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Behavior of Horizontal Well in a Reservoir subjected by a Single Edge Water drive at Late Time Period

OloroObarhire John[1*] and Akpotu Daniel[2]
[1,2]Chemical and Petroleum Engineering, Faculty of Engineering/ Delta State University, Nigeria)
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Abstract: Behavior of horizontal well in edge-water drive reservoirs at late time is the objective of this study and this was carried out by developing a model using source function and Newman product rule. Numerical method was used to compute dimensionless pressure and dimensionless pressure derivative. From the results we can see that P_D became constant from t_D =10 to t_D =10000.This is an indication showing that the flow has encountered boundary, while P'_D has some negativity values. This shows that there is water production due to excess water from edge water support. A clean oil can be produced between when $1 \geq t_D \geq 0.\ 001$.Effect of some parameters were considered. The height of a well has a significant role in the oil production in horizontal well. The higher the value of h_D more oil will be produced. Hence during well completion the height should be considered for optimal production.

I. INTRODUCTION

Horizontal wells have a high large drainage area and other advantages, are widely used in offshore and Land operation[1,2,3]. There are abundant research achievements for water breakthrough law of horizontal well in bottom water reservoir, but fewer in edge water[4,5,6].Oil recovery mechanism which the pressure from unrestricted water is enough to move hydrocarbons out of the reservoir, into the wellbore and up to surface. Water drive reservoirs can have bottom water drive or Edgewater drive. In a bottom water-drive reservoir, water is located beneath the oil gathering, while in an Edgewater-drive reservoir, water is located only on the edges of the reservoir[7,8].

In this paper, edge water–drive will be the recovery mechanism that will be used. There are some works that has been carried out.

Water move from hydrocarbons out of the reservoir, into the wellbore and up to surface. Water drive reservoirs can have bottom water drive or Edgewater drive. In a bottom water-drive reservoir, water is located beneath the oil accumulation, while in an edge water-drive reservoir, water is located only on the edges of the reservoir[9].

Water perform two functions of maintaining pressure and displacing oil towards the production wells. These two facts are valid for both water injection and edge water systems. Under water drive where the reservoir fluid is more viscous than the encroaching water, the water tends to bypass the oil.

Reservoir Physical Model

Reservoir physical models under study is shown in Figure 1[10].It is a reservoir with horizontal well located at x_w ,y_w and z_w in x, y and z directions respectively and is subjected by edge water.

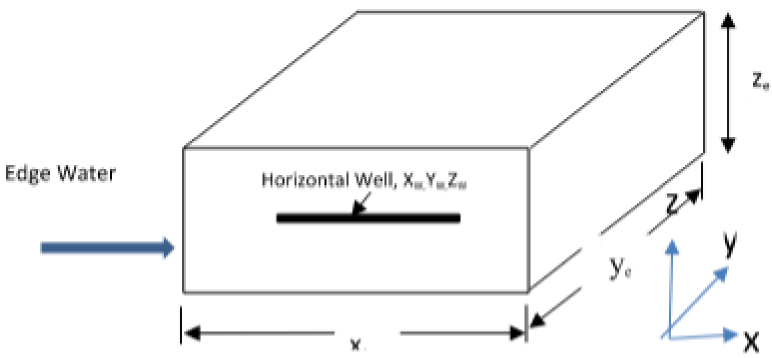

Fig. 1: Reservoir subject to Edge water-drive

II. MATERIAL AND METHODS

The following steps are taken in this work.

1. Boundary condition are chosen for each axis.
2. Appropriate source function for each axis will be selected[11].
3. Newman product rule will be applied to arrive at the pressure expressions.
4. Effect of some parameter will be considered.

Source functions for Figure 1 are carefully chosen from basic instantaneous source functions table for x, y and z axis's given as xi(x), v(y), v (z).

$$S(x_D,t_D) = \frac{8}{\pi}\sum_{n=1}^{\infty}\frac{1}{2n-1}exp\left[-\frac{(2n-1)^2\pi^2 t_D}{{x_{eD}}^2}\right]cos\frac{(2n-1)\pi x_D}{2x_{eD}} * sin\frac{(2n-1)\pi x_D}{x_{eD}}sin\frac{(2n-1)\pi x_{WD}}{x_{eD}} \quad (1)$$

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

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

$$P_{D=2\pi h_D\int_0^{t_D} S(x_D,t_D),S(y_D,t_D),S(z_D,t_D)\partial t_D} \quad (4)$$

Substituting equation 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 edge water.

$$P_D = 16h_D\int_0^{t_D}\sum_{n=1}^{\infty}\frac{\frac{1}{2n-1}exp\left[-\frac{(2n-1)^2\pi^2 t_D}{{x_{eD}}^2}\right]}{cos\frac{(2n-1)\pi x_D}{2x_{eD}}sin\frac{(2n-1)\pi x_D}{x_{eD}}}sin\frac{(2n-1)\pi x_{WD}}{x_{eD}} * \frac{1}{y_D}\left\{1+2\sum_{n=1}^{\infty}exp\left[-\frac{m^2\pi^2 t_D}{y_D}\right]cos\frac{m\pi y_{wD}}{y_D}cos\frac{m\pi y_D}{y_D}\right\} * \frac{1}{h_D}\left\{1+2\sum_{n=1}^{\infty}exp\left[-\frac{l^2\pi^2 t_D}{h_D}\right]cos\frac{l\pi z_{wD}}{h_D}cos\frac{l\pi h_D}{h_D}\right\} \quad (5)$$

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

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

Using Equation 6, Equation 7 is derived as

$$P'_D = 16h_D\left[\sum_{n=1}^{\infty}\frac{\frac{1}{2n-1}exp\left[-\frac{(2n-1)^2\pi^2 t_D}{{x_{eD}}^2}\right]}{cos\frac{(2n-1)\pi x_D}{2x_{eD}}sin\frac{(2n-1)\pi x_D}{x_{eD}}}sin\frac{(2n-1)\pi x_{WD}}{x_{eD}} * \frac{1}{y_D}\left\{1+2\sum_{n=1}^{\infty}exp\left[-\frac{m^2\pi^2 t_D}{y_D}\right]cos\frac{m\pi y_{wD}}{y_D}cos\frac{m\pi y_D}{y_D}\right\} * \frac{1}{h_D}\left\{1+2\sum_{n=1}^{\infty}exp\left[-\frac{l^2\pi^2 t_D}{h_D}\right]cos\frac{l\pi z_{wD}}{h_D}cos\frac{l\pi h_D}{h_D}\right\}\right] \quad (7)$$

Table 1 shows reservoir and well parameters.

xeD	π	y_{eD}	X_D	x_{wD}	y_D	y_{wD}	M	zw_D	z_D	h_D
6	3.1428	2	0.25	0.28	0.74	0.74	1	1.3	0.55	15

TABLE 1: RESERVOIR AND WELL PARAMETERS

III. RESULT

Results are presented below in form of Tables and Figures

TABLE 2: PRESSURE AND PRESSURE DERIVATIVE DISTRIBUTION

t_D	P_D	P'_D
0.001	183.188	2.59E-07
1.00E-02	1.75E+02	2.43E-04
0.1	117.117	0.142673
1	65.78674	52.59596
10	64.88	-965.366
100	64.88	1.10E-06
1000	64.88	-2.00E-112
10000	64.88	0

TABLE 3: EFFECT OF Y_{WD} ON P_D AND P'_D

t_D	$P_{D(ywD=0.74)}$	$P'_{D(ywD=0.74)}$	$P_{D(ywD=1.2)}$	$P'_{D(XwD=1.2)}$	$P_{D(ywD=0.32)}$	$P'_{D(YwD=0.32)}$
0.001	183.188	2.59E-07	183.1881	1.49E-07	183.1881	3.34E-07
1.00E-02	1.75E+02	2.43E-04	1.75E+02	1.41E-04	1.75E+02	3.12E-04
0.1	117.117	0.142673	117.117	0.092529	117.117	0.1767
1	65.78674	52.59596	65.7867	50.1652	65.78674	54.2457
10	64.88	-965.366	64.888	-965.366	64.888	-965.366
100	64.88	1.10E-06	64.888	1.10E-06	64.888	1.10E-06
1000	64.88	-2.00E-112	64.888	-1.97E-112	64.888	-1.97E-112
10000	64.88	0	64.888	0	64.888	0

TABLE 4: EFFECT OF Z_{WD} ON P_D AND P'_D

Td	$P_{D(ZwD=0.55)}$	$P'_{DD(ZwD=0.55)}$	$P_{D(ZwD=0.13)}$	$P'_{D(ZwD=0.13)}$	$P_{D(ZwD=1.3)}$	$P'_{D(ZwD=1.3)}$
0.001	183.188	2.59E-07	187.987	2.66E-07	419.7539	6.64E-07
1.00E-02	1.75E+02	2.43E-04	1.79E+02	2.49E-04	3.99E+02	6.23E-04
0.1	117.117	0.142673	119.2357	0.145025672	262.9695	0.36259
1	65.78674	52.59596	65.82317	52.596	145.8473	131.4904
10	64.88	-965.366	64.8888	-965.366	144.8889	-2413.416
100	64.88	1.10E-06	64.8888	1.10E-06	144.8889	2.75E-06
1000	64.88	-2.00E-112	64.8888	-1.97E-112	144.8889	-4.93E-112
10000	64.88	0	64.8888	0.00E+00	144.8889	0.00E+00

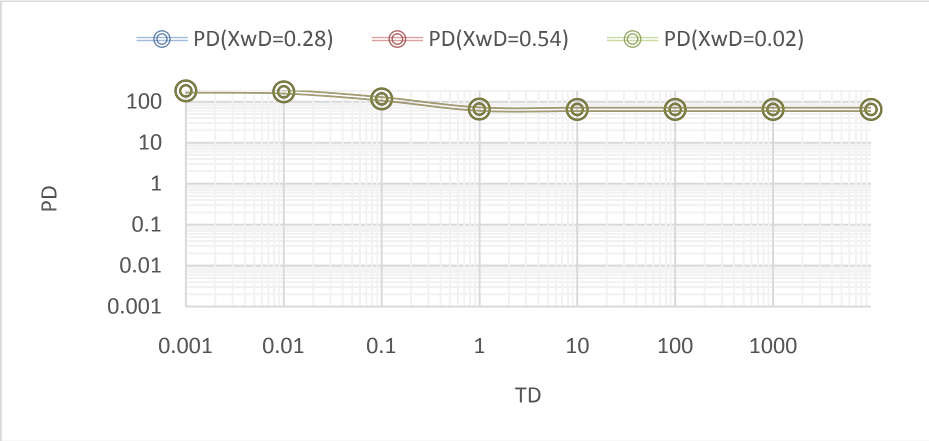

Figure 2: Effect of X_{WD} on P_D and P'_D

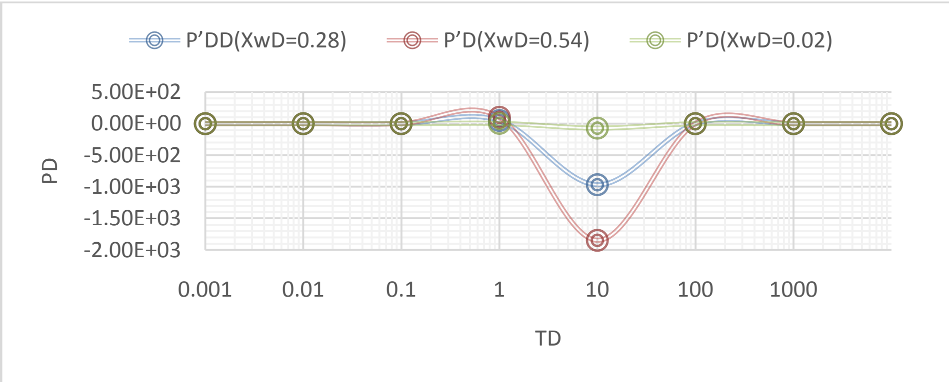

Figure 3: Effect of X_{WD} on P'_D

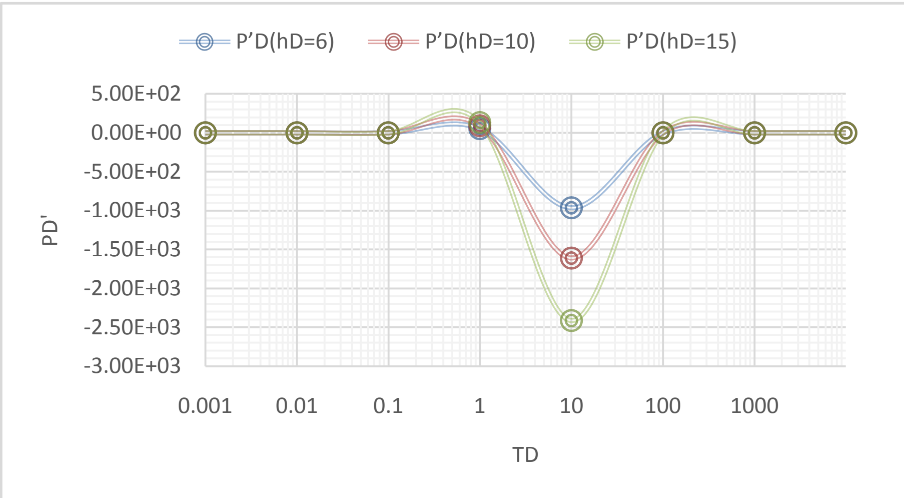

Figure 4: Effect of X_{WD} on P'_D

To determine the effect of y_{wD} on P_D and P'_D, three different values of y_{wD} were used to compute P_D and P'_D. The results are shown in Table 3. The value of P_D became stable at t_D=10 to when t_D became 10000.While the value of P'_D dropped to zero at t_D = 100000.At this point we have water breakthrough. The results of Effect of z_{wD} on P_D and P'_D are shown in Table 4. Figure 2 show the effect of X_{WD} on P_D and P'_D. From the Figure, X_{WD} does not have much effect looking at P_D plot. In figure 3, the effect is clearing seen. From the plot it was observed that the higher the value of X_{WD} the more water will be produce during production. The height of a well has a significant role in the oil production in horizontal well. The higher the value of h_D more oil will be produce as indicated in Figure 4. Hence during well completion the height should be considered for optimal production.

IV. DISCUSSION

The models developed was used and the results are shown in Table 2. The Table gives pressure and pressure derivative distribution subjected by edge water drive. From the results we can see that P_D became constant from t_D =10 to t_D =10000.This is an indication showing that the flow has encountered boundary, while on P'_D column we have negativity values. This shows that there is water production due to excess water from edge water support. A clean oil can be produced between when $1 \geq t_D \geq 0.001$.

To determine the effect of y_{wD} on P_D and P'_D, three different values of y_{wD} were used to compute P_D and P'_D. The results are shown in Table 3. The value of P_D became stable at t_D=10 to when t_D became 10000.While the value of P'_D dropped to zero at t_D = 100000.At this point we have water breakthrough. The results of Effect of z_{wD} on P_D and P'_D are shown in Table 4. Figure 2 show the effect of X_{WD} on P_D and P'_D. From the Figure, X_{WD} does not have much effect looking at P_D plot. In figure 3, the effect is clearing seen. From the plot it was observed that the higher the value of X_{WD} the more water will be produce during production. The height of a well has a significant role in the oil production in horizontal well. The higher the value of h_D more oil will be produce as indicated in Figure 4. Hence during well completion the height should be considered for optimal production.

V. CONCLUSION

There is water production during oil production in horizontal well in reservoir with single edge water drive due to excess water from edge water support.

Nomenclature
YwD = Well coordinate in y-direction
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YwD = Well coordinate in y-direction
YeD = External dimensionless distance along y-axis
XwD = Well coordinate in x-direction
tD= Dimensionless time
PD1 or P'D = Dimensionless 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

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