The acoustic oscillation effect on the saturated pore-medium filtration characteristics with the purpose of oil recovery improvement and intensification of the flow

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Abstract. The article describes a perspective method of the acoustic effect on the saturated pore medium to increase filtration characteristics. A hypothesis of the effect of non-harmonic oscillations of a complex wave profile is formulated, including frequency spectra resonant with both the rock and saturating fluids, which together can cause a synergistic effect repeatedly increasing the filtration rate. A laboratory setup designed for this purpose has been also described.

1. Introduction
The acoustic effect on the reservoir is a promising way to improve the oil recovery and intensify the inflow. The existing theoretical and practical studies in this field indicate the effectiveness of the vibroacoustic effects both from the surface and from the well. [1] The low-frequency surface effects (or seismoacoustic effects), as well as the effect of the downhole wave radiators, contribute to the pressure redistribution and the oil extraction from the blind non-draining areas of the reservoir. [2] While a high-frequency acoustic field leads to a reduction in the oil viscosity, the splitting of the bottomhole zone.

2. Research
As part of the study of existing results on the acoustic effect on the saturated pore medium, the following features are established.

In the low-frequency range of exposure, an increase in the absolute permeability of the artificial core samples to 30% is observed, which is explained by the formation of new filter channels and the change in the packing and orientation of the porous grain medium constituents.

High-frequency and ultrasonic waves affect the rheological properties of non-Newtonian liquids, including oil. Some studies show a decrease in a shear viscosity by 20-30% immediately after exposure with frequencies up to 4.5 MHz and intensity up to 100 kW / m2. The paper [3] presents data on the reduction in the pour point of oils with a high content of paraffins and resins when they are treated with an ultrasonic field and when the dynamic viscosity of the oil decreases.

The filtering of polar and nonpolar liquids through sandstone core models is accelerated up to 10 times in a field of elastic vibrations with an intensity of 1.9 kW / m² and a frequency of 17 kHz. These effects are explained by the surface obliteration layers’ destruction, which leads to an increase in the effective pore cross section and reduces the resistance of liquid filtration.

At acoustic wave frequencies are from 1.2 to 2 kHz, the critical pressure gradient, which is necessary for filtering, is reduced. There is an enlargement of oil particles in the pore canals.
In the course of the experimentation, it was found that an oscillating field with a frequency of 60 Hz and an intensity of 46 W / m² promotes the additional oil displacement from the porous medium after the cessation of its extraction from the sample by the water displacement.

In the theory of the vibrational action, there is the notion of a certain force that arises in the field of elastic vibrations and affects the mobile unit volume.

In total, there are 4 types of similar asymmetries.

I. Power asymmetry
1) the constant force T;
2) the plane inclination relative to the horizon;
3) the difference in modulus of the resistance forces to the F motion.

II. Kinematic asymmetry
The asymmetry of the surface points’ vibration trajectory or the law of the motion along this trajectory. As an example, the harmonic oscillations along the rectilinear trajectory, inclined at a certain angle, are given.

III. Gradient asymmetry
The significant x coordinate dependence of the parameters that determine the motion of the particle.

IV. Wave asymmetry
The movement of the particle occurs in the direction of the traveling wave propagation or of individual impulsive waves.

All these types of asymmetry explain the appearance of the vibrational V force. Further investigations will be carried out taking these features into account.

Thus, due to the manifestation of certain types of asymmetries in the reservoir, when the elastic wave fields are superimposed, the effects that can be good for the filtration and oil displacement arise.

**Figure 1.** a) the physical picture of the asymmetry appearance in the field of elastic vibrations;

b) the introduction of a vibratory V force
To conduct research on the acoustic effect on the filtration process, a laboratory setup has been developed and assembled (Figure 2)

![Laboratory setup of the acoustic effect on the filtration process layout diagram](image)

The experiments on four groups will be performed by means of this laboratory setup, depending on the parameter being investigated: 1) the critical pressure gradient of the filtration beginning; 2) the coefficient of mobility; 3) the oil recovery factor; 4) the effective porosity factor. Figure 3 shows an approximate profile of the oscillation wave, the effect of which will be investigated with the help of this setup.
3. Conclusion
The study of the acoustic effect on saturated pore media makes it possible to conclude that there are resonance frequencies of the rock skeleton and saturating fluids, the impact on which leads to an increase in the filtration rate and an increase in the oil recovery factor. It is assumed that the complex wave profile elastic oscillations’ impact on the oil reservoirs will lead to the mobility factor increase and a more complete hydrocarbons’ recovery due to the displacement from the dead-end pores, the surface tension decrease and the pore medium destruction, leading to an increase in the effective porosity.

References:
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