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INTERMEDIATE MODEL FOR FLUID FILTRATION IN MULTI-LAYERED OIL FIELDS

Tuhtanazarov Dilmurod Solijonovich,
International Islamic Academy of Uzbekistan, Tashkent, Uzbekistan.

Abstract
The motion of gas and oil to the chinks in the layer is very complicated. When the layer is multilayered, the process becomes even more complex. For the research of such tasks, certain number of works were dedicated and studied.

INTRODUCTION

Based on the study of the problems in interacting layers, so-called intermediate model (IM) was proposed in the work[1]. In the current article, this model is applied for the solution of three-layer interacting formation.

Problem statement. Setting tasks on general model.

It is supposed that there is a three-layer interacting stratum with the domain D, with medium one is well permeable and the two extremes are poorly permeable jumpers. Determining the continuous function of the pressure $P_i(x,y,z,t)$, which satisfies the system of differential equations, is required

$$\frac{\partial}{\partial x}\left(K_i(x,y,z)\frac{\partial P_i}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_i(x,y,z)\frac{\partial P_i}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_i(x,y,z)\frac{\partial P_i}{\partial z}\right)= \\ =M_i(x,y,z)\frac{\partial P_i}{\partial t}+F_i(x,y,z,t) \qquad (1)$$

With the initial

$$P_i(x,y,z,0)=\varphi_i(x,y,z) \qquad (2)$$

And the boundary conditions

$$\left.\frac{\partial P_i}{\partial n_0}\right|_{\Gamma}=0 \qquad (3)$$

here n_0 - is outward normal to G; G- is the surface of the area of the filtration D that is under consideration. As a function of $\varphi_i(x,y,z)$, often constant value, which characterizes un-disturbance of the stratum, is taken at the initial stage, neglecting the weight of the liquid column within the power of interlayer i. According to the model Hantusha, instead of solution of problems (1)-(3), we get more simplified problem

[1]Samarskiy A.A. Introduction to the theory of difference schemes.- M.: Nauka, 1971. – p.455 (in Russian).

$$\left.\begin{array}{l}\frac{\partial}{\partial x}\left(K_2\frac{\partial\vartheta_2}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_2\frac{\partial\vartheta_2}{\partial y}\right)=M_2\frac{\partial\vartheta_2}{\partial t}+\overline{F}(x,y,t)-q_{n2};\\ \vartheta_2=\frac{1}{h_2-h_1}\int_{h_1}^{h_2}P_2(x,y,z,t)dz;\\ \vartheta_2\big|_{t=0}=\overline{\varphi}_2(x,y);\quad P_i\big|_{t=0}=\varphi_i(x,y,z);\\ P_1\big|_{z=h_1-0}=\vartheta_2\big|_{z=h_1+0};\qquad P_3\big|_{z=h_2+0}=\vartheta_2\big|_{z=h_2-0};\\ q_{n2}=q_{n1}+q_{n3},\quad q_{ni}=\frac{K_n}{h_i-h_{i-1}}\frac{\partial P_i}{\partial z}\bigg|_{z=h_i},\quad i=1,3;\\ \frac{\partial P_i}{\partial n_0}\bigg|_{h_0,h_1}=0.\end{array}\right\}\qquad(4)$$

Thus, instead of spatial initial problem (1)-(3), comparatively simple, quasi-three-dimensional problem (4) was obtained. In the work[2], the task was considered in this direction, methods of solving were provided in the test data, results were received and analyzed. However, the researchers still face difficulties in solving the tasks with obtained models, occupying more memory and time. With this purpose, we apply more simplified models than the Hantusha intermediate model.

Solution method. In the task (4), averaging motion by spatial variables for determining values of the flow among the layers and the change of the value of the pressure in the jumpers are obtained by so-called the model of material balance (MB)

$$\frac{\partial}{\partial z}\left(K_{ni}(z)\frac{\partial W_i}{\partial z}\right)=M_i(W_i)\frac{\partial W_i}{\partial z}\quad,\ h_{i-1}<z<h_i,\ t>0,\qquad(5)$$

$$W_i\big|_{t=0}=f_i(z),\ z\in[h_{i-1},h_i],\qquad i=1,3,\qquad(6)$$

$$\frac{\partial W_i}{\partial n}\bigg|_{z=h_0,h_3}=0,\quad W_i\big|_{z=h_1,h_2}=\overline{W}_2.\qquad(7)$$

The change of the area of the pressure in the well permeable layer is determined by the solution of the equation

$$\frac{\partial}{\partial x}\left(K_2\frac{\partial\vartheta_2}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_2\frac{\partial\vartheta_2}{\partial y}\right)=M_i\frac{\partial\vartheta_2}{\partial t}+\overline{F}_i(x,y,t)-q_{n2}\qquad(8)$$

with appropriate initial and boundary conditions.

For the calculation of the problem, we move to the dimensionless variables:

$$\overline{K}=\frac{K}{K_x},\quad \overline{\mu}=\frac{\mu}{\mu_x},\quad \overline{x}=\frac{x}{L_x},\quad \overline{y}=\frac{y}{L_y},\quad \overline{z}=\frac{z}{L_z},\quad \overline{P}=\frac{P}{P_x},\quad Q=A\sum_{i=1}^{N}\delta(x-x_i,y-y_i)q_i,$$

[2] Tukhtanazarov D.S. Тухтаназаров Д.С. Developing of mathematical models of filtration of fluids in multilayered formations // Uzbek journal of "Problems of informatics and energetics".–Tashkent, 2014.-№ (in Russian).

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$$A = \frac{L_x \mu_x}{K_x P_x L_y L_z}, \quad t = \tau \frac{K_x}{\mu_x L_x^2}, \quad Qp_x = \frac{L_x \mu_x}{K_x P_x L_y L_z} q_{n2}. \qquad (9)$$

For convenience, we omit the dashes on the variables.

Here, q_{n2} - is the function that acts as an evenly distributed internal drainage.

Thus, the complexity of the original problem (4) is reduced to successive solution of one-dimensional and two-dimensional problems.

For the solution of the problems (5)-(9), we apply the method of the longitudinal cross-circuit[3] and streaming version of the sweep method. The limits of applicability of this model and estimates of values $\|P_i - \vartheta_i\|_c$; $\|\vartheta_i - W_i\|_c$; $\|P_i - W_i\|_c$; were provided in the work [3]. For the analysis of the results of intermediate model compared with the calculation results obtained by the **Discussion.** Hantusha model on the basis for calculation, the following initial data are received:

$$P_i\big|_{t=0} = 1;\ m_1 = m_2 = m_3 = 0.2;\ k_2 = 0.2;\ k_1 = k_3 = 0.05;\ h_0 = 0;\ \ h_1 = 1/12;\ h_2 = 11/12$$

$$;h_3 = 1;\ \varphi_0 = 1;\ \mu = 2;\ \Delta x = 0.01; \Delta y = 0.01;\ \Delta z = 0.02;\ \tau = \frac{Lx \cdot Lx}{86400};\ Lx = 1000\text{м};$$

The values of selections and the location coordinates of the wells are provided in table 1.

Table 1

№	X, m	Y, m	m^3/day	№	X, m	Y, m	m^3/day
1	250	250	18000	6	250	350	18000
2	150	150	18000	7	350	150	18000
3	150	250	18000	8	350	250	18000
4	150	350	18000	9	350	350	18000
5	250	150	18000				

Distribution of the pressure on well permeable layer and the values of flow from jumpers due to the symmetry of the arrangement of selected points (wells) are symmetrical with respect to the medium reservoir. For this reason, in tables 2 and 3 respectively, their values are provided in the quarter of the field. For a complete understanding of their values, they are presented in the form of the contour maps at $T = 720$ a day in Fig.1.

Table 2

520	1.000	1.000	1.000	1.000	0.998	0.994	0.998	0.999	0.996	0.994	0.996
500	1.000	1.000	1.000	1.000	0.998	0.985	0.998	0.999	0.994	0.985	0.994
480	1.000	1.000	1.000	1.000	0.998	0.994	0.998	0.999	0.996	0.994	0.996
420	1.000	1.000	1.000	1.000	0.999	0.999	0.999	0.999	0.999	0.999	0.999
360	1.000	1.000	1.000	1.000	0.999	0.998	0.999	0.999	0.998	0.998	0.998
300	1.000	1.000	1.000	1.000	0.998	0.985	0.998	0.999	0.994	0.985	0.994
240	1.000	1.000	1.000	1.000	0.999	0.998	0.999	0.999	0.998	0.998	0.998
180	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
120	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
60	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Y / X	0	60	120	180	240	300	360	420	480	500	520

[3] Alimov I., Алимов И., Tukhtanazarov D.S. Numerical algorithms for solving two-dimensional hydrodynamic problems using the sweep methods// Uzbek journal of "Problems of informatics and energetics".–Tashkent, 2013.-№5-6.-p.53 (in Russian).

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Table 3

Y \ X	0	60	120	180	240	300	360	420	480	500	520
520	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
500	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
480	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
420	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
360	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
300	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
240	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
180	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
120	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
60	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516
0	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516	0.0516

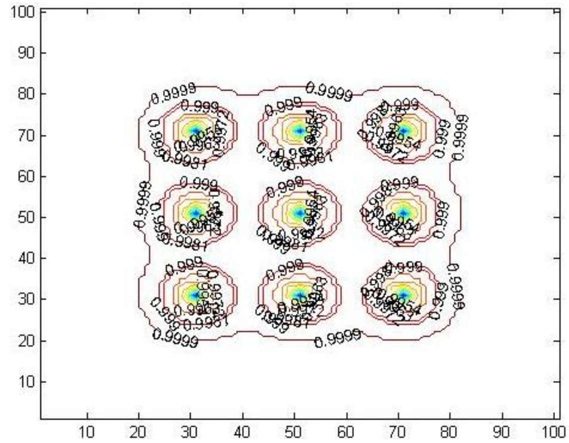

Fig.1

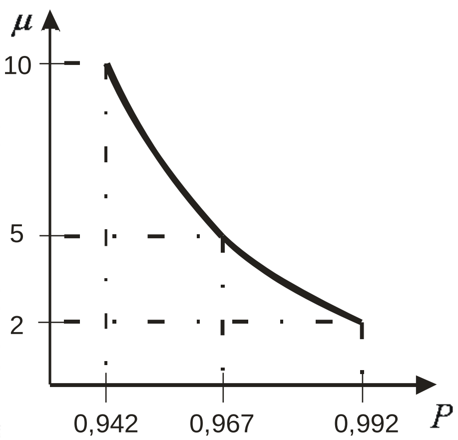

Fig.2

Based on the provided results, the following conclusions can be made. When all wells have equal debits with an increase in the viscosity, pressure is also reduced (fig.2), for $\mu = 2$ the value of the central well is less than that of other wells.

Now let's see how the value of pressure around the well is changing over time. Bearing in mind the symmetry of the results, we'll see one of the neighboring points to the well at different values of the viscosity coefficients of the two models (fig.4).

Table 4

t day	$\mu = 2$				$\mu = 5$			
	Intermediate model		Hantusha Model		Intermediate model		Hantusha Model	
100	0,998	0,989	0,998	0,989	0,998	0,978	0,998	0,978
200	0,997	0,988	0,997	0,988	0,995	0,974	0,995	0,974
500	0,995	0,986	0,995	0,986	0,991	0,969	0,991	0,969
720	0,994	0,985	0,994	0,985	0,990	0,967	0,990	0,967

Conclusion

It is possible to make the following conclusions from the values presented in the above table. The values of pressure are almost the same on both models in the considered example. That is why it is appropriate to apply the intermediate model for these data, because intermediate model is optimal in terms of efficiency of computer time and memory consumption of computational technology.

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