MULTIPHASE FLOW MODELING OF OIL-WATER FLUX

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Studies of the effects caused by redistribution of energy under merge and/or splitting of premixed and pure viscous flows in branch connections and pipe joints of branched pipeline systems are important for fuel and energy sector. The design of high-reliability connectors needs in thorough analysis of regularities of hydrodynamics and of heat-and-mass transfer either within phases or on the boundaries of fluids interaction. Reduction in expenditure of energy on friction caused by the flow of rheological complex viscous mixture and its interaction with pipe wall leads to control of flow patterns, organization of specific flow conditions (e.g. peripheral input of low viscous flow as a lubricant), which increases product delivery to customers. We need to notice [1,2,3] that during the transportation of heavy hydrocarbon mixtures (e.g. high-viscosity petroleum and oil) in pipeline systems considerable saving of power can be reached due to usage of water, that this mixture contains as a lubricant, in case of divided peripheral feed at the input. In such conditions spatial processes of momentum transfer, heat transfer and mass transfer can be predicted due to involvement usage of multiparametric models and effective numerical methods.

Bibliographic analysis shows [4, 5] that dynamics of the structures of interacting phases in the pipeline is characterized by variety of flow patterns and flow conditions. Water-oil flows are frequently unstable even on the sections of constant cross-section and are complicated by structural transfers because of nonlinear unsteady and convective-diffusion interactions within the phases. It is known that in flows of mixtures the formations of spatial phase patterns are possible. They are characteristic for annular, dispersed, stratified, annular dispersed and intermittent flows.

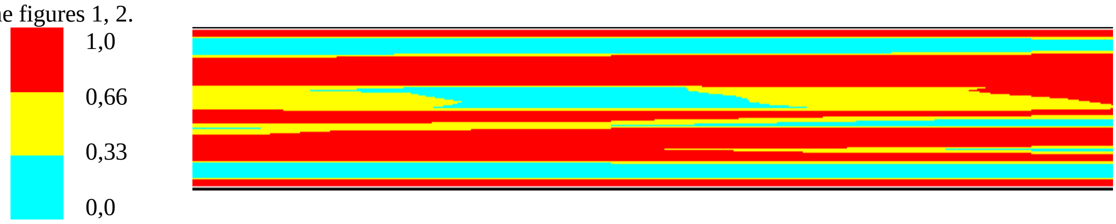
Annular flow is the subject of interest during the transportation of heavy hydrocarbon mixtures. Therefore, processes and mechanisms of regrouping of low-viscosity structure in two-phase flow to peripherical area of pipe wall with higher shear stress are investigated numerically.

Mathematical modeling of flow profile with immiscible phases are viewed in terms of dynamic system equations of two-phase flow taking into account the effects of interphase interaction [4]. The method is based on fractional function **C** that determines volume fractions of the phase in final volume. According to this method the motion of phases is described by one and the same hydrodynamic equation while the values of density and viscosity suffer a break at the surface of a section. The system of determining equation for description of hydrodynamics in steady and unsteady motion of two-phase medium is supplemented with boundary conditions (initial and boundary) for different types of flows and boundary conditions at the surface of phase. The algorithm presupposes **C** function evaluation timing each step, with given phase interface at the initial time. Numerical integration of finite-difference equations is carried out on non-uniform meshes using the algorithm SIMPLE [6].

The prediction algorithm conformity of hydrodynamic and diffusion processes in the motion of drop two-phase media in channels were estimated by means of comparison of changes of local and integral parameters with solutions and experimental data made by other authors [5,7]. The experiment shows that this method allows to predict how the changes of physical characteristics of dynamic structure of the mixture entering the pipe in conditions of unstable phase motions influence on flows and mass transfer in wide range of changes of key parameters (Re=50-4000, L/D =700).

Research data of flow local properties.

The data represented on the figures 1-3 describe the results of investigation of dispersed flow and changes of its structure. There are the images of changes of the structure of turbulent flow in dispersed and annular dispersed flows on the figures 1, 2.



Oil volume fraction

Fig. 1. Annular dispersed flow. D=5,6mm. U_{mix}=2.1 m/s, C_w=0.3

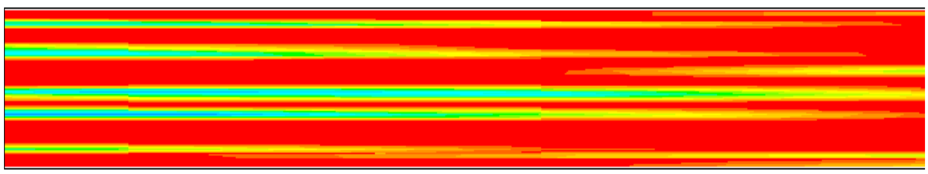
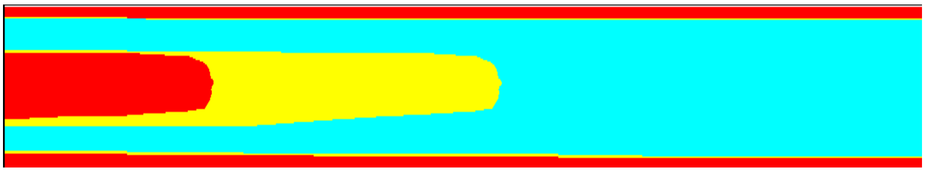
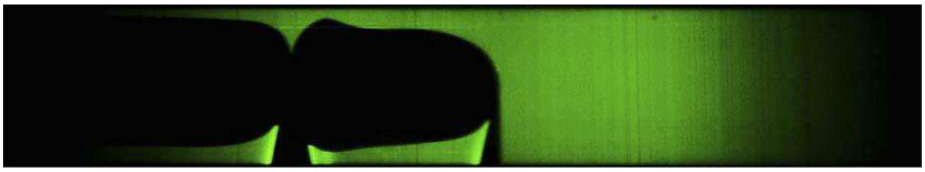


Fig. 2. Dispersed flow. D=5,6mm. U_{mix}=1.94 m/s, C_w=0.1

Results of verification of model and method of analysis are presented on figure 3. Here qualitative and quantitative potential of the method to predict hydrodynamic process and evolution of the flow structure can be regarded. Measurements (fig.3, b) correspond to the data of A.Wegmann, P. R. Rohr[5].



a)



b)

Fig. 3. Piston flow. D=5,6mm. U_{mix}=1.94 m/s, C_w=0.8.
***а*)-model visualization, *б*)- experiment.**

We can find more information about the influence of velocity field and mass on the flow from the analysis of flow pattern map represented on the figure 4. This information also corresponds to the experimental data [5].

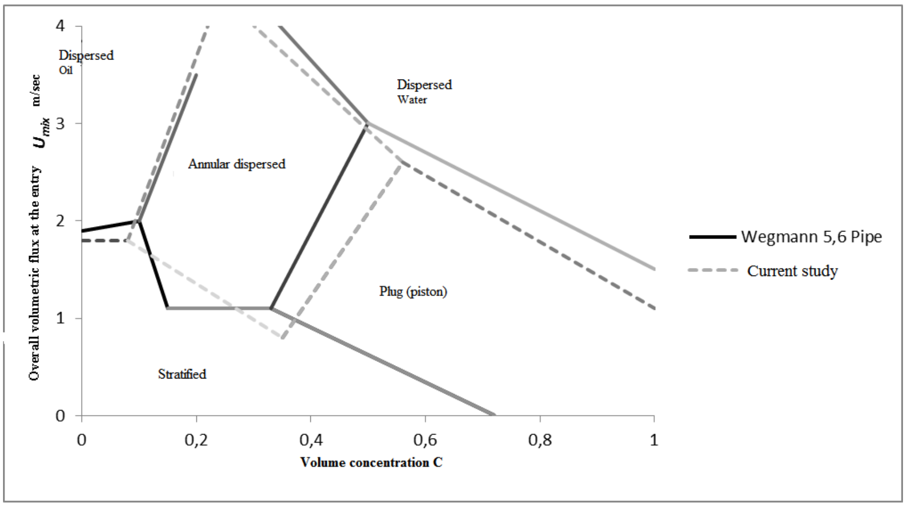


Fig. 4 Flow pattern map

The experiments were made on the plant of Swiss technological university [5]. The principle scheme of the plant is represented in the figure 5.

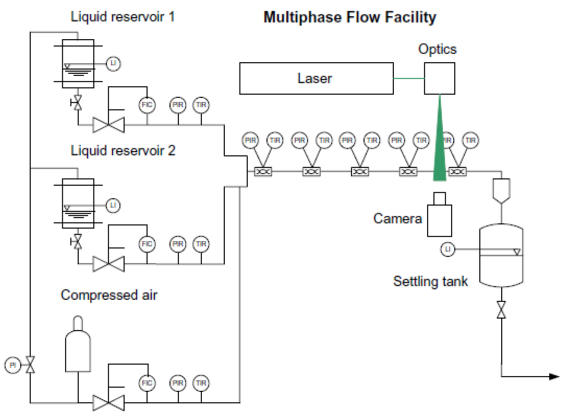


Fig. 5. The scheme of experimental plant.

Integral parameters and their regularities

This paper was aimed at thorough investigation of basic regularities of changes of integral parameters of the flow and mass exchange in dispersed oil-water systems. On the figure 6 there are represented the data of distribution of wall friction over the pipeline and reduction of wall friction relative to high-viscosity core due to formation of water ring. The local hydrodynamic parameters are represented also for mixture complex flow. The data describe the behavior of friction factor at the condition of steady turbulent flow (D=5,6mm. U_{mix}=2.1 m/s, C_w=0.3). It is obvious that in the process of flow motion in the proximal part of the pipeline (x=50 mm) the stable convective and diffusion interactions are formed. They are formed in the processes of momentum transfer and mass transfer which can be predicted by implementation of applied research of friction based on the correlation (ς -x) in the zone x>= 0,05 m.

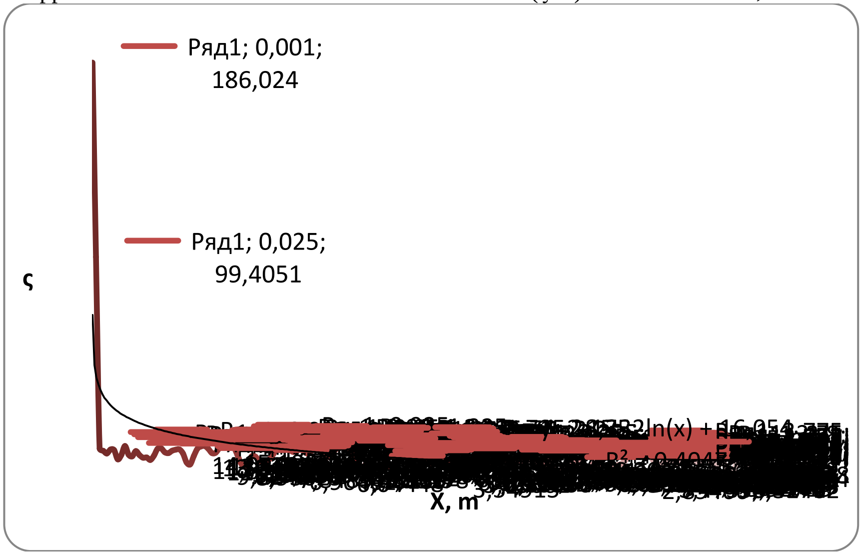


Fig. 6. Distribution of wall friction over the pipeline (D=5,6mm).
U_{mix}=2.1 m/s, C_w=0.3).

Thus, the research helps to predict how the changes of physical characteristics of dynamic structure of the mixture entering the pipe in conditions of unstable phase motions influence on flows and mass exchange. The mechanisms of flow influence on the phase interface are pointed. The generalization of the evaluation of flows of oil-water mixtures are represented as criterion connections for friction factor in wide range of changes of key parameters of phase motions. The reliability of the evaluations was compared with actual data of similar flows made by other authors [5]. The future research is to review flow regimes depending on the structure of the flow at the inlet.

References

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АНАЛИЗ РАБОТЫ НЕФТЕПРОВОДОВ В СЕЙСМИЧЕСКИ АКТИВНЫХ РЕГИОНАХ

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В настоящее время трубопроводный транспорт имеет множество проблем, связанных с промышленной безопасностью, основная из которых геодинамическая безопасность, состоящая из многих факторов, проанализировать которые необходимо для устранения повышенного развития деформаций. Сложнейшей техническим вопросом является строительство и обслуживание подземных нефтепроводов. Это происходит из-за того что сильно затруднен контроль текущего состояния, значительно снижена возможность быстрого мониторинга и ликвидации порывов в трубе.

В Российской Федерации примерно 20% земель подвергаются частым землетрясениям по шкале Рихтера более 7 баллов, более 5% земель - 8-9 баллов. К этим районам относят Северный Кавказ, Прибайкалье, Якутию, Сахалин, Камчатку и Курильские острова.[1]

Метод подземной прокладки имеет достаточно много недостатков, однако он всё же имеет место быть в нефтегазовой промышленности. Так же разрабатываются различные решения технологических проблем, существующих в данном методе прокладки. Во время строительства трубопроводов по схеме проекта Сахалин II/ Фаза II новшеством стало создание «специальных траншей», доктрина которых основывается на положении о