WAVE MOBILIZATION OF OIL DROPS JAMMED IN PORE CHANNELS

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Abstract: On a specially manufactured and assembled experimental equipment for the research of vibro- acoustic influences on porous structures (in which a two dimensional glass model of a real core is used) a study is conducted on the effects of amplitude and frequency characteristics of vibro-acoustic influences on the mobilization of hydro carbon drops (oil and kerosene), which are jammed in restrictions of pore channels during their replacement by distilled water and micellar solution. In order to visualize the flow a microscope together with a digital camera is used. As the porous sample a glass micro model of porous medium which is made with the help of photolithographic technique and represents a structure of pores of a real reservoir rock (a core from an oil reservoir) is used. The experiment has revealed that under the influences of vibro-acoustics the jammed drops of oil pass through the narrowing's of the pore channels at a pressure gradient which is much smaller than that is required for the mobilization of the drops without the influences. Furthermore, it was observed, that vibro-acoustic influence may lead to coalescence of oil ganglia.

On a specially manufactured and assembled experimental equipment for the investigation of vibro-acoustic effect on the flow in porous structure, in which the two dimensional glass model of a real core is used, vibro-acoustic effect with different amplitude-frequency characteristics on mobilization of drops of hydrocarbons (oil and kerosene), which are jammed in restrictions of pore channels, at replacement by distilled water and micellar solution [1] is studied. The researches connected with using of elastic waves in oil industry have begun in the 1950's after the Southern Californian earthquake on July 1952. However the mechanism responsible for the increase of the flow of oil after the earthquake is rather complex and can caused by different earthquake effects not only the seismic wave impact on filtration. The industrial tests on vibro-acoustics and ultra-sonic influences on bottom hole formation zone and oil reservoir for oil recovery increase in the USA and the Soviet Union have reached their peak at the end of the 1970's and the beginning of the 1980's. Some examples of increase of the flow of oil caused by acoustic influences in the scales of oil deposits (USA, China) have recently stimulated considerable interest to such research. There are various viewpoints concerning the basic mechanisms of vibro-acoustic influences on filtration processes:

1) influence on heterogeneity of structure and stress condition of the multilayer system as a whole;

2) self-oscillatory and nonlinear filtration processes in the water-oil saturated porous media and possibility of resonance phenomena in seismic waves;

3) gassing from formation fluid;

4) changes in the viscoelastic characteristics of the formation fluid .

5) capillary phenomena;

6) change of wettability of the pore surface, etc.

The modern state of applied research on application of vibro-acoustic influences on an oil formation for oil recovery increase is characterized by the tendency to the development of laboratory experiments and industrial tests [2].

In this work on specially made and collected experimental installation for research of vibro-acoustic influence on flow in porous structures in which a two-dimensional transparent model of a real core is used, mobilization of drops of hydrocarbons jammed in narrowing's of pore channels is studied during their replacement by distilled water. The scheme of experimental installation is presented in fig.1.

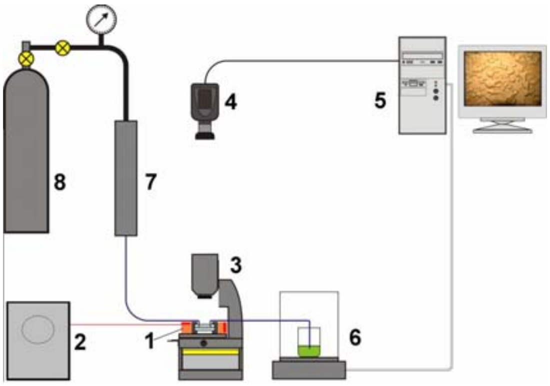

Fig. 1 Experimental set-up for flow visualization by vibro-acoustic impact: 1 – the porous sample in the thermostat with vibrators, 2 - generator, 3 - microscope, 4 - digital video-camera, 5 - computer, 6 - electronic scales, 7 - receiver, 8 - gas bag.

The experimental equipment consists of the porous sample placed in a copper thermostat with vibrators, vibration-acoustic impact is produced by the piezoceramic vibrators which are built into the thermostat block. As the porous sample a glass micro model of porous medium which is made with the help of photolithographic technique and represents a structure of pores of a real reservoir rock (a core from an oil reservoir) is used (fig2.). Voltage of the adjusted frequency (1-20000 Hz) and amplitude (1-100 V) is supplied to the vibrator. That allows the vibrator to oscillate with amplitude to 10 microns. The microscope and a digital video camera have been used for observation. Computer allows for the processing of video images obtained at different spatial scales (from scale of pores to scale since the model). Gas cylinder and receiver allow to specify necessary large pressure drop at the input and output of the model during the initial displacement of oil with distilled water. Further, in experiments on the displacement of residual oil in the acoustic field, a constant flow rate of fluid filtration and a fixed inlet pressure was set by the water column. The highly sensitive electronic scales interfaced to the computer have been used for measurement of the flow rate of a filterable liquid. The porous sample is saturated with oil or kerosene. Then degassed water filtered during 1-5 hours at the fixed inlet pressure of 0.2 MPa to stop the appearance of oil at the output of the model. Drops of oil trapped in pore restrictions remain in the model.

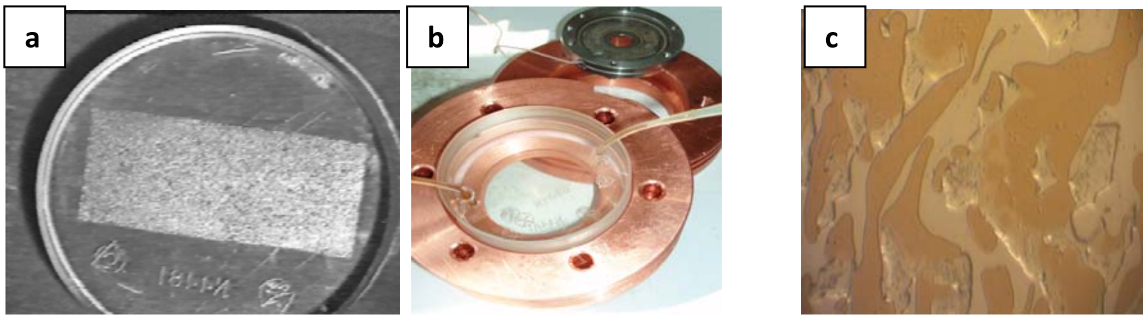

Fig. 2. Glass micromodel of porous medium which are made with the help of photolithographic technique and represents a structure of pores of real reservoir rock: a - plate with the structure etched in the top layer pore the channels displaying a picture of a pore unshlifte of a core (the sizes of a porous layer 40 x 20 mm, depth of a time 15-20 microns, permeability 600 mD, porosity 0.55). b - piezoceramic vibrators which are built into the thermostat block and glass micromodel, c- porous sample filled with oil and water.

Next, create a constant flow rate through the model with the residual oil at a fixed pressure at the inlet. Inlet pressure changed from 0.005 to 0.02 MPa (50 to 200 cm of water column), with an interval of 0.001 MPa (10 cm). For each fixed inlet pressure, gradually changed the frequency of vibro-acoustic effects from 1 to 20 000 Hz at maximum amplitude, while watching the behavior of oil droplets entrapped in the narrowing of pore channels.

Some results of research are presented in fig.3 and fig.4.

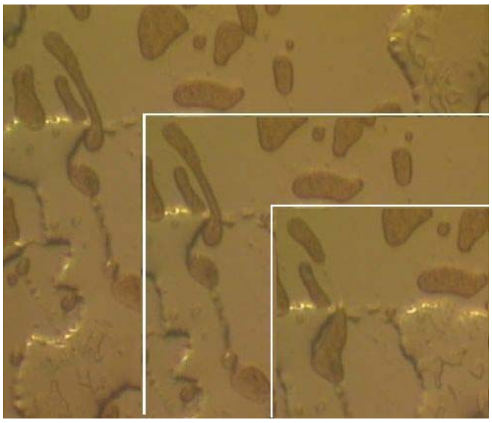

Fig.3. Mobilization of oil ganglia at the pressure 0.014 MPa and frequency 1.2 kHz

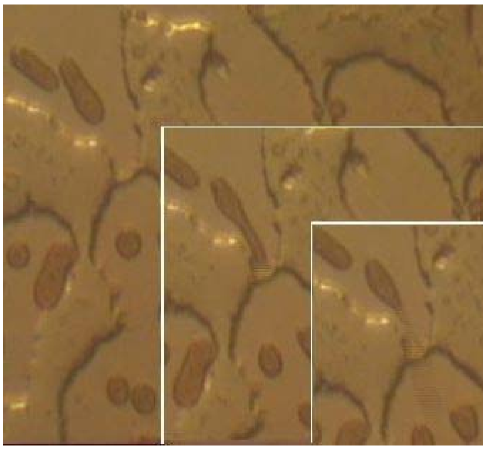

Fig.4. Mobilization of oil ganglia at the pressure 0.015 MPa and frequency 2.0 kHz

While changing the frequency characteristics of vibro-acoustic effect at the maximum amplitude the behavior of the oil drops jammed in restrictions of the pore channels was observed. It has been revealed, that under the vibro-acoustic effect the jammed drops of oil pass through restrictions of pore channels at a pressure gradient much smaller, than it is required for their mobilization without such effect. So the drops of oil jammed in narrowing's were motionless at a filtration of the water up to pressure 0.2 MPa on a model input. Furthermore it was observed that vibro-acoustic effect may lead to coalescence of oil ganglia.

References

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