

$$\rho \frac{dv}{dt} = -gradP + j \times E \tag{3.2}$$

$$\frac{\partial \rho_2^0}{\partial t} + div(\rho_2^0 v_2) = 0 \tag{3.3}$$

$$\rho_2^0 \left(\frac{\partial v_2}{\partial t} + (v_2 \nabla) v_2 \right) = -gradP_2 \tag{3.4}$$

$$\rho_2^0 \frac{d}{dt} \left(u_2 + \frac{v_2^2}{2} \right) = -divq_2 + div(P_{2n} v_2) \tag{3.5}$$

$$j = \sigma E,\ q_v = j^2/\sigma \tag{3.6}$$

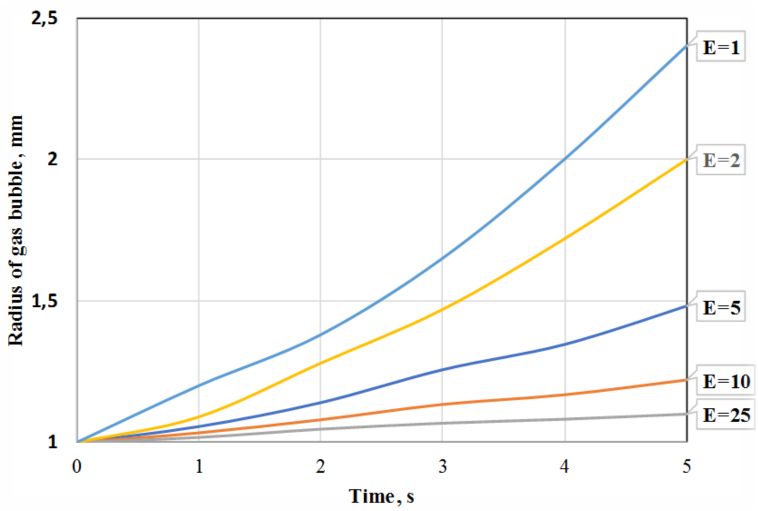

Fig. 4 Gas bubble size vs. time depending on the electric conductivity

Taking into account the motion equation (3.2)and the equilibrium condition, the expression for the evolution of the bubble of gas becomes

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

Σ- coefficient of surface tension, P_∞– pressure of fluid in infinity, $a(t)$– bubbles radius. $a(t)$- are unknown coefficients.

Solving the obtained equations system by the numerical method of Runge- Kutta, we estimated the change in the radius of gas bubbles.

The obtained results depending on the value of electric conductivity were shown in Fig. 5 and 6.

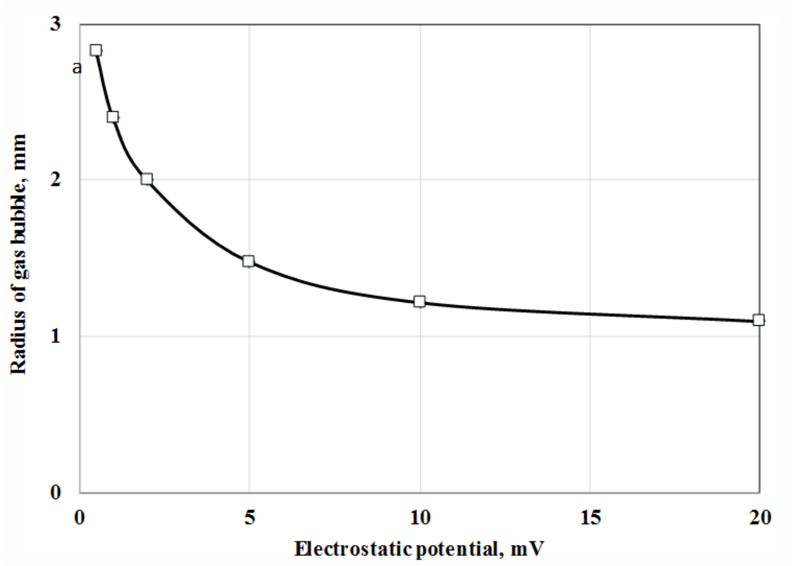

Fig. 5 Gas bubble size vs. electrostatic potentials

4 Conclusion

It was found that the value of electrostatic potentials generated by fluid friction is increased when the radius of existing gas bubbles decreases. In this turn, the regulation of fluid rate and maintaining gas bubbles' initial form is allowed at the fixed E value.

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