ESTIMATION OF PERMEABILITY AND SKIN FACTOR FOR RESERVOIR ROCKS USING WELL TESTING ANAYSIS TECHNIQUES

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Abstract:

This study has been conducted on two wells in Sarir oilfield to follow up the oil well test techniques and methods of analysis of these tests. The main objective of the well testing is to determine the viability of formation for the production of fluids and improved information about the well and the reservoir petrophysical properties (porosity, permeability, skin factor, follow up the barriers). Also testing is mainly carried out to recognize changing the flow rate of the well and the pressure response as a function of time. The data that depend on analysis pressure data is called Transient Pressure Testing. This study is focused mainly on one of the common well testing techniques is the buildup test using suitable software program for well testing calculations. On the other hand, Horner plot and Gringarten type curve are applied for data interpretation. This study has been performed on two oil wells at Sarir field are namely L-004-65 and C-173-65 to investigate the petrophysical characterizations of reservoir rocks. The study exhibits unacceptable results that obtained from calculations of petrophysical properties such as the low permeability (k) values, the positive values of skin factor (s), pressure drop due to skin factor (ΔP_{skin}). According to these results the formation required to be stimulated to enhance these parameters to improve the production rates.

Keywords: Oil well testing, Buildup test, Drawdown test, Horner plot, Gringarten type curve, Reservoir rock, Petrophysical properties.

الملخص

أجريت هذه الدراسة على بئرين لإنتاج النفط بحقل السرير من خلال تقنيات اختبار آبار النفط وطرق تحليل هذه الاختبارات. إن الهدف الأساسي من اختبار الآبار يكمن في تحديد مدى قدرة وقابلية التكوين على إنتاج الموائع ومعرفة بيانات البئر والخصائص البيتروفيزيائية للمكمن (المسامية، النفاذية، عامل الضرر). كما تُجرى هذه الاختبارات أيضاً لمعرفة التغير في معدل تدفق البئر واستجابة الضغط كدالة للزمن. ويطلق على البيانات التي تعتمد على بيانات تحليل الضغط باختبار الضغط الانتقالي. وعليه فإن هذه الدراسة تسلط الضوء في الأساس على أحد التقنيات الشائعة لاختبار الآبار وهو اختبار الضغط التصاعدي من خلال استخدام برامج السوفت وير في إجراء حسابات هذه الاختبارات. ومن جهةٍ أخرى تم تطبيق كل من مخطط هورنر ومنحنى التطابق لجرينجارتن لتفسير البيانات. لقد تمت هذه الدراسة على بئرين بحقل السرير هما *L-004-65* و *C-173-65* لاستقصاء الخصائص البيتروفيزيائية لصخور المكمن. حيث أظهرت هذه الدراسة نتائج غير مقبولة لحسابات الخصائص البيتروفيزيائية مثل تدني قيم النفاذية *(k)* ، وقيم عامل الضرر الموجبة *(s)* والانخفاض الإضافي في قيم الضغط نتيجة عامل الضرر (ΔP_{skin}). وبناءاً على هذه القيم فإن التكوين الصخري يتطلب إجراء عملية تحفيز لتعزيز هذه المعاملات التي من شأنها تعزيز معدلات الإنتاج.

الكلمات الدالة: اختبار آبار النفط، اختبار الضغط التصاعدي، مخطط هورنر، منحنى تطابق جرينجارتن، الخصائص البيتروفيزيائية.

1. INTRODUCTION

During the last two decades, test analysis techniques have changed significantly, with the introduction of high accuracy pressure measurements and powerful computers information that is more accurate and useful is extracted from well tests. The new interpretation methods, using the derivative of the pressure, magnify the characteristic features of the many different types of wells and reservoir. Due to the improved diagnosis of well test data, the number of theoretical solutions available to the interpretation engineer is expanding all the time.

Today well test interpretation computer programs offer a wide range of complex well and reservoir configurations for the analysis of pressure transient test responses.

This study covers most aspects of well test analysis for the today's engineer who has access to powerful computers.

2. Study Objectives

The main aim of the well testing is to determine the viability of formation for the production of fluids and improved information about the well and the reservoir. Testing is mainly carried out to recognize changing the flow rate of the well and the pressure response as a function of time and determination of reservoir characteristic features.

The objective of this study is the follow up the gas well test techniques and methods of analysis of these tests. Pressure transient data interpretation:

1. To evaluate the tested reservoir and tested well
2. Well performance–well productivity or injectivity, bottom hole pressure, and absolute open flow potential
3. Reservoir characterization – the type of the tested reservoir and tested well, formation pressure, effective permeability, skin, and distance to boundaries, etc.

3. Location of Study

The study has been carried out on testing of two oil wells located in Sarir, which is representing the major oil field comared with the other fields in Libya (Figure 1). The studied oilfields are namely L-004-65 and C-173-65 as shown in Figures 2 and 3 respectively.

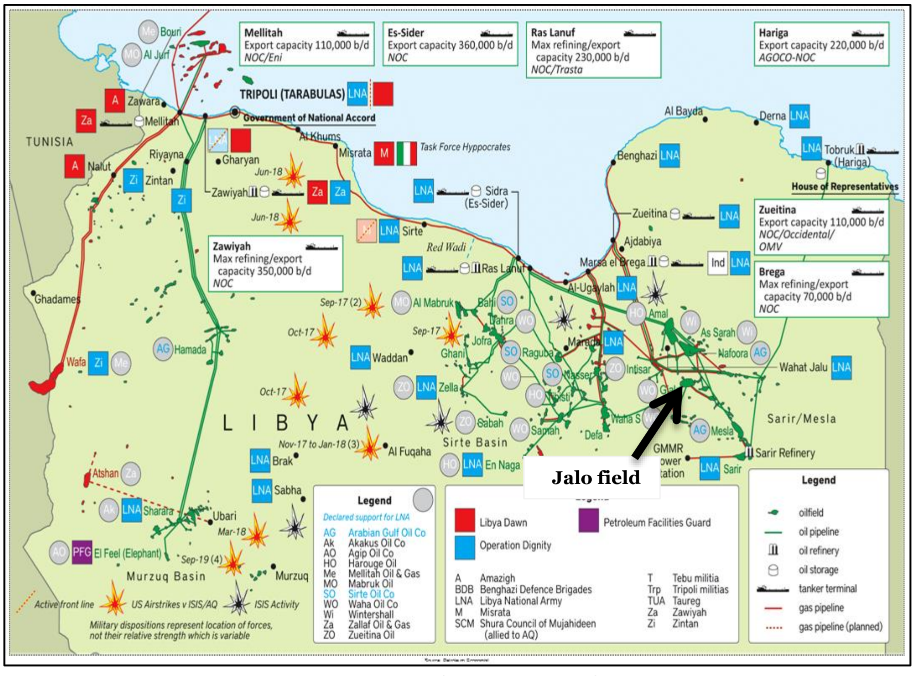

Fig. 1 A map shows locations of oil and gas fields in Libya [1]

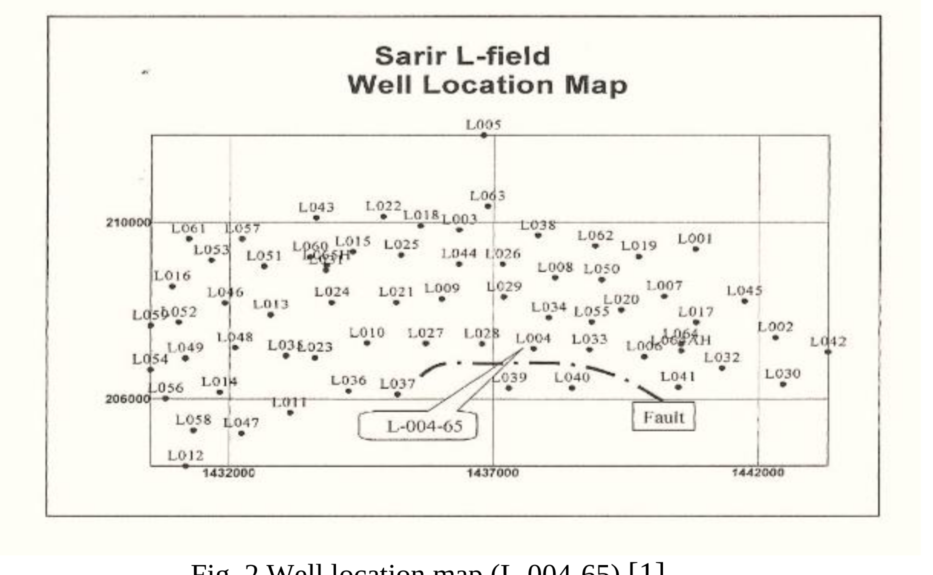

Fig. 2 Well location map (L-004-65) [1]

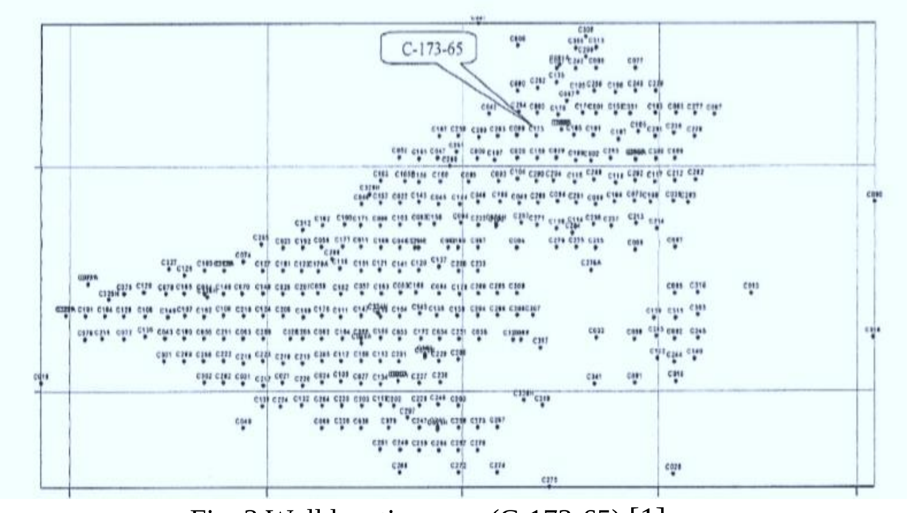

Fig. 3 Well location map (C-173-65) [1]

4. METHODOLOGY

4.1. Pressure Buildup Test

Pressure buildup analysis describes the buildup in wellbore pressure with time after a well has been shut in. One of the principal objectives of this analysis is to determine the static reservoir pressure without waiting weeks or months for the pressure in the entire reservoir to stabilize [2].

Pressure build up testing requires shutting in a producing well and recording the resulting increase in the wellbore pressure as a function of shut-in time. The most common and simplest analysis techniques require that the well produce at a constant rate for a flowing time of t_p, either from startup or long enough to establish a stabilized pressure distribution, before shut in. Traditionally, the shut-in time is denoted by the symbol Δt.

4.2 Horner Plot

A pressure buildup test is described mathematically by using the principle of superposition. Before the shut-in, the well is allowed to flow at a constant flow rate of Q_o STB/day for t_p days. At the end of the flowing period, the well is shut in with a corresponding change in the flow rate from the "old" rate of Q_o to the "new" flow rate of Q_{new} = 0, i.e., $Q_{new} - Q_{old} = -Q_o$. Calculation of the total pressure change which occurs at the sand face during the shut-in time is basically the sum of the pressure changes that are caused by:

Flowing the well at a stabilized flow rate of Q_{old}, i.e., the flow rate before shut-in Q_o, and is in effect over the entire time of t_p + Δt the net change in the flow rate from Q_o to 0 and is in effect over Δt [3]. The composite effect is obtained by adding the individual constant-rate solutions, at the specified rate–time sequence as:

$$P_i - P_{ws} = (\Delta P)_{total} = (\Delta P)_{due\ to\ (Q_o - 0)} + (\Delta P)_{due\ to\ (0 - Q_o)} \qquad [1]$$

Where:

P_i = initial reservoir pressure, psi.

P_{ws} = wellbore pressure during shut in, psi.

The above expression indicates that there are two contributions to the total pressure change at the wellbore resulting from the two individual flow rates. The first contribution results from increasing the rate from 0 to Q_o and is in effect over the entire time period t_p + Δt, thus:

$$(\Delta P)_{Q_O - 0} = \left[\frac{162.6(Q_O - 0)B_O\mu_O}{kh}\right] \times \left[\log\left(\frac{k\left(t_p + \Delta t\right)}{\emptyset\mu_o c_t r_w^2}\right) - 3.23 + 0.87s\right] \qquad [2]$$

The second contribution results from decreasing the rate from Q_o to 0 at t_p, i.e., shut-in time, thus:

$$(\Delta P)_{0 - Q_O} = \left[\frac{162.6(0 - Q_O)B_O\mu_O}{kh}\right] \times \left[\log\left(\frac{k\Delta t}{\emptyset\mu_o c_t r_w^2}\right) - 3.23 + 0.87s\right] \qquad [3]$$

The pressure behaviour in the well during the shut-in period is then given by:

$$P_i - P_{ws} = \left[\frac{162.6Q_O B_O \mu_O}{kh}\right] \times \left[\log\left(\frac{k(t_o + \Delta t)}{\emptyset \mu_o c_t r_w^2}\right) - 3.23\right] - \frac{162.6(-Q_o)\mu_o B_o}{kh}\left[\log\frac{k\Delta t}{\emptyset \mu_o c_o r_w^2} - 3.23\right] \quad [4]$$

Expanding this equation and cancelling terms gives:

$$P_{ws} = P_i - \frac{162.6Q_o \mu_o B_o}{kh}\left[\log\left(\frac{t_p + \Delta t}{\Delta t}\right)\right] \quad [5]$$

where:

P_i = initial reservoir pressure, psi.

P_{ws} = sand face pressure during pressure buildup, psi.

t_p = flowing time before shut-in, hours.

Q_o = stabilized well flow rate before shut-in, STB/day.

Δt = shut-in time, hours.

The pressure buildup equation, i.e., Equation [5] was introduced by Horner[4] and is commonly referred to as the Horner equation.

Equation [5] is basically an equation of a straight line that can be expressed as:

$$P_{ws} = P_i - m\left[\log\left(\frac{t_p + \Delta t}{\Delta t}\right)\right] \quad [6]$$

This expression suggests that a plot of P_{ws} vs. $(t_p + \Delta t)/\Delta t$ on a semilog scale would produce a straight-line relationship with intercept P_i and slope m, where:

$$m = \frac{162.6Q_o B_o \mu_o}{kh} \quad [7]$$

or

$$k = \frac{162.6Q_o B_o \mu_o}{mh} \quad [8]$$

where:

m = slope of straight line, psi/cycle

k = permeability, md

This plot, commonly referred to as the Horner plot, is illustrated in Figure 4. Note that on the Horner plot, the scale of time ratio $(t_p + \Delta t)/\Delta t$ observed from Equation [5] that $P_{ws} = P_i$ when the time increases from right to left. It is ratio is unity. Graphically this means that the initial reservoir pressure, P_i , can be obtained by extrapolating the Horner plot straight line to $(t_p + \Delta t)/\Delta t = 1$.

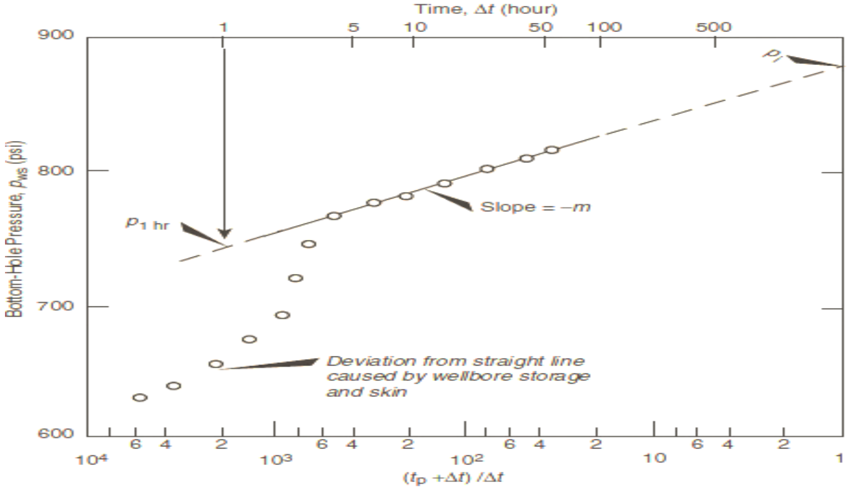

Fig. 4 Horner plot [3]

The time corresponding to the point of shut-in, t_p can be estimated from equation [9].

$$t_p = \frac{24N_p}{Q_o} \qquad [9]$$

where:

N_p = well cumulative oil produced before shut in, STB.

Q_o = stabilized well flow rate before shut in, STB/day.

t_p = total production time, hours.

Earlougher [4] pointed out that a result of using the superposition principle is that the skin factor, s, does not appear in the general pressure buildup equation, Equation [5] that means the Horner-plot slope is not affected by the skin factor; however, the skin factor still does affect the shape of the pressure buildup data. In fact, an early time deviation from the straight line can be caused by the skin factor as well as by wellbore storage.

The deviation can be significant for the large negative skins that occur in hydraulically fractured wells. The skin factor does affect flowing pressure before shut-in and its value may be estimated from the buildup test data plus the flowing pressure immediately before the buildup test, as given by:

$$s = 1.151\left[\frac{P_{1\,hr} - P_{wf\ at \Delta t=0}}{|m|} - \log\left(\frac{k}{\emptyset \mu c_t r_w^2}\right) + 3.23\right] \quad [10]$$

With an additional pressure drop across the altered zone of:

$$\Delta P_{skin} = 0.87|m|s$$

where:

$P_{wf\ at\ \Delta t=0}$ = bottom-hole flowing pressure immediately before shut in, psi.

s = skin factor.

$|m|$ = absolute value of the slope in the Horner plot, psi/cycle.

r_w= wellbore radius, ft.

The value of P_{1hr} must be taken from the Horner straight line.

Frequently, the pressure data does not fall on the straight line at 1 hour because of wellbore storage effects or large negative skin factors. In that case, the semilog line must be extrapolated to 1 hour and the corresponding pressure is read.

It should be noted that for a *multiphase flow*, Eequations [5] and [10] become:

$$P_{ws} = P_i - \frac{162.6 q_t}{\lambda_t h}\left[\log\left(\frac{t_p + \Delta t}{\Delta t}\right)\right] \quad [11]$$

$$s = 1.151\left[\frac{p_{1\,hr} - p_{wf\ at\ \Delta t=0}}{|m|} - \log\left(\frac{\lambda_t}{\emptyset c_t r_w^2}\right) + 3.23\right] \quad [12]$$

With:

$$\lambda_t = \frac{k_o}{\mu_o} + \frac{k_w}{\mu_w} + \frac{k_g}{\mu_g} \quad [13]$$

$$q_t = Q_o B_o + Q_w B_w + \left(Q_g - Q_o R_s\right) B_g \quad [14]$$

or equivalently in terms of GOR as:

$$q_t = Q_o B_o + Q_w B_w + (GOR - R_s) Q_O B_g \qquad [15]$$

where:
q_t = total fluid voidage rate, bbl/day.
Q_o = oil flow rate, STB/day.
Q_w = water flow rate, STB/day.
Q_g = gas flow rate, scf/day.
R_s = gas solubility, scf/STB.
B_g = gas formation volume factor, bbl/scf.
λ_t = total mobility, md/cp.
k_o = effective permeability to oil, md.
k_w = effective permeability to water, md.
k_g = effective permeability to gas, md.
The wellbore storage coefficient C is, by selecting *a point on the log–log unit-slope straight line* and reading the coordinate of the point in terms of Δt and ΔP:

$$C = \frac{q\Delta t}{24\Delta P} = \frac{QB\Delta t}{24\Delta P} \qquad [16]$$

where
Δt = shut-in time, hours
ΔP = pressure difference ($P_{ws} - P_{wf}$), psi
q = flow rate, bbl/day
Q = flow rate, STB/day
B = formation volume factor, bbl/STB

With a dimensionless wellbore storage coefficient as given by equation [28] as:

$$C_D = \frac{0.8936C}{\emptyset h c_t r_w^2} \qquad [17]$$

4.3 Type Curves

The type curve analysis approach was introduced in the petroleum industry by Agarwal [5,6] as a valuable tool when used in conjunction with conventional semilog plots. A type curve is a graphical representation of the theoretical solutions to flow equations. The type curve analysis consists of finding the theoretical type curve that "matches" the actual response from a test well and the reservoir when subjected to changes in production rates or pressures.

The match can be found graphically by physically superposing a graph of actual test data with a similar graph of type curve(s) and searching for the type curve that provides the best match. Since type curves are plots of theoretical solutions to transient and pseudosteady-state flow equations, they are usually presented in terms of dimensionless variables (e.g., P_D, t_D, r_D, and C_D) rather than real variables (e.g., ΔP, t, r, and C). The reservoir and well parameters, such as permeability and skin, can then be calculated from the dimensionless parameters defining that type curve.

4.3.1 Gringarten Type Curve

During the *early-time period* where the flow is dominated by the wellbore storage, the wellbore pressure is described by Equation [18] as:

$$P_D = \frac{t_D}{C_D} \quad [18]$$

or

$$\log(P_D) = \log(t_D) - \log(C_D) \quad [19]$$

This relationship gives the characteristic signature of wellbore storage effects on well testing data which indicates that a plot of P_D vs. t_D on a log–log scale will yield a straight line of a *unit slope* [7-10].

At the end of the storage effect, which signifies the beginning of the infinite-acting period, the resulting pressure behavior produces the usual straight line on a semilog plot as described by:

$$P_D = \frac{1}{2}[\ln(t_D) + 0.80901 + 2s] \quad [20]$$

It is convenient when using the type curve approach in well testing to include the dimensionless wellbore storage coefficient in the above relationship. Adding and subtracting ln(C_D) inside the brackets of the above equation gives:

$$P_D = \frac{1}{2}[\ln(t_D) - \ln(C_D) + 0.80901 + \ln(C_D) + 2s] \qquad [21]$$

or, equivalently:

$$P_D = \left[\ln\left(\frac{t_D}{C_D}\right) + 0.80907 + \ln(C_{De^{2s}})\right] \qquad [22]$$

Where:

P_D = dimensionless pressure.

C_D = dimensionless wellbore storage coefficient.

t_D = dimensionless time.

s = skin factor.

Equation [22] describes the pressure behavior of a well with a wellbore storage and a skin in a homogeneous reservoir during the transient (infinite-acting) flow period. Gringarten [7] expressed the above equation in the graphical type curve format shown in Figure 5 In this figure, the dimensionless pressure P_D is plotted on a log–log scale versus dimensionless time group t_D/C_D.

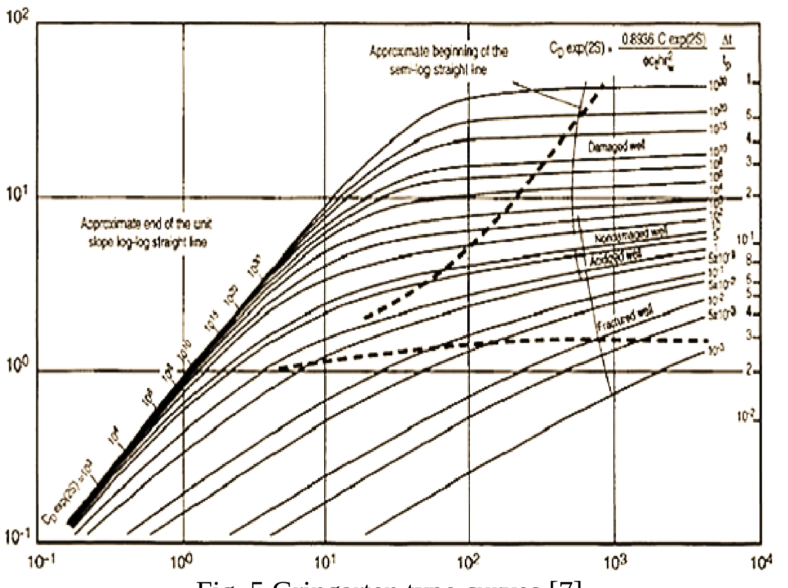

Fig. 5 Gringarten type curves [7]

The resulting curves, characterized by the dimensionless group C_{De}^{2s} , represent different well conditions ranging from damaged wells to stimulated wells [7].

(1) Dimensionless pressure P_D.
(2) Dimensionless ratio t_D/C_D .
(3) Dimensionless characterization group C_{De}^{2s}.

The above three dimensionless parameters are defined mathematically for both the drawdown and buildup tests as follows.

5. RESULTS AND DISCUSSION

The data which obtain from testing will be analysis for drawdown and buildup tests by using software program, and the data from the Bourdet [11], reference which to be considered accurate enough for engineering analysis. The firstly will start with analyzing data of drawdown test and secondary will analyses data of buildup test.

6. STUDIED WELLS

Several pressures build up analyzed as case studies from Sarir oil field, the Sarir oil field studied cases are well L-004-65 and well C-173-65 both produce from the Sarir group formation.

6.1. Pressure Build Up Analysis (L-004-65)

Well L-004-65 was completed as an oil producer in July 1966. the initial flow rate was 840 BOPD, peak production rate was 4704 BOPD in October 1968. (Sarir oil field).

Reservoir properties	*Oil properties*	*Production parameters*
$\emptyset = 0.175$	B_0 =1.1511RB/STB	$t_p = 96\ hr$
r_w= 0.36 ft	μ_o = 1.09 cp	q_o=614 STB/D
c_t= 9.67×10^{-6} psia^{-1}	h = 130 ft	

Table 1 shows the measured pressure gauge data record and calculations for test interpretations.

Table 1 pressure versus time data for well L-004-65. [12]

Δt	P_{wf}	$\Delta t + t_p/\Delta t$	ΔP	Δt_e	Δt	P_{wf}	$\Delta t + t_p/\Delta t$	ΔP	Δt_e
0	3039		0		0.6667	3086	145	47	0.662102
0.0167	3050	5761	11	0.016697	0.8333	3088	116.2	49	0.826129
0.05	3059	1921	20	0.049974	1.1667	3096	83.29	57	1.152691
0.0833	3062	1153	23	0.083228	1.5	3100	65	61	1.476923
0.1333	3067	721	28	0.133115	1.8333	3106	53.36	67	1.798946
0.2	3071	481	32	0.199584	2.3333	3108	42.14	69	2.277934
0.2667	3072	361	33	0.265961	2.8333	3112	34.88	73	2.752076
0.3333	3075	289	36	0.332147	3.3333	3112	29.8	73	3.221445
0.5	3082	193	43	0.497409	3.8333	3116	26.04	77	3.686113

From Figure 6 P_{1hr} = 3093 psi, m = -75 psi/cycle.

Calculate K

$$k = \frac{162.6Q_o B_o \mu}{|m|h} = \frac{162.2\times614\times1.1.1511\times1.09}{75\times130} = 12.84 \text{ md}$$

Calculate skin factor and Pressure drop due to **s**

$$s = 1.151\left[\frac{P_{i-}P_{wf}}{|m|} - \log\left(\frac{k}{\Phi\mu c_t r_w^2}\right) + 3.23\right]$$

$$s = 1.151\left[\frac{3093-3039}{75} - \log\left(\frac{12.2}{0.175\times1.09\times9.67\times10-6\times(0.36)\text{^}2}\right) + 3.23\right]$$

= - 4.365

Since the skin is negative there is a permeability improvement around the wellbore most likely due to effective acidization.

From Figure 7 ΔP=20 psi , Δ_{te}= 0.05

Calculate reservoir properties:

$$C = \frac{QB\Delta t_e}{24\Delta P} = \frac{614\times1.1511\times0.05}{24\times20} = 0.073$$

$$C_D = \frac{0.8936C}{\Phi h c_t r_w^2} = \frac{0.8936\times0.073}{0.175\times130\times9.67\times10-6\times0.36\text{^}2} = 2310$$

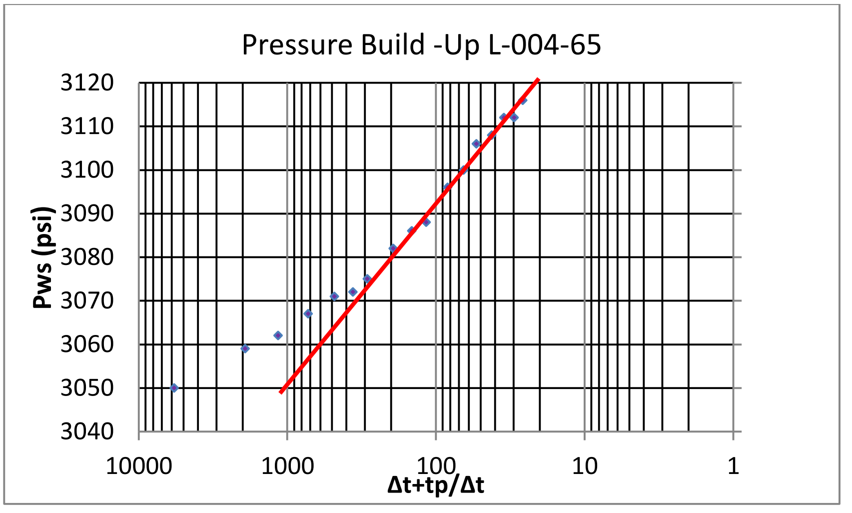

Fig. 6 Horner Plot (Well L-004-65)

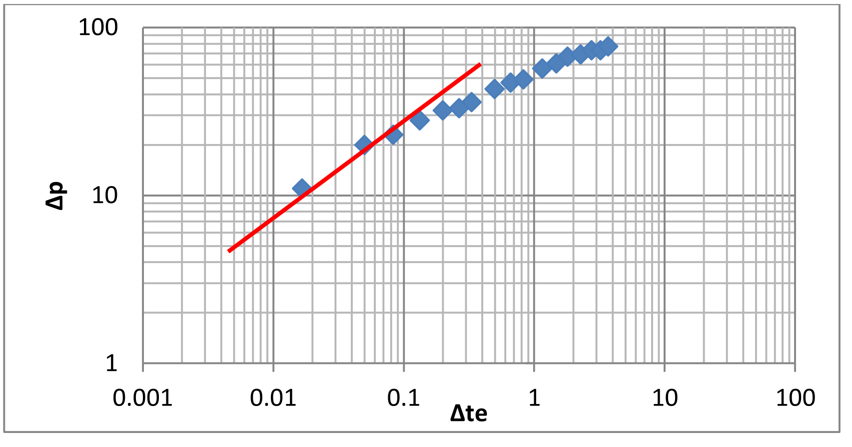

Fig. 7 Log-log plot. data from Table 1

6.2. Pressure Build Up Analysis (C-173-65)

Well C-173-65 was completed as an oil producer in July,1980. well C-173-65 was put on production on February 23^{rd},1987. (Sarir oil field)

Reservoir properties	***Oil properties***	***Production parameters***
$\emptyset = 0.17$ r_w= 0.359 ft c_t = 9.49×10^{-6} psia^{-1} H = 162 ft	B_o = 1.112 RB/STB μ_o= 1.5 cp	$t_p = 116\ hr$ q_o= 1478 STB/D

From Figure 8 P_{1hr} = 3174 psi , ***m***= 7 psi/cycle.

Calculate *K*

$$k = \frac{162.6Q_o B_o \mu}{|m|h} = \frac{16.2\times1478\times1.112\times1.5}{7\times162} = 353.49 \text{ md}$$

Calculate skin factor and Pressure drop due to **s**

$$s = 1.151\left[\frac{P_i - P_{wf}}{|m|} - \log\left(\frac{k}{\Phi\mu c_t r_w^2}\right) + 3.23\right]$$

$$s = 1.151\left[\frac{3174-3064}{7} - \log\left(\frac{354.44}{0.17\times1.5\times9.49\times10-6\times(0.3594)^{\wedge}2}\right) + 3.23\right] = 11.38$$

ΔP_{skin} = 0.87$|m|s$ = 0.87× 7 × 11.38 = 69.3 psi.

Table 2 pressure versus time data for well C-173-65. [12]

Δt	P_{wf}	$\Delta t + t_p/\Delta t$	$\Delta P\ (psi)$	Δt_e
0	3064			
0.0167	3070	6947.11	6	0.016698
0.0333	3079	3484.48	15	0.03329
0.05	3094	2321	30	0.049978
0.0667	3109	1740.13	45	0.066662
0.0833	3115	1393.56	51	0.08324
0.167	3146	695.61	82	0.16676
0.25	3165	465	92	0.249462
0.333	3171	349.53	107	0.332047
0.4167	3171	279.38	107	0.415208
0.5	3172	233	108	0.497854

0.8333	3173	140.62	109	0.827357
1	3174	117	110	0.991453
1.5	3175	78.33	111	1.480851
2	3176	59	112	1.966102
3	3176	39.67	112	2.92437
4	3176	30	112	3.866667
5	3176	24.02	112	4.793388
6	3176	20.33	112	5.704918
7	3176	17.57	112	6.601626
8	3176	15.5	112	7.483871
9	3176	13.89	112	8.352
10	3176	12.6	112	9.206349

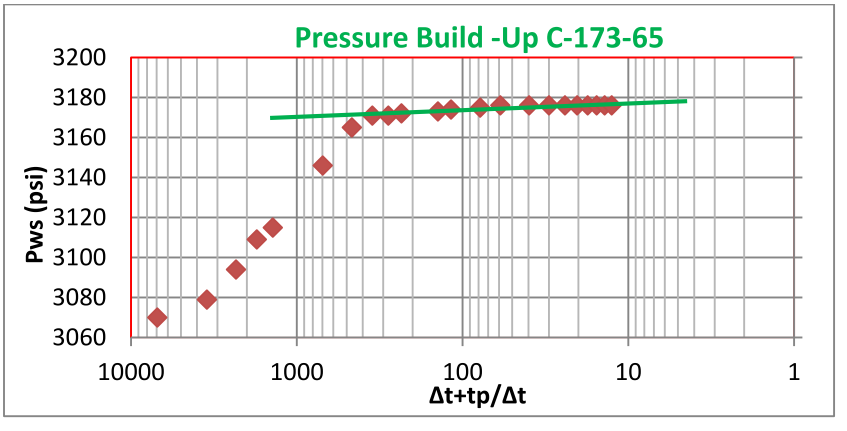

Fig. 8 Horner plot (well C-173-65)

From Figure 9 ΔP=20 psi , Δt_e= 0.038

Calculate reservoir properties:

$$C = \frac{QB\Delta_{te}}{24\Delta p} = \frac{1478\times1.112\times0.038}{24\times20} = 0.130$$

$$C_D = \frac{0.8936C}{\phi h c_t r_w^2} = \frac{0.8936\times0.130}{0.17\times162\times9.49\times10-6\times0.359\text{\^{}}2} = 345$$

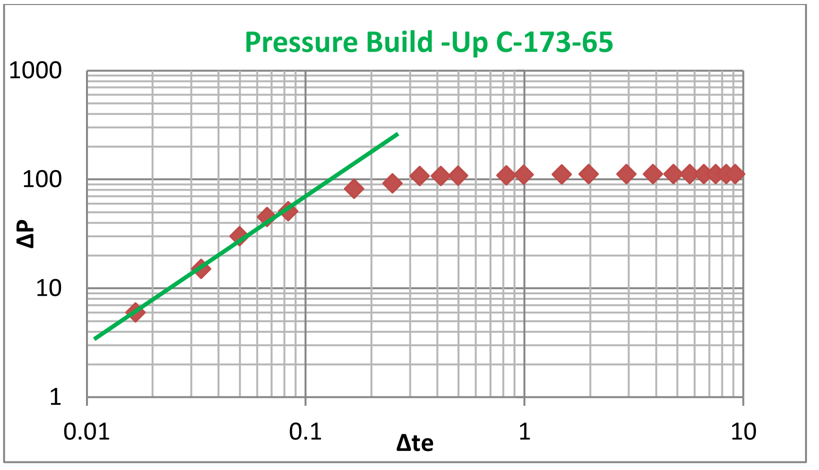

Fig. 9 Log-log plot from Table 2

From Figure 10 the data matched the curve with dimensionless group of $C_D e^{2s} = 10^{10}$ and match the point.

Gringarten values are:

$(P_D)_{MP} = 1.79$ $(\Delta P)_{MP} = 100$

$(\Delta t_e)_{MP} = 1$ $(t_D/C_D)_{MP} = 14.8$

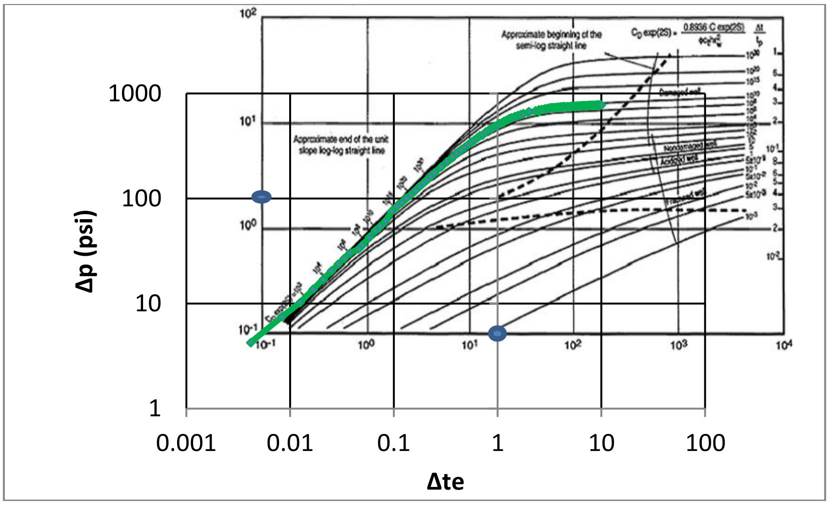

Fig. 10 Buildup data plotted on log-log graph paper and matched to type curve by Gringarten

From the match calculate the following properties:

$$k = \left[\frac{141.2QB\mu}{h}\right]\left(\frac{P_D}{\Delta p}\right)_{MP} = \left[\frac{141.2\times174\times1.06\times2.5}{107}\right]\left(\frac{1.79}{100}\right) = 10.89 \text{ md}$$

$$c = \left[\frac{0.0002951kh}{\mu}\right]\left(\frac{\Delta_{te}}{t_D/C_D}\right)_{MP} = \left[\frac{0.0002951\times10.96\times107}{2.5}\right]\left(\frac{1}{14.8}\right) = 0.00929$$

$$C_D = \left[\frac{0.8936}{\phi hc_t r_w^2}\right]c = \left[\frac{0.8936}{0.25\times107\times4.2\times10^{-6}\times0.29^2}\right]\times 0.009353 = 879$$

$$s = \frac{1}{2}\ln\left[\frac{(C_D e^{2s})_{MP}}{C_D}\right] = \frac{1}{2}\ln\left[\frac{10^{10}}{884.56}\right] = 8.13$$

The conventional the pressure buildup analysis by using the Horner plot approach and compare the results with those obtained by using the Gringarten type curve approach revealed a similarity between them (Table 3).

Table 3 Compare between Horner plot approach and Gringarten type curve approach.[12]

Property	*Horner plot*	*Gringarten type curve*
k	10.67 md	10.89 md
S	7.19	8.13
c	0.00922	0.00929
C_D	872	879

7. CONCLUSION

This study has been conducted on oil wells using software program for well testing analysis techniques to distinguish the characterizations of reservoir. The following conclusion can be drawn:

1. The study relay on the principle two methods that represent by buildup test techniques in the light of Horner plot and Gringation type curve.
2. The obtained results from buildup tests for the two wells show that the a low permeability (k) for Well L-004-65

(12.84 md) and negative value of skin factor (-4.365), while for Well C-173-65 displays a higher value (353.49 md) and positive value of skin factor (11.83); as well as Gringarten values are (11.89 md) and (8.13) respectively. This means that the reservoir needs to stimulate to improve the petrophysical properties to enhance the production rates.

3. The study exhibits unacceptable results that obtained from calculations of petrophysical properties such as the low permeability (k) values, the positive values of skin factor (s), pressure drop due to skin factor (ΔP_{skin}). According to these results the formation required to be stimulated to enhance these parameters.
4. However, the calculated data can be regarded as a good results for evaluation reservoir characterization as pressure transient analysis.

Symbol	*Definition and Units*
q_o	*oil flow rate, stb/day*
k	*undamaged permeability, md*
h	*thickness, ft*
r_e	*external radius, ft*
r_w	*wellbore radius, ft*
μ_o	*viscosity of oil, cp*
B_o	*oil formation volume factor, rb/stb*
A_r	*cross-sectional area at radius r*
s	*skin factor*
C_w	*water compressibility ,psi*
C_o	*oil compressibility ,psi*
C_t	*total compressibility ,psi*
B_w	*water formation volume factor*

B_g	*gas formation volume factor*
B_o	*oil formation volume factor*
Δ_t	*total flowing time since the last shut-in , hr*
Δt_e	*Agarwal equivalent time , hr*
t_p	*total flowing time since the last shut-in ,hr*
t_D	*dimensionless time*
t	*flowing time .hr*
P_D	*dimensionless pressure*
C	*wellbore storage coefficient ,bbl/psi*
C_D	*dimensionless wellbore storage coefficient*
C_A	*shape factor*
p_D	*dimensionless pressure*
P_e	*external pressure, psi*
p_{wf}	*shut-in pressure ,psi*
p_{ws}	*flow pressure just before shut-in ,psi*

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