Model to Study Pressure Behavior of Horizontal Well Subjected by Both Bottom Water and Gas Cap at Late Time

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Abstract

A model to study the behavior of pressure in a horizontal well subjected by both bottom water and Gas cap and bottom water drives at a late period has been developed using source function and numerical technique was used for the computation from the results. The following are pressure decreases with time to when $tD=1000$ and pressure derivative also decrease to when $tD =100$. The pressure became stable when $tD \geq 100$ as shown in Figures 2,3 and 4. This behavior is an indication that reservoir fluid has encountered a boundary. From Figure 3 and 4, it was observed that the decline rate increases with time to a point when $tD \geq 100$. At this point, the Gas cap which acts as a drive is not active. Hence, there will be no increase in production at this stage.

Keywords: pressure, horizontal well, model, gas cap, reservoir.

1. INTRODUCTION

The horizontal well Method is well well-known for enhancing the well productivity of low-permeability reservoirs, especially for reservoirs with a gas cap or bottom water [1–3]. Drilling horizontal wells are important to maximizing oil production compared to vertical wells as well as to lessen near-wellbore disorder in high and low permeability reservoir. The financial achievement with the horizontal wells not only large with reserves but also the production is of a short period compared to vertical wells [4]. In this work, a model would be developed. The objective is to study the Pressure behavior of a horizontal well that is subjected to both bottom water and gas cap at a late time and

determine the effect of some well parameters.

1.1. Description of the model

Figure 1 represents the 3D of the reservoir model and axial description of the reservoir of length x_e in the x -direction, length y_e in the y -direction, and length z in z -direction subjected by Top Gas cap and bottom water. It has horizontal well positions y_w , x_w , and z_w in y , x , and z directions respectively.

Fig. 1 Reservoir sealed at x and y axis's and subjected by Top Gas cap and Bottom water [2]

2. MATERIALS AND METHODS

To study the behaviors of pressure in a horizontal well subjected by Both Bottom Water and Gas Cap at a Late Time was done by following the methodology process [5 – 8]. Fig. 2 represent the 4 steps

Fig.2 Behavior study of pressure in a horizontal well subjected by Both Bottom Water and Gas Cap at Late Time methodology

From Figure 1, at the x-position, well encounter an infinite slab source from an infinite slab reservoir in which the top is a constant-pressure boundary [7-8]. Hence, the appropriate

$$S(x_D, t_D) = \frac{2}{x_{eD}} \left\{ 1 + \frac{2x_{eD}}{\pi} \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{n^2 x_{eD}^2 t_D}{x_{eD}} \right] \sin \frac{n\pi x_{wD}}{x_{eD}} \cos \frac{n\pi x_{wD}}{x_{eD}} \cos \frac{n\pi x_D}{x_{eD}} \right\} \quad (1)$$

$$S(y_D, t_D) = \frac{1}{y_D} \left\{ 1 + 2 \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{m^2 \pi^2 t_D}{y_D} \right] \cos \frac{m\pi y_{wD}}{y_D} \cos \frac{m\pi y_D}{y_D} \right\} \quad (2)$$

$$S(z_D, t_D) = \frac{1}{h_D} \left\{ 1 + 2 \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{l^2 \pi^2 t_D}{h_D} \right] \sin \frac{l\pi z_D}{z_D} \sin \frac{l\pi z_{wD}}{h_D} \right\} \quad (3)$$

Putting equations 1 2 and 3 in 4 we have Equation 5 as the pressure distribution for reservoir sealed at x and y axes and subjected by top Gas cap and bottom water. This model (Equation 5) Reservoir with underlain water and Top gas cap.

$$P_D = 2\pi h_D \int_0^{t_D} S(x_D, t_D) S(y_D, t_D) S(z_D, \tau) d\tau \quad (4)$$

$$P_D = 2\pi h_D \left[\frac{2}{x_{eD}} * \frac{1}{y_D} \left\{ 1 + 2 \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{m^2 \pi^2 t_D}{y_D} \right] \cos \frac{m\pi y_{wD}}{y_D} \cos \frac{m\pi y_D}{y_D} \right\} * \frac{1}{h_D} \left\{ 1 + 2 \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{l^2 \pi^2 t_D}{h_D} \right] \sin \frac{l\pi z_D}{h_D} \sin \frac{l\pi z_{wD}}{h_D} \right\} \right] \quad (5)$$

Equation 5 is the dimensionless pressure for the reservoir system. The dimensionless pressure derivative is given as

$$p'_D = t_D \frac{\partial p_D}{\partial t_D} \quad (6)$$

Using Equation 6, Equation 7. The dimensionless pressure derivative of Equation 5 is

$$\begin{aligned} \text{given as } P'_D = & \frac{4\pi}{x_{eD} y_D} \left\{ 1 + \frac{2x_{eD}}{\pi} \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{n^2 x_{eD}^2 t_D}{x_{eD}} \right] \sin \frac{n\pi x_{wD}}{x_{eD}} \cos \frac{n\pi x_{wD}}{x_{eD}} \cos \frac{n\pi x_D}{x_{eD}} \right\} * \left\{ 1 + \right. \\ & 2 \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{m^2 \pi^2 t_D}{y_D} \right] \cos \frac{m\pi y_{wD}}{y_D} \cos \frac{m\pi y_D}{y_D} \left. \right\} * \frac{1}{h_D} \left\{ 1 + \right. \\ & 2 \sum_{n=1}^{\infty} \frac{1}{n} \exp \left[-\frac{l^2 \pi^2 t_D}{h_D} \right] \sin \frac{l\pi z_D}{z_D} \sin \frac{l\pi z_{wD}}{h_D} \left. \right\} \end{aligned} \quad (7)$$

3. RESULTS AND DISCUSSIONS

Equation 5 is solved using the Gauss-Legendre quadrature, a numerical method at the final flow period⁸. Equation 7 does not need any integration but the direct substitution of reservoir system parameters is assumed. The solutions are presented in Table 1.

**Table 1: Horizontal well (X_eD , XD , XwD , yD , YwD , ZwD , zD , hD):
(6,0.25,1,0.74,0.74,0.3,0.55,30)**

Td	PD	PD'
0.001	29.74	2.23E-01
1.00E-02	2.85E+01	2.10E-01
0.1	2.09E+01	1.41E-01
1	1.45E+01	1.05E-01
10	1.02E+01	6.74E-02
100	5.92E+00	4.25E-02
1000	5.66E+00	4.25E-02
10000	5.66E+00	4.25E-02

Fig. 3 Effect of X on Dimensionless Pressure

Fig. 4 Effect of X_{eD} on Dimensionless Pressure Derivative

Table 2: Effect of y_{eD} on Dimensionless Pressure and Dimensionless Pressure Derivative

Td	PD ($h_D=30$)	PD' ($h_D=30$)	PD ($h_D=20$)	PD' ($h_D=20$)	PD($x_{eD}=10$)	PD'($x_{eD}=10$)
0.001	29.74	2.23E-01	29.74	3.34E-01	29.74	6.69E-01
1.00E-02	2.85E+01	2.10E-01	2.85E+01	3.15E-01	2.85E+01	6.31E-01
0.1	2.09E+01	1.41E-01	2.09E+01	2.11E-01	2.09E+01	4.23E-01
1	1.45E+01	1.05E-01	1.45E+01	1.58E-01	1.45E+01	3.16E-01
10	1.02E+01	6.74E-02	1.02E+01	1.01E-01	1.02E+01	2.02E+00
100	5.92E+00	4.25E-02	5.92E+00	6.38E-02	5.92E+00	1.28E-01
1000	5.66E+00	4.25E-02	5.66E+00	6.38E-02	5.66E+00	1.28E-01
10000	5.66E+00	4.25E-02	5.66E+00	6.38E-02	5.66E+00	1.28E-01

Table 2 shows the effect of y_{eD} on Dimensionless Pressure and Dimensionless Pressure Derivative. This was done by altering the value of y_{eD} with time and the result shows that y_{eD} does not vary Dimensionless Pressure and Dimensionless Pressure Derivative for horizontal well subjected to Gas cap at a late period. Table 3 shows the variation of h_D on Dimensionless Pressure and Dimensionless Pressure Derivative. This was also done by varying the value of h_D with time and the result shows that h_D does not affect Dimensionless Pressure as shown in Figure 5, but it affects Dimensionless Pressure Derivative for horizontal well subjected to Gas cap at a late period as shown in Figure 6.

Table 3: Effect of h_D on Dimensionless Pressure and Dimensionless Pressure Derivative

Td	PD($y_{eD}=2$)	PD'($y_{eD}=2$)	PD($y_{eD}=10$)	PD'($y_{eD}=10$)	PD($x_{eD}=20$)	PD'($x_{eD}=20$)
0.001	29.74	2.23E-01	29.74	2.23E-01	29.74	2.23E-01
1.00E-02	2.85E+01	2.10E-01	2.85E+01	2.10E-01	2.85E+01	2.10E-01
0.1	2.09E+01	1.41E-01	2.09E+01	1.41E-01	2.09E+01	1.41E-01
1	1.45E+01	1.05E-01	1.45E+01	1.05E-01	1.45E+01	1.05E-01
10	1.02E+01	6.74E-02	1.02E+01	6.74E-02	1.02E+01	6.74E-02
100	5.92E+00	4.25E-02	5.92E+00	4.25E-02	5.92E+00	4.25E-02
1000	5.66E+00	4.25E-02	5.66E+00	4.25E-02	5.66E+00	4.25E-02
10000	5.66E+00	4.25E-02	5.66E+00	4.25E-02	5.66E+00	4.25E-02

Fig. 5 Effect of h_D on Dimensionless Pressure

Fig. 6 Effect of h_D on Dimensionless Pressure Derivative

4. CONCLUSIONS

The pressure became stable when $tD \geq 100$. This behaviour is an indication that reservoir fluid has encountered a boundary.

2. It was observed that the decline rate increases with time to a point when $tD \geq 100$. At this point, the Gas cap which acts as a drive is not active. Hence, there will be no increase in production at this stage. Therefore, well can be abandon or subject to Secondary recovery.

Nomenclature

$P'D$ = Pressure derivative

PD = dimensionless Pressure

hD = dimensionless height

xD = arbitrary dimensionless distance along the x-axis

yD = arbitrary dimensionless distance along the y-axis

ZD = arbitrary dimensionless distance along the z-axis

zwD = Well coordinate in z-direction

ywD = Well coordinate in y-direction

xwD = Well coordinate in x-direction

yeD = External dimensionless distance along y-axis

xeD = External dimensionless distance along x-axis

zeD = External dimensionless distance along z-axis

tD = Dimensionless time

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