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EFFECT OF WELL STIMULATION ON THE SKIN FACTOR IN ELONGATED RESERVOIRS

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Because of fluvial deposition or faulting, many reservoirs around the world may possess a long and narrow geometry in which linear flow is expected to take place once radial flow vanishes, if existed. In any system through which a fluid flows, a change in the path direction causes additional pressure drop. Hydrocarbon reservoirs are not the exception to the rule. A change from radial flow to linear flow will be reflected as an additional pressure drop which may be referred as a skin factor, or more specifically, a geometric skin factor.

A couple of studies in the oil literature have named skin factors due to the change in flow patterns. Besides this, most of the commercial softwares may neither include nor calculate these types of skin factors since the simulations are normally run using the image methods, then, skin factors due to changes in flow path may be neglected.

Using the only methodology available to estimate the linear skin factors, it has been found from the experience on some field cases that this parameter is quite high in some cases and very small in other systems. Therefore, this paper is committed to the determination of the factors affecting the value of the linear skin factor and their impact on reservoir management.

It was found that neither reservoir permeability nor reservoir elongation had a significant impact on the linear skin factor value; however, the well stimulation does play an important role. The more damaged the well, the higher the linear skin factor value. From our simulation study, we found out that no matter if the well has a zero mechanical skin factor, still the linear skin factor has a high value. Besides, we demonstrated that the total skin factor increases as the linear skin factor increases with a ratio of 2,7385: 1,7385. Two Colombian field cases were worked with the purpose of verifying the findings of this article.

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Muchos yacimientos en el mundo poseen una geometría larga y estrecha causada por depositaciones fluviales o fallamiento. En ellos, se espera el desarrollo del flujo lineal una vez que el regimen de flujo radial, si lo hubiere, se desvanezca. En un sistema a través del cual existe flujo de fluidos, cualquier cambio en la trayectoria de flujo origina una caída de presión adicional. Los yacimientos de hidrocarburos no se exceptúan de esta regla. Un cambio de flujo radial a flujo lineal se refleja como una caída de presión adicional la cual podría tratarse como un factor de daño.

Los factores de daño debido al cambio de patrones de flujo han sido mencionados un par de veces en la literatura petrolera. Además de ésto, la mayoría de los programas de computador comerciales no incluyen la determinación de este tipo de factores de daño puesto que sus simulaciones usan el método de las imágenes, y por lo tanto, los factores de daño debido a cambios en la dirección de flujo podrían estar siendo ignorados.

En este trabajo se determinó por la experiencia del uso de la única metodología disponible para estimar los factores de daño lineales en algunos casos de campo, que éstos pueden tener valores muy altos en algunos casos o muy pequeños en otros sistemas. Por lo tanto, el propósito de este artículo es el de determinar los agentes que afectan el valor del factor de daño lineal y su impacto en la administración del yacimiento.

Se encontró que ni la permeabilidad ni la elongación del yacimiento tuvieron un impacto significativo en el valor del factor de daño lineal; sin embargo, el grado de estimulación en el pozo sí juega un papel importante. Entre mayor sea el daño en el pozo, mayor será el valor del factor de daño lineal. En nuestro estudio de simulación, encontramos que aunque el pozo posea cero daño mecánico, todavía el valor del factor daño lineal es alto. Además, demostramos que el factor de daño total se incrementa con el factor de daño lineal en una proporción de 2,7385:1,7385, respectivamente. Trabajamos dos casos de campo en yacimientos Colombianos para verificar los descubrimientos presentados en este artículo.

Palabras clave: *flujo lineal, flujo radial, flujo parabólico, presión de pozo, daño de pozo, estimulación de pozo.*

NOMENCLATURE

A	Area, ft^2
B	Oil volume factor, bbl/STB
c_t	Compressibility, 1/psi
b_x	Well position, ft
h	Formation thickness, ft
k	Permeability, md
P	Pressure, psi
P_{wf}	Well flowing pressure, psi
q	Flow rate, bbl/D. For gas reservoirs the units are Mscf/D
r_w	Well radius, ft
s	Mechanical Skin factor
s_{DL}	Geometric skin factor due to the convergence from radial to dual linear flow
s_L	Geometric skin factor due to the convergence from linear to dual linear flow, or from radial to linear flow when dual linear flow is absent
t	Time, hr
X_E	Reservoir length, ft
Y_E	Reservoir width, ft
W_D	Dimensionless reservoir width, Y_E/r_w

GREEK SYMBOLS

Δ	Change, drop
$\varnothing$	Porosity, fraction
μ	Viscosity, cp

SUFFICES

assum	Assumed
calc	Calculated
D	Dimensionless
DL	Dual-linear
i	Intersection or initial conditions
L	Linear
PB	Parabolic
r	radial flow
w	Well

S.I. METRIC CONVERSION FACTORS

Bbl x 1,589 873	E - 01 = m³
cp x 1,0*	E - 03 = Pa-s
ft x 3,048*	E - 01 = m
ft² x 9,290 304*	E - 02 = m²
psi x 6,894 757	E + 00 = kPa

INTRODUCTION

We recognize a representative number of pressure tests conducted in channelized systems which may result from faulting, fluvial deposition or deep sea fans. Even though, these types of systems occur quite often in nature, just few studies have been devoted to their analyses.

Ehlig-Economides and Economides (1985) presented an analytical solution for linear flow to a constant-planar source solution in drawdown tests without considering the linear skin factor. They provided a methodology to estimate permeability, channel width and the extent of well drainage area. Also, Wong, Mothersele, Harrington and Cinco-Ley (1986) presented a mathematical model excluding the linear skin factor. They presented new type curves for transient pressure analysis in rectangular systems. They also applied conventional techniques to actual field data. Later, Massonet, Norris and Chalmette (1993) presented a descriptive study of flow simulations in geological complex channelized reservoirs. They did not mention anything related to the additional pressure drop due to the channel geometry. Larsen and Hovdan (1987) presented a conventional method to analyze pressure data in linear-type reservoirs following a similar fashion as for the radial flow regime with some modifications added by the $\sqrt{t}$ plots. This combination permits the determination of reservoir width, flow capacity, skin and well location. Mattar (1997) presents a set of equations for well test interpretation without type curves. Among these, he presented an equation for the estimation of the channel width, but no solution was devoted to estimate the linear skin factor.

Only Larsen and Hovdan (1987) and Nutakki and Mattar (1982) included in their model an additional pressure drop due to the convergence of the flowlines near the wellbore. They, Nutakki and Mattar (1982), did provide a conventional methodology to estimate the linear skin factor from the intercept observed on a Cartesian plot of pressure versus the square root of time. Their equation was dependent mainly on the reservoir width, transmissibity and wellbore radius. However, they only focused on a linear flow term. Much later, Escobar *et al*. (2004) presented an exhaustive and comprehensive study for interpretation of well pressure test in elongated reservoirs. They employed the *TDS* technique, Tiab (1993), to provide a step-by-step methodology to determine reservoir parameters. They introduced two new concepts: dual linear flow, when there exist two linear flows taking place along the two lateral sides of the reservoir as depicted by the dashed arrows in Figure 1. This is represented by a half-slope line on the pressure derivative curve of Figure 2. Once the near lateral boundary has been reached by the transient pressure wave, only there remains a (single) linear flow along the longer side of the reservoir, as also shown by the solid arrows (representing streamlines) of Figure 1. Notice that the pressure derivative displays a rapid change of the intercept, although its half-slope still remains (Figure 2). This classification may sound to be unnecessary for either conventional or type-curve methods; however, it results truly important for the application of *TDS* technique. They provided analytical equations to estimate both the dual linear and linear skin factor from a pressure and pressure derivative plot. Escobar, Muñoz, Sepulveda and Montealegre (2005) further investigated on elongated systems and discovered a new flow regime in these systems which they called "*parabolic flow*". An equation to estimate the skin factor due to the change from dual linear to parabolic flow is presented by Escobar *et al*. (2005). The reader is strongly recommended to check this reference for a better understanding of the present document.
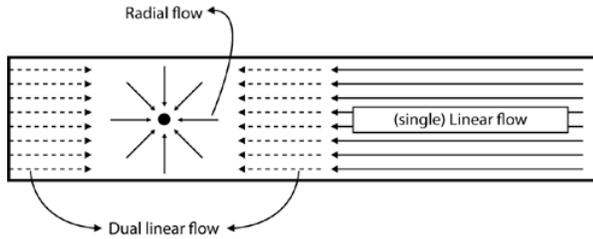
Figure 1. Illustration of radial, (single) linear and dual linear flow regimes
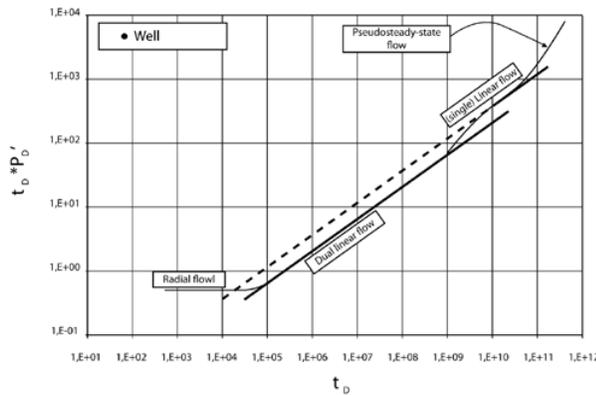
Figure 2. Log-log of dimensionless pressure derivative vs. dimensionless time for a rectangular reservoir with the well off-centered regarding its lateral boundaries, after Escobar *et al.* (2004)

This work uses the mathematical model presented by Escobar *et al.* (2004) and their methodology for estimation of the linear skin factors to study the effect of reservoir permeability, reservoir geometry and mechanical skin factor on the dual linear skin factor.

FORMULATION

Earlougher (1977) provided the mathematical model to account for the pressure behavior of a vertically fractured well in an infinite system:

$$P_D = \sqrt{\pi t_{D_L}} \tag{1}$$

The mathematical model presented in equation 13 by Ehlig-Economides and Economides (1985) was:

$$P_D = 2\pi \sqrt{t_{D_L}} \tag{2.a}$$

On the other hand, the mathematical expression responsible of the dimensionless pressure behavior as

proposed by Nutakki and Mattar (1982) (their equation 5), and by Larsen and Hovdan (1987) (their equation 5), following Earlougher´s model was:

$$P_D = \sqrt{\pi t_{D_L}} + S_L = \frac{\sqrt{\pi t_D}}{W_D} + S_L \tag{2.b}$$

In which, the dimensionless time were defined as:

$$t_D = \frac{0.0002637 kt}{\phi \mu c_t r_w^2} \tag{3.a}$$

$$t_{D_L} = \frac{t_D}{W_D^2} \tag{3.b}$$

Escobar *et al.* (2004) found out that none of the above models described the actual pressure behavior of a well in a channel reservoir. Then, they provided new governing equations to account for the dimensionless pressure and dimensionless pressure derivative behaviors during linear and dual linear flow regimes in elongated systems, as follows:

$$P_D = 2\pi \sqrt{t_{D_L}} + S_L = \frac{2\pi \sqrt{t_D}}{W_D} + S_L \tag{4.a}$$

$$P_D = 2\sqrt{\pi t_{D_L}} + S_{DL} = \frac{2\sqrt{\pi t_D}}{W_D} + S_{DL} \tag{4.b}$$

$$(t_D * P_D')_L = \frac{\pi \sqrt{t_D}}{W_D} \tag{5.a}$$

$$(t_D * P_D')_{DL} = \frac{\sqrt{\pi t_D}}{W_D} \tag{5.b}$$

It is well known from fluid mechanics that an additional pressure drop takes place when the direction of the fluid changes in any system. Figure 3 clearly explains this phenomenon in two pipe systems with the purpose of establishing an analogy with a reservoir.
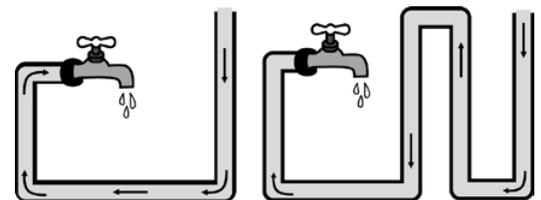
Figure 3. Additional friction losses due to change of flow direction

The lower pressure losses are presented in the left-hand system since it possesses less fluid path changes. The fact that the flow direction path changes from radial to linear flow causes an additional pressure drop in a channelized reservoir system.

Escobar *et al*. (2004) defined the true or total skin factor as:

$$s_t = s + s_{DL} + s_L \qquad (6.a)$$

If the well is centered along the reservoir, only dual linear flow develops, then *Equation 6.a* becomes:

$$s_t = s + s_{DL} \qquad (6.b)$$

For a off-centered well located inside a closed rectangular reservoir, once dual linear flow vanishes, the parabolic behavior shows up, as explained in detail in the work by Escobar *et al*. (2005).

$$s_t = s + s_{DL} + s_{PB} \qquad (6.c)$$

The dual linear, linear and parabolic geometric skin factors found in channel reservoir as presented by Escobar *et al*. (2004) and Escobar *et al*. (2005) were:

$$s_L = \left(\frac{\Delta P_L}{(t*\Delta P')_L} - 2 \right) \frac{1}{34.743 Y_E} \sqrt{\frac{kt_L}{\phi \mu c_t}} \qquad (7.a)$$

$$s_{DL} = \left(\frac{\Delta P_{DL}}{(t*\Delta P')_{DL}} - 2 \right) \frac{1}{19.601 Y_E} \sqrt{\frac{kt_{DL}}{\phi \mu c_t}} \qquad (7.b)$$

$$s_{PB} = \left(\frac{\Delta P_{PB}}{(t*\Delta P')_{PB}} + 2 \right) \left(\frac{123.16 b_x}{Y_E} \right) \sqrt{\frac{\phi \mu c_t}{kt_{PB}}} \qquad (7.c)$$

It is important to clarify that by the time the work of Escobar *et al*. (2004) was published; the parabolic flow was not discovered yet, therefore, not included in the oil industry literature. By that time, this flow regime was labeled as "pseudohemispherical flow" since the goal of that work was not characterizing such a flow regime.

The mechanical skin factor, s, which is conventionally estimated by reading the well pressure at time of one hour during the radial flow regime, can be estimated by the *TDS* technique using equation 2.34 by Tiab (1993). Also, use equation 2.8, reported by Tiab (1993), to calculate reservoir permeability.

ANALYSIS OF VARIABLES IMPACTING THE LINEAR SKIN FACTOR VALUES

Some Colombian reservoirs may possess elongated geometry since they were formed by fluvial deposition especially in the basin of the Magdalena River Valley. Our experience when determining the linear skin factors on some actual field cases has tremendously called our attention. In some cases, we estimated very low linear skin factors, let us say less than 0,01. However, in other cases our estimation of the linear skin factor was so high, even greater than 10. After this, we considered to conduct a study to find out the causes of these huge differences in the values of the linear skin factors, so that, a better well assessment can be taken into account.

Based upon the above considerations, we choose reservoir permeability, reservoir length and the degree of well damage/stimulation as the sensitive variables to affect the value of the linear skin factor.

Impact of reservoir permeability

Using the parameters provided in the first column of Table 1, labeled as Run # 1, we simulated the pressure and pressure derivative behavior of a well for different permeability values of 50, 100, 200, 400 and 800 md. Next, the dual linear skin factor was estimated using *Equation 7.b* by reading the pressure and pressure derivative values at any time during dual linear flow regime, t_{DL}. Results of these computations are reported in Table 2. It is important to point out that even though the mechanical skin factor was set to zero, the dual linear skin factor is still very high. We also observe in Table 2 that there exists a very small -practically insignificant- reduction of the dual linear factor as the permeability increases.

Impact of reservoir length

Since no significant influence of permeability was observed on s_{DL}, the next step was to change the reservoir length. We expected that the effect of reservoir length, X_E, could be more significant since the convergence from radial flow to linear flow is more severe as the reservoir becomes narrower. For this purpose, the reservoir and fluid properties of the third column in Table 1 (Run # 2) were used to run

Table 1. Reservoir, well and fluid parameters for simulation and field examples

PARAMETER	RUN # 1	RUN # 2	RUN # 3	EXAMPLE 1	EXAMPLE 2
μ, cp	3,2	3,2	3,2	Not given	3,5
B, rb/STB	1,23	1,23	1,23	1,0	1,07
c_t, 1/psi	1,00E-06	1,00E-06	1,00E-06	3,4E-4	9E-6
$\varnothing$, %	10	10	10	24	24
r_w, ft	0,33	0,33	0.33	0,625	0,51
k, md	Variable	60	60	Not given	Not given
h, ft	60	60	60	148	14
q, BPD	200	200	200	61,1952*	1400
s	0	0	Variable	Not given	Not given
X_E, ft	3200	Variable	3200	Not given	Not given
Y_E, ft	1600	800	800	53	360
P_{wf}, psi				32,17	Not given
P_i, psi	4000	4000	4000	Not given	Not given
b_x, ft	Not given	Not given	Not given	Not given	284
* Two-phase flow rate (water and oil)					

the analytical experiments with X_E = 1600, 3200, 6400, 12800, 25600, 51200 feet, while Y_E was kept to 800 feet. This means that the X_E/Y_E ratio of 2, 4,

8, 16, 32, and 64 were employed for the sensitivity analysis.

As for the permeability impact case, *Equation 7.b* was used to estimate the dual linear skin factor, s_{DL}, for each reservoir length as reported in Table 3. Since the mechanical skin factor was also taken as zero, the dual linear skin factor was so high, too; more than 11. As expected, the higher the X_E/Y_E ratio, the higher the dual linear skin factor increases due to the increase of flow convergence. However, the effect is very small and, for practical purposes, it could be ignored.

Table 2. Influence of permeability on dual linear skin

k, md	t_{DL}, hr	ΔP_{DL}	$(t*\Delta P)_{DL}$	s_{DL}
50	12,7128	339,197	59,5761	10,49788
100	6,37151	169,669	29,8234	10,49787
200	3,19332	84,8699	14,9294	10,49787
400	1,60045	42,4526	7,47359	10,49777
800	1,00982	22,1478	4,19886	10,49295

Impact of well damage/stimulation

Since not relevant impact of both reservoir permeability and reservoir geometry was obtained in ther former two cases in which we considered the well had zero damage or zero mechanical skin factor, we decided to vary the mechanical skin factor value from -6 to +6. For this particular case, we employed the properties of the fourth column of Table 1, labeled as Run # 3. The simulated pressure and pressure derivative results are reported in Figure 4.

Using equation 2.34 from Tiab (1993), the mechanical skin factor was computed from the pressure and pressure derivative value at any arbitrary time during

Table 3. Influence of reservoir length on dual linear skin

X_E, ft	X_E/Y_E	t_{DL}, hr	ΔP_{DL}	$(t*\Delta P)_{DL}$	s_{DL}
1600	2	2,5365	273,216	26,9365	11,32485
3200	4	5,06107	295,247	37,7026	11,45493
6400	8	12,7128	339,197	59,5761	11,49985
12800	12	40,2015	431,76	105,769	11,52805
25600	16	63,7151	486,521	133,126	11,53305
51200	64	100,982	555,397	167,574	11,53352
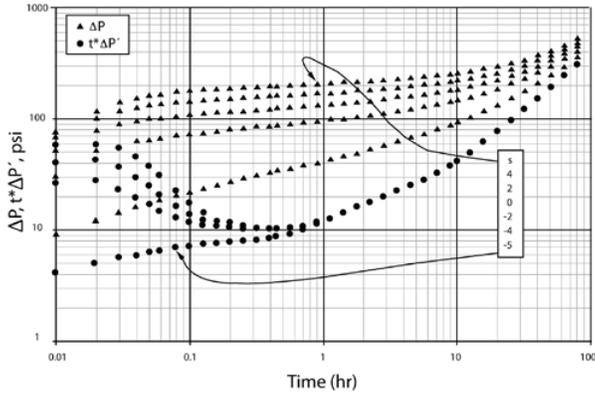
Figure 4. Pressure and pressure derivative for a well inside the center of a closed rectangular reservoir for different reservoir mechanical skin factors

radial flow, tr, and was found to be in certain agreement with the input values. See results of these calculations in Table 4 at the scalc column. As before, the dual linear skin factor, s_{DL}, was calculated with *Equation 7.b* using appropriate values of pressure and pressure derivative read at any arbitrary time, t_{DL}, during the dual linear flow regime. Results of these computations are also reported in Table 4. Finally, we computed the total or true skin factor using *Equation 6.b* as the summation of $s_{assum} + s_{DL}$.

Notice in Table 4 the great impact of the degree of well stimulation on the dual linear skin factor. When the well is stimulated the dual linear skin factor tends to zero. On the other hand, the more severe the well damage, the higher the dual linear skin factor.

Figure 5 was built for comparative purposes. There, we can observe a linear dependence of the dual linear skin factor on the mechanical skin factor. It is then obvious to expect a higher linear dependence of the total skin factor on the mechanical skin factor, as well. It was found out that the total skin factor reduces at a rate of 2,7385 units while the dual linear skin factor reduces at a rate of 1,7385 units as the well becomes more stimulated. It is also advisable to point out that for a zero mechanical skin factor, the dual linear skin factor, s_{DL}, has a value of 10,48. Besides, even though after stimulating the well with a mechanical skin factor s of -2, still a total positive skin factor value remains. From the linear trend equation provided in Figure 5, the well will have zero total damage when the mechanical skin factor is reduced to -6,05.
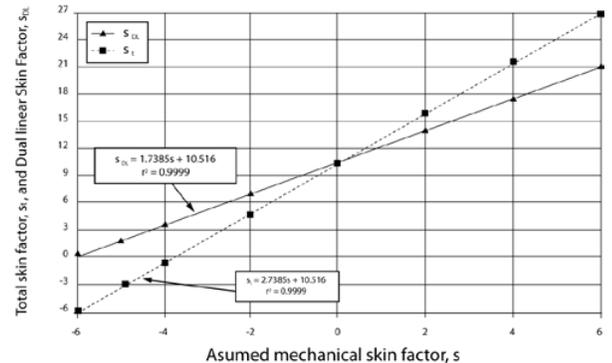
Figure 5. Dependence of dual linear skin and total skin factor on the mechanical skin factor

Table 4. Influence of mechanical skin factor, s, on dual linear skin

s_{assum}	s_{calc}	t_{DL}, hr	ΔP_{DL}, psi	$(t*\Delta P)'_{DL}$, psi	t_r, hr	ΔP_r, psi	$(t*\Delta P)'_r$, psi	s_{DL}	$s_t = s_{DL}+s_{assum}$
6	4,50	3,58296	265,794	22,4586	0,451069	235,658	10,4453	20,99	26,99
4	2,87	3,58296	228,787	22,435	0,451069	198,777	10,3007	17,49	21,49
2	1,21	3,58296	191,781	22,4118	0,451069	161,897	10,1418	13,99	15,99
0	-0,51	3,58296	154,774	22,3889	0,451069	125,015	9,97876	10,48	10,48
-2	-2,29	3,58296	117,768	22,3651	0,451069	88,1343	9,81433	6,97	4,97
-4	-4,05	3,58296	80,8332	22,3062	0,451069	51,5017	9,45649	3,47	-0,53
-5	-4,81	3,58296	62,6718	22,1426	0,451069	34,0901	8,68447	1,77	-3,23
-6	-5,38	3,58296	45,8551	21,5553	0,451069	19,3025	6,91727	0,27	-5,73

VERIFICATION ON FIELD CASES

It has been found along this article that the degree of damage/stimulation of a well is the key factor responsible for the value of the linear skin factor. We desired to verify this remark on actual field cases, and for that reason, two field cases were taken to follow this observation.

Example 1. A pressure buildup test was run in a Colombian reservoir on the Magdalena River Valley sedimentary basin. Pressure and pressure derivative data are plotted in Figure 6, and fluid, well and reservoir parameters are presented in the fourth column of Table 1.

Solution. As seen in Figure 6, once radial flow vanishes, the dual linear flow regime develops. This is formed by two linear flows, one of them occurring along one of the reservoir's lateral sides and the other along the other side. In other words, isobaric lines flow linearly at opposite sides of the well from the reservoir lateral sides. This flow regime is recognized by a ½-slope line on the pressure derivative curve. As for the example, the dual linear flow is very typical of long reservoirs and masks the single linear flow when the well is centered with respect of the extreme boundaries. It is inferred from the test, that the reservoir has all its boundaries close to flow; therefore, pseudosteady-state is expected to develop once dual linear flow vanishes.

From the pressure and pressure derivative plot, Figure 6, only radial flow and dual linear flow are clearly

identified. The following information was read from this plot:

$t_r = 14,2561$ hr $\qquad t_{DL} = 78,2561$ hr

$(t*\Delta P')_r = 8,6932 \qquad (t*\Delta P')_{DL} = 17,3184$ psi

$\Delta P_r = 72,65$ psi $\qquad \Delta P_{DL} = 91,76$ psi

Again, the permeability/viscosity ratio and mechanical skin factor were calculated, respectively, using equations 2.8 and 2.34 taken from Tiab (1993). The dual linear (geometric) skin factor was estimated with *Equation 7.b* It was obtained $k/\mu = 3,2568$ md/cp, $s = 0,8$, $s_{DL} = 6,61$.

This time, the total skin factor is computed with *Equation 6.b*, resulting to be 7,41. From this field example, we observe that a damage well leads to a high total skin factor, as proposed by the article.

Example 2. Escobar *et al*. (2004) presented an example of a pressure drawdown test run in a well in a channelized reservoir in the Eastern Planes basin in Colombia. This reservoir has a constant-pressure lateral boundary near the well, therefore, parabolic flow is expected to be developed. Reservoir and well parameters are given in the fifth column of table 1 and pressure and pressure derivative data are given in Figure 7.
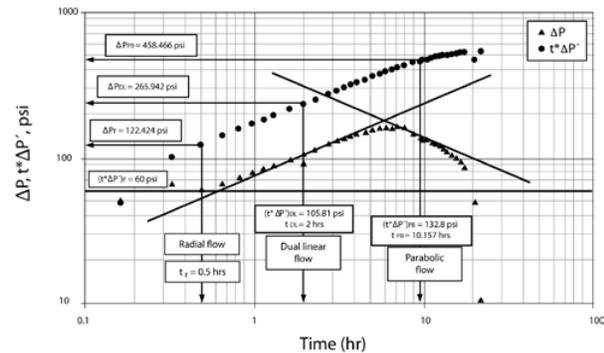
Figure 7. Pressure and pressure derivative for example # 2

Solution. It is inferred from the test that the well is closer to a constant-pressure lateral boundary; therefore, steady-state flow will dominate the test at later times. From the pressure derivative plot given in Figure 7, we can observe the presence of parabolic

Figure 6. Pressure and pressure derivative for example # 1

flow between, approximately, 7 to 12 hours. This flow regime, characterized by a pressure derivative slope of -½, takes place when the well is near a constant-pressure boundary and the pressure disturbance reaches it. Afterwards, a simultaneous action of the single linear flow on one lateral side of the reservoir and the steady-state, on the other side of the reservoir occurs. We believe that the constant-pressure boundary dominates the transient behavior pressure but its effect is interrupted by the presence of the well, then linear parallel isobaric lines have to be deformed; therefore, the higher pressure drop is seen at the right side of the well at the center of the reservoir. At these points, pressure from the left side is hard to be transmitted to the right side. For more clarification on this issue, the work of Escobar *et al*. (2005) is recommended to be checked.

As shown in Figure 7, it is observed that radial, dual linear, parabolic and steady state flows are developed. The parabolic flow is due to effect of the constant-pressure boundary once dual linear flow vanishes, and this is well explained by Escobar *et al*. (2005). The following parameters were read from Figure 7:

t_r = 10,157 hr $\quad\quad$ $(t*\Delta P')_r$ = 60 psi
t_{DL} = 2 hr $\quad\quad\quad$ $(t*\Delta P')_{DL}$ = 105,81 psi
t_{PB} = 10,157 hr $\quad\quad$ $(t*\Delta P')_{PB}$ = 132,873 psi

$$\Delta P_r = 122,424 \text{ psi}$$
$$\Delta P_{DL} = 265,942 \text{ psi}$$
$$\Delta P_{PB} = 458,466 \text{ psi}$$

Once more, a permeability value of 440,7 md was obtained both from equation 2.8 and a mechanical skin factor, s of -4,53 was estimated with equation 2.34 reported by Tiab (1993). The geometric skin factors, e.g., dual linear skin factor, s_{DL} = 0,44, and the parabolic skin factor, s_{PB} = 0,022, were estimated using *Equations 7.b* and *7.c*, respectively. Then, the total skin factor is -4,07.

From this example we verify that, a stimulated well leads to a low dual skin factor. Therefore, the example follows and agrees with the exposed theory.

Note: The examples should be worked with more detail using the procedures provided by Escobar *et al*. (2004).

CONCLUSION

- So far, literature has completely neglected the skin factors due to changes in flow path in elongated reservoirs which leads to an inappropriate evaluation and assessment of well management. The exposed theory and the worked field examples confirmed that as the mechanical skin factor increases, the linear, dual linear and parabolic skin factors contribute with a higher degree to the total well damage/stimulation. Both permeability and reservoir length have a very low influence on the dual linear skin factor. We expect the same influence for the linear and parabolic skin factors.

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