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THE MECHANISM OF OIL DISPLACEMENT FROM FORMATIONS UNDER WATER-GAS IMPACT

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Annotation: Displacement is carried out under the action of hydrodynamic forces in the presence of a two-phase flow region. Gas displacement ratio is generally lower than water displacement ratio.
Keywords: reservoir oil, gas, dissolution, hydrocarbon gas, gas repression.

Reservoir oil and non-equilibrium gas - dry at high reservoir pressure or enriched, coming into contact with each other exchange components, changing their initial properties. The dissolution of gas in water-saturated oil increases the volumetric ratio of the oil and decreases its viscosity. Therefore, along with the enhancement of the clear flow regime under the water-gas impact, these factors contribute to a greater increase in the displacement coefficient compared to the injection of equilibrium (dry) gas and water.

The essence of the enhanced oil recovery method with a combination of high-pressure water and gas injection is to obtain high reservoir sweep achieved during waterflooding and high displacement capacity of hydrocarbon gas.

Based on modern concepts of oil displacement processes, there are three modifications of water-gas treatment:

1. Waterandgasrepression.
2. Water-gas treatment in the mode of limited solubility of injected gas and reservoir oil.
3. Water-gas treatment in miscible displacement mode.

The gas repression regime is characterized by the absence of mass transfer between the liquid and gas phases. Displacement is carried out under the action of hydrodynamic forces in the presence of a two-phase flow region. The gas displacement ratio of oil is generally lower than the water displacement ratio. The mode of limited mutual solubility is characterized by mass transfer between the liquid and gas phases, as a result of which a transition zone is formed. The composition and properties of the liquid and gaseous phases in the transition zone vary along their length, but there is a clear distinction between them due to the two-phase flow. The displacement factor in this regime is higher than the displacement factor during gas overbalance and may exceed the displacement factor during waterflooding.

The regime of inorganic mutual solubility (miscible displacement) occurs under certain thermodynamic conditions (pressure, temperature), the composition of the injected gas and oil. In this mode, the composition and properties of the filtering agent along the length of the transition zone change smoothly from the properties of reservoir oil to the properties of the injected gas. The displacement ratio is practically independent of the properties of the reservoirs and approaches unity. The unlimited solubility regime is an extreme case of the limited solubility regime. With an increase in the injected gas components C_2 and above, the displacement ratio increases. At a certain percentage of these components, the regime of unlimited solubility sets in.

The mode of mutual unlimited solubility can also be achieved by increasing the injection pressure. Even pure methane and oil at high injection pressures (60-70 MPa) will be mutually soluble. However, it is almost impossible to use this method due to the low reservoir pressures of the productive formations of most fields..

The efficiency of the gas injection process largely depends on the injection technology. When gas is injected in a state of complete mutual solubility, oil recovery is lower than the oil recovery of the waterflooding method. This is explained by the low coverage of the reservoir by the displacement process. The injected gas moves mainly through highly permeable layers. After a breakthrough into a production well, gas filtration proceeds through the gas-polluted layers due to a sharp decrease in their filtration resistance. Despite the complete displacement of oil from these interlayers, the total amount of oil produced is less compared to the waterflooding method. This is explained by the fact that the sweep rate is much higher in the waterflooding method, while the displacement rate itself is lower than the rate at gas injection in miscibility mode.

The main idea of using water-gas mixtures is to use the beneficial properties of water and gas as displacement agents. It was noted above that the miscible gas with oil displaces the volume occupied by the gas almost completely. Since the surface tension and the wetting angle at the water-gas and water-oil interface in the pore space can be assumed to be the same in the first approximation, the displacement coefficients of gas by water and oil by water will slightly differ.

Therefore, the water injected after gas injection will not completely displace the gas. The gas will be "pinched". The amount of trapped gas is determined from the results of laboratory experiments and is β (residual gas in fractions of the initial oil-saturated and effective pore volume). If a slug of miscible gas in excess of β is injected into the reservoir before water injection, the oil recovery factor of such a process will be maximum: the displacement factor is the same as when oil is displaced by a miscible gas, and the sweep efficiency is the same as in the waterflooding method.

Injecting miscible gas into the waterflooded reservoir will not change the picture. Being more "related" to oil, the gas will displace the residual oil after water to the residual oil after gas (naturally, the previously injected water will also be displaced).

When water is injected after gas, the residual gas and residual oil values will remain at the level of the first process, when gas displaced oil and water displaced gas.

From the foregoing, a possible industrial method of using water-gas mixtures follows - the injection of a slug of miscible (wet) gas into a flooded or completely oil-saturated reservoir, followed by pushing the slug with water, the efficiency of such a process will be high. The economic feasibility of applying the method significantly depends on the degree of waterflooding before the start of the injection of the gas rim, since before extracting additional oil from the injection of gas, the previously injected water must be extracted approximately in the volume of the oil displacement coefficient.

Applying the above reasoning to the case of gas injection in the partial dissolution mode, the second possible industrial method of using water-gas mixtures is substantiated - the injection of a gas rim in the partial miscibility mode into a flooded or completely oil-saturated reservoir, followed by pushing the gas rim with water.

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