The Sweep out of QAS by a Liquid with Viscous-Plastic Properties

Salavatov T.Sh., Dadash-zada M.A., Mansurova S.I.
Azerbaijan State University of Oil and Industry

Abstract: *The exploration of the sweep out of a gas by a liquid with anomalous properties was conducted. The analysis showed that the velocity of motijn the sweep out of during gas by a viscous-plastic fluid, also depends on the pressure corresponding to the beginning of the fluid animation. In this case the development time of the gas reservoir is extend, and pressure rebuild more effective when contour is not static.*

Keywords: *Speed of contour motion, development time, permeability, pressure of fluid animation beginning.*

I. Introduction

Great theoretical and practical interest of the sweep out of gas with liquids with different physical properties is occured. Practice shows that the gas sweep out in the well under effect the head of the edge waters, herewith occurs advancing contours water content during the development of gas fields under conditions of a water-drive.

Early works [1, 2, 3], consider questions about the sweepoutof gas by water, with taking into account the physical properties of the sweepout liquid. Often the authors did not take into account density variations of gas and liquid, which sweepout the gas.

Practice shows, that in a number of deposit there is a water-drive, in which the development of a gas deposit accompanied by the advancement of contour waters, leading to a decrease in the volume of the pore space of the gas-bearing part of the deposit. The analysis shows that the rate of the contour waters advancement depends on the rate of the reservoir pressure fall in the gas recervoir.

The pressure drop determines the decline of production rate of gas wells, which determines the required number of wells for maintain nance of preset level of gas production from the recervoir.

Numerous tasks of developing gas fields show that a amount of the possible rate of advance of the gas-water contente depend range of tasks and including the well spacing in the gas area. The advancing the contour, not take account this parameter a can chance to large checking in calculating gas reserves, which are determined from actual data on pressure drop and gas production. From the analysis make, the relevance actuality and great practical magnitude of this given is question.

In the article propose a method for sweepout a gas with a liquid with anomalous properties. Laboratory and theoretical studies show that variation in the physical properties of the liquid have a large degree of influence on the rate of advancement contact , which influence the rate fall of formation pressure.

With taking into account mentioned above, in this paper we consider the tasks of sweepout of a gas by a liquid with viscous-plastic properties. Prime, the sweepout of a gas with a liquid with anomalous properties under conditions of one-dimensional gas and liquid to the linear law of filtration is considered. Figure 1 shows the reservoir model. As can be seen from the figure, the formation area is limited by the power contour and the liquid-saturated contour. Formation area limited by the power contour, liquid contour and the gallery saturated with gas. We regard the rectilinear gallery as a series of wells, the character of the motion of liquid and gas to such series of wells arranged with straight line, in the form of a chain of wells along the contour line of gas reservoir.

We assume, that the gas flow rate, which is reduced to atmospheric pressure and reservoir temperature, the gas viscosity are constant, then the pressure at all points of the gas-bearing region, including the gas-bearing contour, will be the same and equal to the average –volume of formation gas-bearing region.

The analysis shows that during the study the motion of a liquid in the liquid area, it is considered as a contour of the formation as an isobar. Then the velocity of the fluidity contour can be defined as:

$$\vartheta = \frac{k}{m\xi}\frac{P_c - \overline{P} - \Delta P_0}{x} \tag{1}$$

where ϑ - is the velocity of the liquid contour with viscous-plastic properties;
k -permeability of the formation over the liquid;
m -porosity of the formation;
P_c - pressure on the formation contour;
ξ -structural viscosity of a viscous-plastic fluid;
ΔP_0 - pressure corresponding to the beginning of the fluid with viscous-plastic properties flow;
$\overline{P}$ - weighted average pressure.

Should be noted, that the weighted average pressure in the gas reservoir changes with time as it would change under conditions of the gas regime at which the contour does not move. Then according to the laws of underground hydromechanics:

$$\overline{P} = \frac{P_c\Omega - Q_g P_0 t}{\Omega} \tag{2}$$

Where Ω = (L_c-x_0) B·h·m - is the initial volume of the pore space in the gas-bearing area;h- formation thickness;
P_c-is the initial pressure equal to the contour pressure;
t-time, expiration from the beginning of the development of the gas reservoir;
P_0 - atmospheric pressure;
B -is the formation width.
Solving these equations together, we have:

$$\vartheta = \frac{k}{m\xi}\left(\frac{Q_g P_0 t}{x\Omega} - \frac{\Delta P_0}{x}\right) \tag{3}$$

Displacement of the fluidity contour for an elementary period of time is equal to:

$$\vartheta = \frac{dx}{dt} = \frac{k}{m\xi}\left(\frac{Q_g P_0 t}{x\Omega} - \frac{\Delta P_0}{x}\right) \tag{4}$$

After dividing the variables, have

$$xdx = \frac{k}{m\xi}\left(\frac{Q_g P_0 t}{x\Omega} - \frac{\Delta P_0}{x}\right)dt \tag{5}$$

Integrating this equation with following boundary conditions

x = x_0 ; t = 0

x = x_b ; t = 0

We have

$$x_v = \sqrt{x_0^2 + \frac{k}{\xi}\left(\frac{Q_g P_0 t^2}{\Omega} - 2\Delta P_0 t\right)} \tag{6}$$

whereQ_g -is the production of the formation gas per time unit.
Taking into account the initial volume of pore space in the gas-bearing area:

$$x_v = \sqrt{x_0^2 + \frac{k}{\xi}\left(\frac{Q_g P_0 t^2}{(L_c - x_0)Bhm^2} - 2\Delta P_0 t\right)} \tag{7}$$

This formula makes it possible to determine the position of the liquid contour at any point in time under conditions of development of a gas reservoir, when a quantity of gas is constant per time unit.

This formula shows the dependence of the advancing of the contour of liquid with viscous-plastic properties according on various parameters, including permeability, porosity, structural viscosity, the size of the gas reservoir, the distance from the feed to the liquid contour and the pressure, corresponding to the beginning of flow of the fluid with viscous-plastic properties .

To determine the dependence of the final advance of the contour with accordance of the development rate of the gas deposit, the above-determined formulas can determine, instead of time, the time for the complete extraction of gas from the deposit

$$T = \frac{\Omega P_c}{P_0 Q_g} = \frac{mBh(L_c - x_0)P_c}{P_0 Q_g} \quad (8)$$

Then we have

$$x_{ult} = \sqrt{x_0^2 + \frac{P_c kT}{\xi m}\left(1 - \frac{2\Delta P_0}{P_c}\right)} \quad (9)$$

As can be seen from the formula, when the rate of gas extraction is characterized by the gas flow rate, the final value of the fluid contour with viscous-plastic properties decreases, i.e,

$$x_{ult} = \sqrt{x_0^2 + \frac{k(L_c - x_0)BbP_c^2}{\xi Q_g P_0}\left(1 - \frac{2\Delta P_0}{P_c}\right)} \quad (10)$$

As can be seen from the formula, the finite value of the advancing of the liquid contour with anomalous properties decreases, with an increase in the anomalous properties of the displaced liquid.
Now let's define the time of the gas deposit development:

$$T = \frac{\xi m(x_{ult}^2 - x_0^2)}{kP_c(1 - \frac{2\Delta P_0}{P_c})} \quad (11)$$

As can be seen from the displacement of a gas of a liquid with viscous-plastic properties, the development time of the gas deposit increases. Experiments and field observations have shown that the increase of the development time of the gas reservoir and the more effective pressure recovery in it due to the advancement of the contour. This increases the coverage of the gas part of the formation. In the case when $\Delta P_0=0$ we have the well-known formula given in [3].

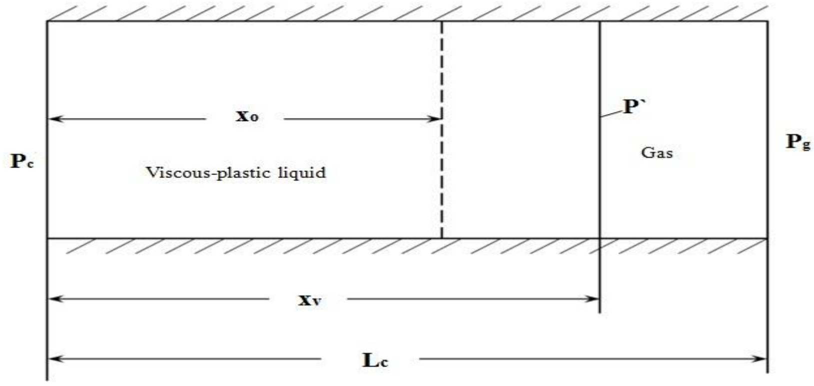

Fig.1. Sweepout of gas with viscous-plastic liquid reservoir model.

Conclusions: When gas is expelled by a viscous-plastic fluid, the time development time of a gas reservoir increases.

The analysis carried out shows that with the increase in the development time of the gas deposit, the effect of pressure recovery in the formation increases due to the advance of the contour, which leads to an increase in the coverage of the gas reservoir.

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