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EXPERIMENTAL STUDY OF OIL DISPLACEMENT BY INHOMOGENEOUS SYSTEM FROM INHOMOGENEOUS POROUS MEDIUM

Abstract

Results of experimental results of oil displacement by the viscous-elasticity systems from the non-homogeneous porous medium are presented.

Obtained results show that one of the main factors of displacement process is the dependence of velocity change from the shear velocity. Due to experimental study influence of displacement velocity to the efficiency of oil recovery is observed. Experiments on the different non-homogeneous two-layer porous medium is carrying out and shown, that the oil recovery coefficient may be increasing, if the shear velocity is changing.

The completeness of oil displacement has a great value in bed stimulation and bottom- hole zone treatment. The great ratio of oil and water mobility by flooding of deposit leads to the stability infraction of displacement front. Starting from this fact, oil-recovery increase methods assume that the displacement completeness is achieved both by improving physical- chemical properties of oil, and leveling the oil mobility and displacement system in a porous medium [1-5]. The investigations show that by displacement of viscoelastic and by viscoelastic systems in a porous medium, the picture is different. A defining factor here is the presence of viscisity alternation depending on the displacement velocity that leads to other regularities of displacement process [6-8]. This must be considered by carrying out various technological actions. In existing investigations, the influence of the velocity to the displacement by polymercontaining compositions, especially in laminary-heterogeneous stratum (with contacting stringers) is not considered [9]. The choice of laminary-heterogeneous porous medium with contacting layers as the investigation object is stipulated by the necessity of mass transfer accounting between two porous systems interior to the sample, i.e. existing tests are mainly carried out in homogeneous, laminary-heterogeneous with non- contacting layers (in two- layer model of a stratum) or zonally- heterogenoeous model of a stratum, but in industrial conditions, the girt between the heterogeneous stratum layers is permeable in various degrees.

The displacement process (simulation condition observed [10] of newtonian oil (transformer oil served as the oil model) in homogeneous and laminary-heterogeneous (with contacting layers) porous media under various filtration velocities was studied. The sceme of experimental installation is in fig. 1. The installation incluedes: 1-vacuum line; 2- porous medium column (astratum model); 3-housing of the column; 4- sample manometers; 5- valves; 6- PVT bomb; 7- housing of PVT bomb; 8- separating piston of PVT bomb; 9- displacing fluid-tank; 10- distributive manifold; 11- metering pump; 12- ultrathermostat; 13- pressure transducer «Sapfir- 22 DI»; 14- recorder; 15- pressure regulator; 16- measuring glass.

Experiments were carried out by the plan:

- high pressure column was filled by a porous medium, the installation was strapped by fig.1, permeability air was determined, and vacuum processing of the installation was performed under constant thermostating;

- by means of press, the stratum model was saturated with transformer oil up to full saturation with simultaneous measure of the stratum porous volume;

- necessary pressure was created in the entrance and exit of the column, transformer oil was filtrated up to steady consumption establishment and then the permeability of the porous medium to fluid was determined;

- PVT pump was filled with water or polymer composition of PAA 0.02% and surfactant 0.005% concentration;

- transformer oil was displaced by working fluid under steady overfall of pressure, and the amount of displaced transformer oil was determined in displacement process.

Experiment was carried out in following porous media:

- homogeneous, built by the quartz sand of 0.314- $0.25 \cdot 10^{-3}$ m fraction;

- laminar-heterogeneous with contacting homogeneous layers (with permeability ratio of layers that equals to 10), achieved by using separating partition, gradually receding in column filling process.

The displacement was continued up to outcome of clear water. Tests were carried out under 303^0 K temperature. The results were registrated in the form of dependence of oil-recovery on the velocity of filtration.

In the first series of experiments, the tests were carried out in homogeneous porous medium with 3 mkm^2 permeability to air under various filtration velocities. We see from results in fig. 2, that the decrease of non-aqueous-oil-recovery is observed for aqua and polymer composition with growth of filtration velocity, in case when the displacement coefficient for polymer composition is higher than 10-20. We must note that similar results are also obtained for ultimate recovery.

In the second series of experiments, the tests were carried out in a laminar-heterogeneous porous medium with 3 mkm^2 permeability to air, under different filtration velocities. The results are in fig. 3 (indicator graph- curve 1 for a polymer composition is given for comparison). As we see from the figure, the dependence of non- aqueous-oil-recovery on the filtration velocity has a non-monotone character (curve 2) for a polymer composition. The maximal oil-recovery is achieved in the field of dilatant flow of polymer composition (up to inflection point B of S-shaped indicator graph). In the velocity fields corresponding to Newtonian (up to point A) and pseudoplastic flow (after the inflection point) of a polymer composition, the oil- recovery has lower values. Similar results are obtained for ultimate recovery too.

Low values for non-aqueous oil- recovery in the field of velocities corresponding to Newtonian flow (up to point A) is explained by the fact that in this case a polymer composition is filtered mainly on high- permeable layer.

To explain the obtained results, we consider a simplified scheme of polymer composition flow in a laminary- heterogeneous stratum [11]. Indeed, let the filtration of a polymer composition takes place in two parallel layers with k_1 and k_2 permeability (under other equal conditions), $k_1 >> k_2$, and corresponds to degree law. Then, by degree law of filtration

$$Q_1/Q_2 = (k_1/k_2)(k_1/k_2)^{(1-n)/2n}.$$

As we see from the obtained expression for Newtonian fluid $(n=1)$, the consumption ratio equals to permeability ratio; the consumption ratio is decreasing for the dilatant fluid $(n>1)$, i.e. the filtration profile is levelled, but for the pseudo-plastic

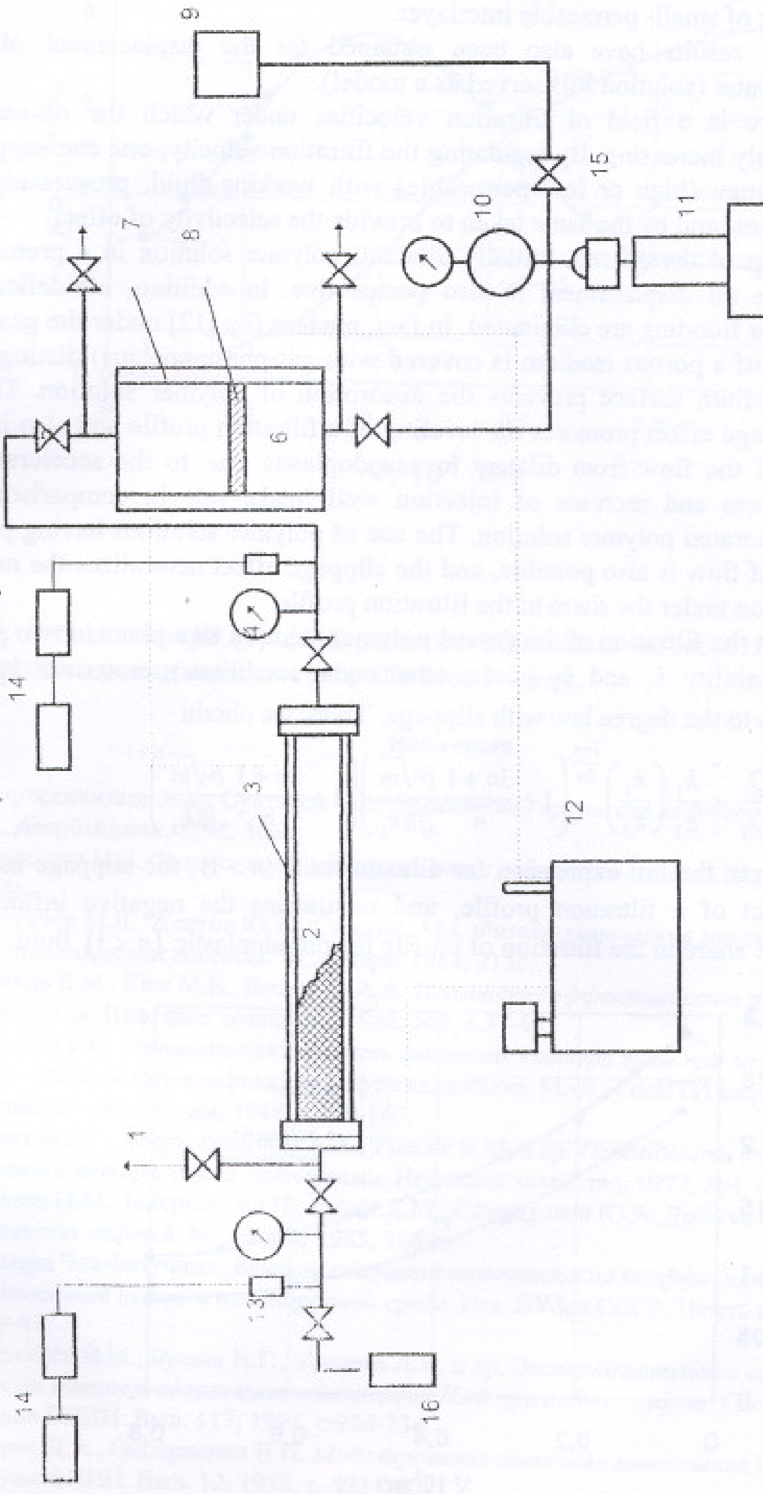

Fig. 1. The scheme of experimental installation.

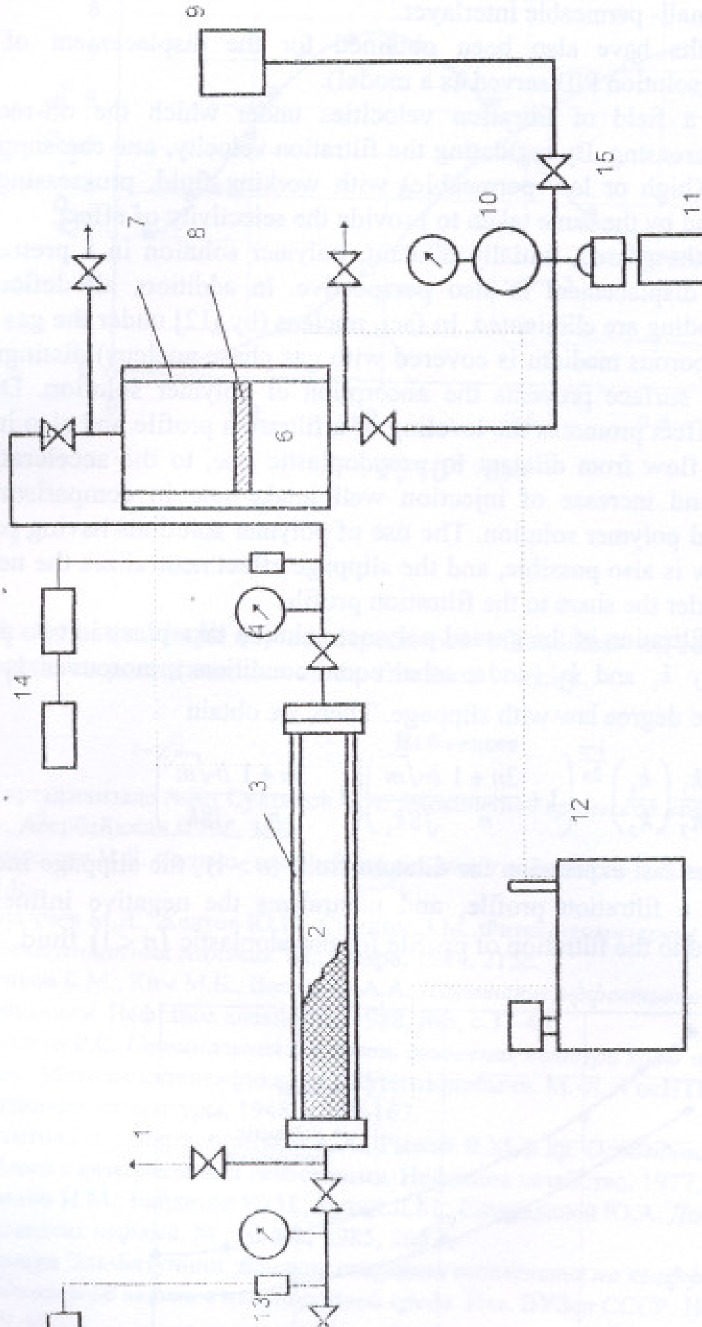

Fig. 1. The scheme of experimental installation.

fluid $(n<1)$, the permeability differences are increasing. We are to note that by [1], the higher is the leveling of filtration profile under the displacement by dilatant fluids, the higher is the power of small- permeable interlayer.

Analogous results have also been obtained for the displacement of non-newtonian oil by water (solution PIB served as a model).

Thus, there is a field of filtration velocities under which the oil-recovery coefficient is sharply increasing. By regulating the filtration velocity, one can supply the given field of stratum (high or low permeable) with working fluid, prossessing non-newtonian properties, and by the same taken to provide the selectivity of effect.

Application of the gassed, initially dilatant, polymer solution in a pretransient phase state as the oil displacement is also perspective. In addition, all deficiencies inherent in polymer flooding are eliminated. In fact, nucleus (by [12] under the gas factor 0.1-10 m^3 surface of a porous medium is covered with gas phase nucleus) distinguished on the porous medium surface prevents the absorption of polymer solution. Dilatant property and slippage effect promotes the leveling of a filtration profile and also in view of modification of the flow from dilatant to psendoplastic one, to the acceleration of development process and increase of injection well intake rate in comparison with pumping of non- aerated polymer solution. The use of polymer solutions having pseudo-plastic character of flow is also possible, and the slippage effect neutralizes the negative influence of dilution under the share to the filtration profile.

Indeed, let the filtration of the gassed polymer solution take place in two parallel layers with permeability k_1 and k_2 (under other equal conditions), moreover $k_1 >> k_2$ and it corresponds to the degree law with slippage. Then, we obtain

$$\frac{Q_1}{Q_2}=\frac{k_1}{k_2}\left(\frac{k_1}{k_2}\right)^{\frac{1-n}{2n}}\left(1+\frac{3n+1}{n}\frac{b\sqrt{m}}{\sqrt{8k_1}}\right)\left(1+\frac{3n+1}{n}\frac{b\sqrt{m}}{\sqrt{8k_2}}\right)^{-1}.$$

We see from the last expression for dilatant fluid $(n>1)$, the slippage increases the leveling effect of a filtration profile, and neutralizes the negative influence of delusion under the share to the filtration of profile for psendoplastic $(n<1)$ fluid.

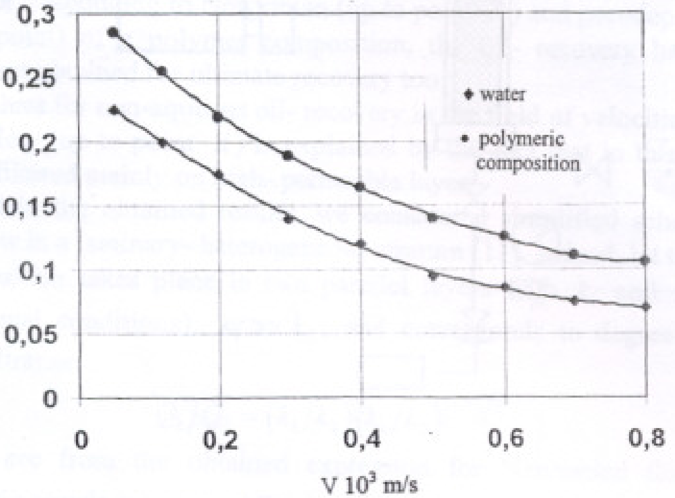

Fig. 2. In dependence of aqualess oil-recovery on the velocity of fluid filtration for heterogeneous porous medium.

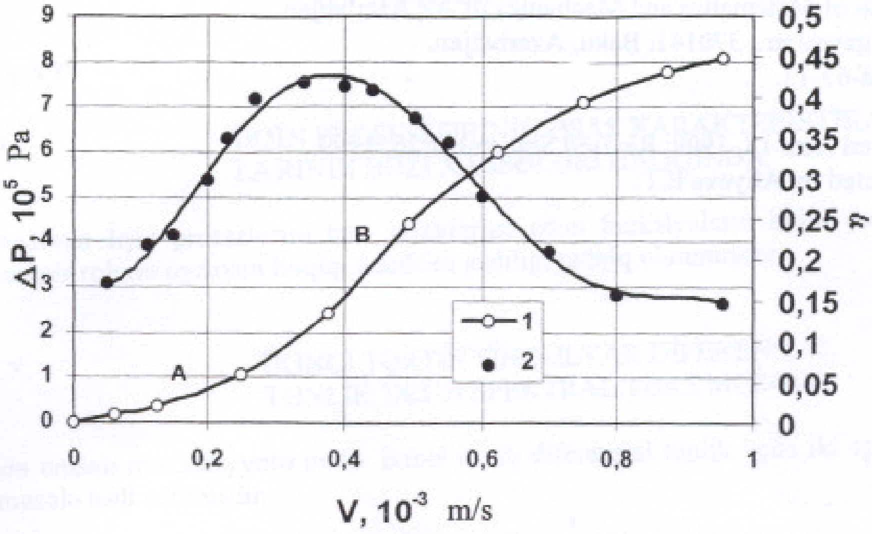

Fig. 3. Indicator Graph (1) ad dependence of aqualess oil-recovery (2) in laminar-heterogeneous porous medium on the filtration velocity.

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