

Simulation of gas condensate deposits development

Garib I. Jalalov · Khasay A. Feyzullayev ·
Mubariz S. Khalilov

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Abstract. *A computational method has been developed, which allows modeling the process of gas-condensate systems inflow on a gas mode to the well system, as well as various methods of influencing the reservoir and the well bottom zone. The regularity of the accumulation of retrograde condensate in the deposits and the well bottom zone and the high efficiency of the well bottom zone treatment with various gases in order to increase their productivity even in the final stage of development have been established.*

Keywords. gas-condensate mixture · retrograde condensate · volatility of components · composition of vapor and liquid phases · reservoir porosity and permeability

Mathematics Subject Classification (2010): 76N25, 80A17, 76T10

1 Introduction

The effectiveness of development deeply embedded deposits, reached value of depth resources extraction coefficient and dynamics of extracted production component composition are determined considerably with mass-exchange processes and physicochemical properties of layer fluids phases. Therefore, to predict of the development such fields and investigation of sought regularities, usage of models based on multicomponent filtration theory is required. Gas-condensate fields belong to difficult development of objects with intensive phase transitions and considerable alterations of physicochemical properties of

G.I. Jalalov
Oil and Gas Institute of Azerbaijan National Academy of Sciences,
9, F. Amirov st., Baku, Azerbaijan AZ1000
E-mail: dzhalalovgarib@rambler.ru

Kh.A. Feyzullayev
SOCAR's "Oil Gas Scientific Research Project" Institute
H. Zardabi Av., 88a, Baku, Azerbaijan AZ1122
E-mail: feyzullayev_xasay@gmail.com

M.S. Khalilov
Baku State University
Z. Khalilov st., 23, Baku, Azerbaijan AZ1148
E-mail: khalilov_mubariz@mail.ru

filtrated phases. It is necessary to view two-phase filtration flows during research of exploitation tasks in exhaustion mode (full or partial maintenance of layer pressure) of layer energy. This is caused by retrograde processes occurred everywhere or in separate zones of the productive layer. As a result, filtration of gaseous and liquid phases may be possible. At the same time, initial gas-condensate system is demonstrated with N hydrocarbon and not hydrocarbon components. The forecasting of natural-gas condensate fields exploitation efficiency at filtration of multicomponent hydrocarbon mixes with phase transitions is possible only through mathematical modelling methods [8, 9].

2 Formulation of the problem

On the basis of assumption about local thermodynamic equilibrium of phases and Darcy's law validity, isothermal filtration of multicomponent gas-condensate mix is described by differential equations system [8, 9]:

$$\begin{aligned} & \nabla \left[\left(\frac{khf_L(s_L)\rho_L}{\mu_L M_L} x_i + \frac{khf_V(s_V)\rho_V}{\mu_V M_V} y_i \right) \nabla p \right] = \\ & = \frac{\partial}{\partial t} \left[mh \left(\frac{\rho_L s_L}{M_L} + \frac{\rho_V s_V}{M_V} \right) z_i \right] \pm \sum_{\nu=1}^n Q_i^\nu(t) \delta(x - x_\nu) \delta(y - y_\nu), \\ & i = \overline{1, N}, (x, y) \in D, t \in (0, T), \end{aligned} \quad (2.1)$$

where $f_V(s_V)$ and $f_L(s_L)$ relative phase permeabilities, for gas and liquid phases; s_V and s_L coefficients of porous environment saturation, for vapour and liquid phases accordingly; p -pressure; t -time; x_i, y_i - molar content of the i component in liquid and gas phases accordingly; z_i - summary molar content of the i component in the mix; ρ_V and ρ_L - molar density of gas and liquid phases accordingly; M_L and M_V average molecular weight of liquid and gas phases accordingly; $\delta(\cdot)$ -Diracs function; $Q_i^\nu(t)$ - density of the ν source (drain) by the i component at the moment of t ; x_ν, y_ν - coordinates of the fifth elementary source(drain); n -number of elementary sources (drains).

Besides, ratios have to be carried out:

$$\sum_{i=1}^N x_i = \sum_{i=1}^N y_j = 1, \sum_{i=1}^N z_i = 1. \quad (2.2)$$

Meeting existence condition of local thermodynamic equilibrium, system of equations (2.1) is closed by following ratios:

$$\begin{aligned} \rho_V &= \rho_V(P, T, z_1, z_2, \dots, z_{N-1}, z_N), \rho_L = \rho_L(P, T, z_1, z_2, \dots, z_{N-1}, z_N), \\ \mu_V &= \mu_V(P, T, z_1, z_2, \dots, z_{N-1}, z_N), \mu_L = \mu_L(P, T, z_1, z_2, \dots, z_{N-1}, z_N), \\ s_V &= 1 - s_L, s_L = \frac{(1 - V) \rho_V M_L}{(1 - V) \rho_V M_L + V \rho_L M_V}. \end{aligned} \quad (2.3)$$

Properties of gas and liquid phases (2.3), which are necessary at solving of the equations system (2.1), (2.2) are determined from system of $2N + 2$ equations [7, 8]:

$$\begin{cases} f_{i,L} - f_{i,V} = 0, i = \overline{1, N} \\ x_i L + y_i V - z_i = 0, i = \overline{1, N} \\ \sum_{i=1}^N y_i - 1 = 0 \\ L + V = 1 \end{cases} \quad (2.4)$$

In the system (2.4), the first N equations describe conditions of thermodynamic equilibrium equality of component volatility in the coexisted vapour and liquid phases. Volatilities of the components in vapour $f_{i,V}$ and liquid $f_{i,L}$ phases are calculated on the basis of well-known thermodynamic ratios, using equations of phases state [5, 7, 10].

Calculation of phase equilibrium using equations of state is based on precise application of classic thermodynamic positions of multicomponent systems to equality of the mix components chemical potentials in all corresponding phases.

Calculation algorithm of the vapour and liquid phases composition consists of the following [8]:

1. Initial information is set: critical temperature T_c and pressure p_c , and also acentric factor ω - for each component of the viewing system; composition of the initial mix in molar portions; working pressure p and temperature T .

2. Initial approaches of distribution coefficients are calculated for every component by the formula [5], which provides better convergence reckoning algorithms.

$$k_i^0 = \left\{ \frac{p_{ci}}{p} \exp \left[5.372697(1 + \omega_i) \left(1 - \frac{T_{ci}}{T} \right) \right] \right\}. \quad (2.5)$$

3. Phase concentrations are calculated

$$\sum_{i=1}^N (y_i - x_i) = \sum_{i=1}^N \frac{z_i(k_i - 1)}{V(k_i - 1) + 1} = 0, \quad (2.6)$$

and molar portion of gas phase V is determined and accordingly molar portion of liquid phase L , as $1 - V = L$.

4. Molar portions of component mix in vapour y_i and liquid x_i phases are found with help of the equations

$$y_i = z_i k_i / [V(k_i - 1) + 1], x_i = z_i / [V(k_i - 1) + 1]$$

5. Coefficients a , b and c of equation of state are solved [5]

$$p = RT \left[\frac{1}{V - b} - \frac{a}{V(V + c)} \right], \quad (2.7)$$

by formulas

$$a = \frac{\alpha R^2 T_c^2}{p_c} \varphi(T), b = \frac{\beta R T_c}{p_c}, c = \frac{\delta R T_c}{p_c},$$

$$\alpha = \Omega_c^3, \beta = Z_c^* + \Omega_c - 1, \sigma = -Z_c^* + \Omega_c \left[0.5 + (\Omega_c - 0.75)^{1/2} \right],$$

$$\delta = -Z_c^* + \Omega_c \left[0.5 - (\Omega_c - 0.75)^{1/2} \right], \varphi(T) = \left[1 + \Psi \left(1 - \left(\frac{T}{T_c} \right)^{0.5} \right) \right]^2, \varphi(T_c) = 1.$$

In addition, equation of state (2.7) is the most accurate indicator of system phase state at the big range of pressures and compositions. Values of the equation of state parameters for oil-gas-condensate system components are given in Table 1. Equation of state coefficients for liquid phase:

$$a_m = \sum_{i=1}^N \sum_{j=1}^N x_i x_j a_{ij}, a_{ij} = (1 - c_{ij}) (a_i a_j)^{0.5}, b_m = \sum_{i=1}^N x_i b_i, c_m = \sum_{i=1}^N x_i c_i,$$

$$A_m = a_m \frac{p}{R^2 T^2}, B_m = b_m \frac{p}{RT}, C_m = c_m \frac{p}{RT},$$

$$B_i = b_i \frac{p}{RT}, C_i = c_i \frac{p}{RT}, (i = \overline{1, N}).$$

Equation of state coefficients for vapour phase:

$$a_m = \sum_{i=1}^N \sum_{j=1}^N y_i y_j a_{ij}, b_m = \sum_{i=1}^N y_i b_i, c_m = \sum_{i=1}^N y_i c_i,$$

$$A_m = a_m \frac{p}{R^2 T^2}, B_m = b_m \frac{p}{RT}, C_m = c_m \frac{p}{RT},$$

$$B_i = b_i \frac{p}{RT}, C_i = c_i \frac{p}{RT}, (i = \overline{1, N}).$$

Table.1.

Substance	Ω_c	Z_c^*	Ψ
Nitrogen	0,75001	0,34626	0,37182
Dioxide	0,75282	0,31933	0,74212
Hydrogen sulfide	0,78524	0,30418	0,38203
Methane	0,75630	0,33294	0,37447
Ethane	0,77698	0,31274	0,49550
Propane	0,76974	0,31508	0,53248
Isobutane	0,78017	0,30663	0,63875
H-Butane	0,76921	0,31232	0,57594
	0,75001	$Z_c^* = 0,3357 - 0,0294\omega$	$\Psi = 1,050 + 0,105\omega + 0,482\omega^2$ $\omega < 0,4489$; $\Psi = 0,429 + 1,004\omega + 1,561\omega^2$ $\omega \geq 0,4489$

6. Cubic equation regarding the compressibility z is solved:

$$z^3 + (C - B - 1)z^2 + (A - BC + C)z - AB = 0. \quad (2.8)$$

Therefore, ρ_L and ρ_V are determined with following way:

$$\rho_L = \rho_L^{at.} \frac{pT_0}{p_0 T M_L} \cdot \frac{1}{z_{\min}},$$

where p_0 - atmospheric pressure; T_0 - working temperature; $M_L = \sum_{i=1}^N x_i M_i$; $M_V = \sum_{i=1}^N y_i M_i$; M_i molecular mass of the i component.

7. Sequentially, volatilities of components in vapour $f_{i,V}$ and liquid $f_{i,L}$, liquid phases are determined:

$$\ln f_{i,V} = \ln(y_i p) - \ln(z - B_m) - \frac{A_m}{(C_m - D_m)} \left(\frac{2 \sum_{i=1}^N y_i a_{ij}}{a_m} - \frac{c_i - d_i}{c_m - d_m} \right) \times$$

$$\begin{aligned}
& \times \ln \left(\frac{z + C_m}{z + D_m} \right) + \frac{B_i}{z - B_m} - \frac{A_m}{C_m - D_m} \left(\frac{C_i}{z + C_m} - \frac{D_i}{z + D_m} \right) \\
\ln f_{i,L} = & \ln(x_i p) - \ln(z - B_m) - \frac{A_m}{(C_m - D_m)} \left(\frac{2 \sum_{i=1}^N x_i a_{ij}}{a_m} - \frac{c_i - d_i}{c_m - d_m} \right) \times \\
& \times \ln \left(\frac{z + C_m}{z + D_m} \right) + \frac{B_i}{z - B_m} - \frac{A_m}{C_m - D_m} \left(\frac{C_i}{z + C_m} - \frac{D_i}{z + D_m} \right). \quad (2.9)
\end{aligned}$$

8. Distribution coefficients of components mix are corrected by the formula:

$$k_i^{(m)} = k_i^{(m-1)} f_{i,L} / f_{i,V}, i = 1, 2, 3, \dots, N. \quad (2.10)$$

9. Carrying out of inequality is checked

$$|(f_{i,L} / f_{i,V}) - 1| > \epsilon, i = 1, 2, 3, \dots, N. \quad (2.11)$$

If this condition is observed at least for a component, then return to Points 3 is carried out. Otherwise, found compositions of vapour and liquid phases (y_i and x_i) are equilibrium and reckoning has been completed.

At the forecasting of indicators of natural-gas condensate deposit exploitation, it is necessary to take the following initial and boundary conditions under consideration:

$$p(x, y, t) |_{t=0} = p_0(x, y), (x, y) \in D, \quad (2.12)$$

$$z_i(x, y, t) |_{t=0} = z_i^0(x, y), i = 1, 2, \dots, N, (x, y) \in D, \quad (2.13)$$

$$\left. \frac{p(x, y, t)}{\partial n} \right|_{\Omega} = 0, (x, y) \in \Omega, t \in (0, T). \quad (2.14)$$

Initial conditions (2.12)-(2.13) take distribution of phase pressure and compositions into account by gas content area. Condition (2.14) characterizes the condition of external board Ω impermeability of deposit productive zone D .

Above-mentioned closed equation system of initial and boundary conditions allows to model processes of extraction exploitation and technological parameters.

3 The numerical algorithm for solving the problem

Introducing the notation

$$\Phi_i(p, s_L, s_V) = kh\alpha_i, \Psi(p, s_L, s_V) = mh\varphi, \frac{\partial \Psi}{\partial p} = \Psi'_p, \frac{\partial \Psi}{\partial s_L} = \Psi'_{s_L},$$

$$\alpha_i = \frac{1}{1 + V(k_i - 1)} \left(\frac{f_L \rho_L}{\mu_L M_L} + k_i \frac{f_V \rho_V}{\mu_V M_V} \right), i = 1, 2, \dots, N - 1;$$

$$\varphi = \frac{s_L \rho_L}{M_L} + \frac{s_V \rho_V}{M_V}; \bar{Q}^\nu(t) = \sum_{i=1}^N Q_i^\nu(t); \alpha = \sum_{i=1}^N \alpha_i;$$

and applying to the given system (2.1),(2.12)-(2.14) integro-interpolation method, numerical solving of the task in uneven grids knots (x_5, y_j, t_n) will be found in form of the following differential tasks:

$$\begin{aligned} & \frac{1}{\Delta x_e} \left[\Phi_{ie+1/2,j}^{n+1} \frac{p_{e+1,j}^{n+1} - p_{e,j}^n}{\Delta x_{e+1/2}} - \Phi_{ie-1/2,j}^{n+1} \frac{p_{e,j}^{n+1} - p_{e-1,j}^{n+1}}{\Delta x_{e-1/2}} \right] + \\ & + \frac{1}{\Delta y_j} \left[\Phi_{ie,j+1/2}^{n+1} \frac{p_{e,j+1}^{n+1} - p_{e,j}^{n+1}}{\Delta y_{j+1/2}} - \Phi_{ie,j-1/2}^{n+1} \frac{p_{e,j}^{n+1} - p_{e,j-1}^{n+1}}{\Delta y_{j-1/2}} \right] = \\ & = \left(\psi'_{pe,j} \frac{p_{e,j}^{n+1} - p_{e,j}^n}{\Delta \tau} + \psi'_{sLe,j} \frac{s_{Le,j}^{n+1} - s_{Le,j}^n}{\Delta \tau} \right) z_{ie,j}^{n+1} + \\ & \quad + \psi_{e,j}^n \frac{z_{ie,j}^{n+1} - z_{ie,j}^n}{\Delta \tau} \pm \sum_{\nu=1}^M Q_{ie,j}^{\nu n+1}, \end{aligned} \quad (3.1)$$

$$\begin{aligned} & \frac{1}{\Delta x_e} \left[\alpha_{e+1/2,j}^{n+1} \frac{p_{e+1,j}^{n+1} - p_{e,j}^{n+1}}{\Delta x_{e+1/2}} - \alpha_{e-1/2,j} \frac{p_{e,j}^{n+1} - p_{e-1,j}^{n+1}}{\Delta x_{e-1/2}} \right] + \\ & + \frac{1}{\Delta y_j} \left[\alpha_{e,j+1/2}^{n+1} \frac{p_{e,j+1}^{n+1} - p_{e,j}^{n+1}}{\Delta y_{j+1/2}} - \alpha_{e,j-1/2}^{n+1} \frac{p_{e,j}^{n+1} - p_{e,j-1}^{n+1}}{\Delta y_{j-1/2}} \right] = \\ & = \psi'_{pe,j} \frac{p_{e,j}^{n+1} - p_{e,j}^n}{\Delta \tau} + \psi'_{sLe,j} \frac{s_{Le,j}^{n+1} - s_{Le,j}^n}{\Delta \tau} \pm \sum_{\nu=1}^M \bar{Q}_{e,j}^{\nu n+1}, \end{aligned} \quad (3.2)$$

$$\begin{aligned} p_{e,j}^0 &= p_{0e,j}, e = 1, 2, \dots, N_x; j = 1, 2, \dots, N_y, \\ z_{ie,j}^0 &= z_{0ie,j}, i = 1, 2, \dots, N, \end{aligned} \quad (3.3)$$

$$\begin{aligned} p_{0,j}^n &= p_{1,j}^n, j = \overline{1, N_y}; n = 1, 2, \dots, \\ p_{N_x-1,j} &= p_{N_x,j}; p_{e,0}^n = p_{e,1}^n; p_{e,N_y-1} = p_{e,N_y}^n, i = 1, \overline{N_x}, \end{aligned} \quad (3.4)$$

where

$$s_{Le,j}^n = \frac{(1-V) \rho_{ve,j}^n M_{Le,j}}{(1-V) \rho_{ve,j}^n M_{Le,j} + V \rho_{Le,j}^n M_{Ve,j}} \Delta \tau = \frac{t_n}{n}, n = 1, 2, \dots$$

$$x_{e+1/2} = x_e + \frac{1}{2} \Delta x_{e+1/2}, \Delta x_{e+1/2} = x_{e+1} - x_e, e = \overline{1, N_x},$$

$$y_{j+1/2} = y_j + \frac{1}{2} \Delta y_{j+1/2}, \Delta y_{j+1/2} = y_{j+1} - y_j, j = \overline{1, N_y},$$

$$\Delta x_e = \frac{1}{2} (x_{e+1/2} + x_{e-1/2}), e = \overline{0, N_x}, x_1 = 0, x_{N_x} = l_{x_1}, N_{x_1} = N_x + 1,$$

$$\Delta y_j = \frac{1}{2} (y_{j+1/2} + y_{j-1/2}), j = \overline{0, N_y}, y_1 = 0, y_{N_y} = l_{y_1}, N_{y_1} = N_y + 1.$$

System solving algorithm (3.1)-(3.4) consists of the following. Pressure area is found from the equations (3.2) by point-to-point method of Jacobi [6]. Further, concentration area is found from the equations (3.1) for components. Before beginning of the calculations, vapour-liquid equilibrium is reckoned on each step to get α_i and φ .

(3.1)-(3.2) is conservative by all i . However, the condition $\sum_{i=1}^N z_{ie,j} = 1$ in each knot of grid (e, j) is carried out inaccurately, and with an error $o(\tau)$, which does not allow it to be entirely conservative. Corrector is entered to eliminate this deficiency, giving specified value of pressure p and compositions z_i . At the same time, it is necessary to solve the first $(N - 1)$ differential equations (3.1) to determine z_1, z_2, \dots, z_N and z_N may be found from $\sum_{i=1}^N z_i = 1$ condition.

A program was developed to realize the described algorithm and a certain sample has been viewed.

4 Forecasting performance of the process of treatment well bottom hole zone by gas injection

Forecasting of technological indicators of development was implemented on (as a sample) V block of Bulla-Deniz natural-gas condensate field VII horizon which is the most shipped gas-condensate field of the country.

We can note the following specifics deep mining Bulla-Deniz on main object-deposit of VII horizon: very high initial layer pressure more than 71 MPa and high well productivity. Deposit temperature was 102°C , pressure in the beginning of was approximately 71 MPa. Density of liquid phase 800 kg/m^3 , molecular mass - 160, gasoline content of gas phase 362 g/m^3 .

Layer gas-condensate mix of researching object is characterized with the following initial average composition (molar portion, %) methane 88.69; ethane 4.11; propane 1.47; butane 0.77; pentane plus high-boilings; carbon dioxide 0.02.

Structural map of VII horizon V block, current gas and condensate outputs of researching object by wells and physical properties of phases and component portions in each phase (determined with analytic way by equation of state (2.7), coming from component composition of the mix at the current pressures and temperatures) may be taken from [8]. Relative permeabilities of gas and condensate were found at the adaptation of hydrodynamic model by development history data of this field:

$$f_V(s_L) = 0.9 \cdot (1 - s_L)^{2.89}, f_L(s_L) = 0.78 \cdot s_L^2.$$

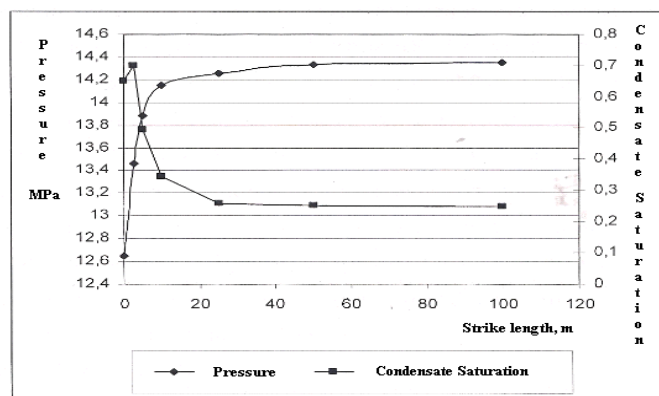


Fig. 1. Distribution profile of pressure and condensate-saturation by layer striking (well 46)

Using above-mentioned mathematical modeling of multicomponental filtration of hydrocarbons, accumulation mechanism of retrograde condensate in bottom hole of the well and its fluidity features in the process of deposit exploitation have been researched, and the results of calculations are presented on the Fig.1. (46th well, as a sample). Accordingly, distribution profile of pressure and saturation of collector with condensate in the bottom hole zone. According to implemented researches (Fig. 1.), process of retrograde condensate accumulation is developing with the following way. At the initial moment, high saturation zone has formed around the well, which has extended into the deep of layer, eventually. Then, the saturation at the bottom hole of well is commenced decrease. Gradual reduction of saturation was followed by profile saturation smoothing. Maximal radius of high saturation zone of collector with liquid at the moment of its disbandment was 50-60 m.

Accumulation of retrograde condensate at the gas-condensate well bottom hole is among the main causes of its productivity decrease. So, it is proper to use retrograde condensate eliminating (from the bottom hole zone) methods to increase productivity. "Dry" hydrocarbon gas or "dry" gas, which contains nitrogen or carbon dioxide with various ratios, was used to delete retrograde condensate. It should be noted that the impact on retrograde condensate of different gases was studying in numerous experiments on physical layer models [1-4], and these experiments was mainly conducted by researching basic features of mass-exchange processes between phases and evaporation effectiveness of different liquid components into gas phase. So, the experiment results are interesting from point of bottom hole zone processing of gas-condensate wells and they confirm the possibility of retrograde condensate eliminating from layer bottom hole zone with "dry" gas by its evaporation and transfer in gas phase into layer deep. However, they can not give full review on between gas-condensate mix and forced "dry" gas in well bottom hole conditions. This is due to considerable alteration of gas-condensate mix component composition and retrograde liquid, values of pumped "dry" gas and also thermobaric conditions by well bottom hole zone capacity.

On the basis of above-mentioned mathematic modelling, physical phenomena arising during processing of well 46 bottom hole with "dry" gas. According to [1], required amount of pumped "dry" gas will be 3.6 mln. m³. The result of forecast calculations after the processing by "dry" hydrocarbon gas is showed on the Fig. 2. The distribution of collector condensate-saturation at its processing with "dry" gas is indicated on this picture. Such processing of the well allows eliminating of condensate from a certain zone (5-10 m radius) around the well. The productivity is increasing at the initial moment by 1.8 times during well exploitation after its processing (Fig.2.).

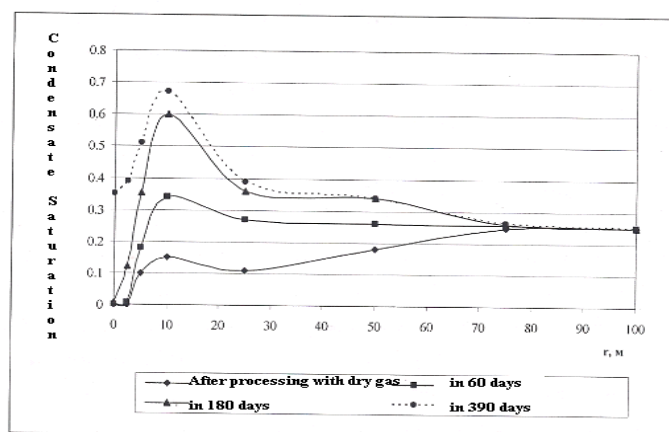


Fig. 2. Condensate-saturation alteration of collector at the bottom hole zone (well 46) in exploitation after its processing with dry gas.

Well exploitation process after its processing is followed by repeated accumulation of liquid phase at the well bottom hole. On the viewed sample, exploitation of the well with 1.4 MPa depression leads to condensate-saturation at the well bottom hole in a month. Maximum value of the saturation with liquid phase is increasing to 0.25-0.28. The zone with high saturation values not only extends, but also approaches the well. In the course of time, high saturation zone extends towards the well and in 5 months after the processing, saturation at the well bottom hole increases to 0.17-0.19 at the stable value of maximal saturation. Exploitation of the well continues until the equality of its productivity and measurements values according to period before "dry" gas pumping. Their term is 390 days. Accumulated at the well bottom hole condensate possesses mobility only in very small zone (radius 5-10m) where condensate-saturation is higher than threshold values of its mobility. Outside this zone, it is not mobile. Layer liquid-saturation is decreased by "dry" gas pumping, mainly because of intermediate and heavy components evaporation. Therefore, it is enriching of pumped gas by these components, but liquid phase remained in the processing zone turned out to be non-equilibrium gas phase in layer system. At the same time, liquid remained after processing is near the well. Along with the dry hydrocarbon gas, non-hydrocarbon gases such as nitrogen and carbon dioxide with different ratios can also be used as gaseous agents for the removal of retrograde condensate. The difference in the nature of the interaction of hydrocarbon and non-carbon-hydrogen gases with a retrograde liquid is manifested in the preferential evaporation of various fractions and components of the liquid. This leads to a different quantitative change in the condensate saturation of the well bottom zones when they are treated with different types of gas agents. The results of the calculations are presented in Table 2 of which shows that the use of non-hydrocarbon gases in the composition of the dry gas can be effectively used to increase the productivity of producing wells.

Table 2.

Composition of pumped gas	Pumping value, mln. m ³	Well discharge				Estimated extraction without processing		Additional summary extraction after processing	
		before processing		after processing		by condensate, t/day	by gas, ths. m ³ /day	by condensate, t/day	by gas, ths. m ³ /day
		by condensate, t/day	by gas, ths. m ³ /day	by condensate, t/day	by gas, ths. m ³ /day				
-	-	12.0	210.4	-	-	4680	82056	-	-
"Dry" gas	3.6	-	-	5.54	239.3	-	-	1378.9	11300
"Dry" gas with nitrogen	3.6, including "dry" gas-2.81, N ₂ -0.79	-	-	14.83	240.4	-	-	1046.7	11000
"Dry" gas with carbon dioxide gas	3.6, including "dry" gas-2.52, CO ₂ -1.08	-	-	15.77	236.2	-	-	1566.0	10700

5 Conclusions

The developed mathematical model of equilibrium filtration of a multicomponent gas-condensate mixture taking into account phase transitions, as well as the method and software of numerical solution of equations allow to simulate various mining options both in depletion mode and using various modifications of the bottom-hole gas treatment technology to increase gas condensate productivity.

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