

A new set of type curves simplifies well test analysis

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10-second summary

Recently developed type curves are presented, which greatly simplify the evaluation of buildup-type well test information. The basis on which these curves were developed and actual examples of their use are discussed. Curves used in the discussion are those that apply to the most commonly found situation, that is, a well with wellbore storage and skin in a homogeneous reservoir.

IN A CONVENTIONAL WELL TEST, the measured value of pressure change is of limited value. For ex-

ample, to say, "after a shut-in of 3 hours, pressure increased by 500 psi" reveals nothing in terms of reservoir properties. However, the statement "after a shut-in of 3 hours, pressure was still increasing by 10 psi per hour" is much more meaningful.

All methods for the analysis of data from well testing are based on the Diffusivity Equation for fluid flow through porous media. This equation is in terms of the differential of pressure with respect to time. It is this quantity, therefore, that is significant and which should, ideally, be measured. Mechanical bottomhole pressure recorders, however, are not capable of measuring rate of pressure change with respect to time, and this has restricted traditional well test analysis solely to a consideration of pressure behavior. New generation electronic bot-

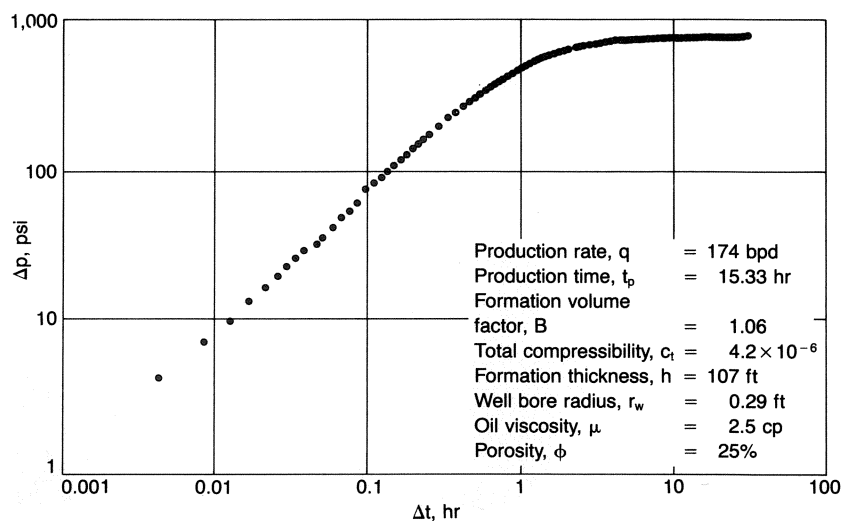


Fig. 1—Using data from example 1, a conventional pressure versus time log-log plot is constructed to help in identifying well and reservoir behavior.

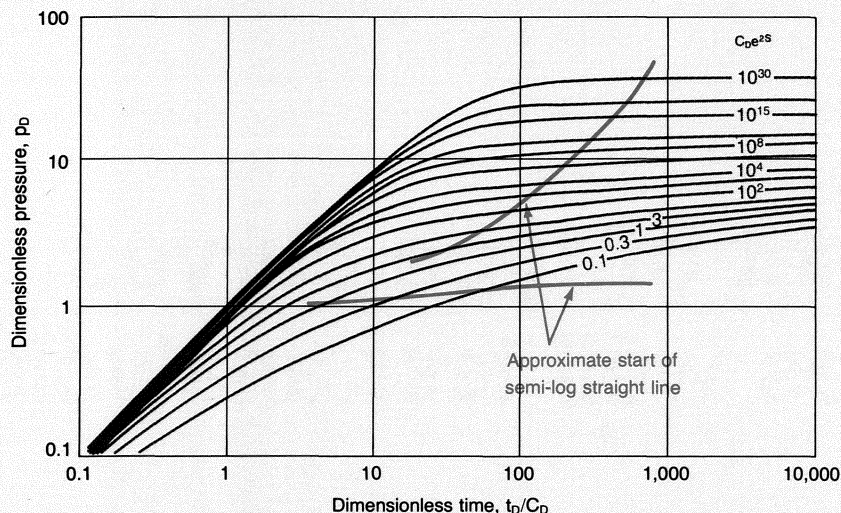


Fig. 2—Type curves for a well with wellbore storage and skin in a reservoir with homogeneous behavior. Note that at large values of dimensionless time the curves become very similar, making it difficult to obtain an accurate match.

TABLE 1—Well test data for Example 1

Elapsed time, hr	Pressure, psi	Elapsed time, hr	Pressure, psi
0.00000	3,086.33	1.87500	3,719.26
4.16668	3,090.57	2.00000	3,732.23
8.33333	3,093.81	2.25000	3,749.71
1.25000	3,096.55	2.37500	3,757.19
1.66667	3,100.03	2.50000	3,763.44
2.08333	3,103.27	2.75000	3,774.65
2.50000	3,106.77	3.00000	3,785.11
2.91668	3,110.01	3.25000	3,794.06
3.33333	3,113.25	3.50000	3,799.80
3.75000	3,116.49	3.75000	3,809.50
4.58333	3,119.48	4.00000	3,815.97
5.00000	3,122.48	4.25000	3,820.20
5.83333	3,128.96	4.50000	3,821.95
6.66668	3,135.92	4.75000	3,823.70
7.50000	3,141.17	5.00000	3,826.45
8.33333	3,147.64	5.25000	3,829.69
9.58333	3,161.95	5.50000	3,832.64
1.08333	3,170.68	5.75000	3,834.70
1.20833	3,178.39	6.00000	3,837.19
1.33333	3,187.12	6.25000	3,838.94
1.45833	3,194.24	6.75000	3,838.02
1.62500	3,205.96	7.25000	3,840.78
1.79167	3,216.68	7.75000	3,843.01
1.95833	3,227.89	8.25000	3,844.52
2.12500	3,238.37	8.75000	3,846.27
2.29167	3,249.07	9.25000	3,847.51
2.50000	3,261.79	9.75000	3,848.52
2.91668	3,287.21	1.02500	3,850.01
3.33333	3,310.15	1.07500	3,850.75
3.75000	3,334.34	1.12500	3,851.76
4.16668	3,356.27	1.17500	3,852.50
4.58333	3,374.98	1.22500	3,853.51
5.00000	3,394.44	1.27500	3,854.25
5.41668	3,413.90	1.32500	3,855.07
5.83333	3,433.83	1.37500	3,855.50
6.25000	3,448.05	1.45000	3,856.50
6.66668	3,466.26	1.52500	3,857.25
7.08333	3,481.97	1.60000	3,857.99
7.50000	3,493.69	1.67500	3,858.74
8.12500	3,518.63	1.75000	3,859.48
8.75000	3,537.34	1.82500	3,859.99
9.37500	3,553.55	1.90000	3,860.73
1.00000	3,571.75	1.97500	3,860.99
1.06250	3,586.23	2.05000	3,861.49
1.12500	3,602.95	2.12500	3,862.24
1.18750	3,617.41	2.22500	3,862.74
1.25000	3,631.15	2.32500	3,863.22
1.31250	3,640.86	2.42500	3,863.48
1.37500	3,652.85	2.52500	3,863.99
1.43750	3,664.32	2.62500	3,864.49
1.50000	3,673.81	2.72500	3,864.73
1.62500	3,692.27	2.85000	3,865.23
1.75000	3,705.52	3.00000	3,865.74

tomhole pressure gauges, however, allow the rate of change of pressure with time to be accessible. Analysis based on this pressure differential, $\Delta p'$, is more sensitive and powerful than analysis based only on pressure, Δp . This article presents a new set of type curves for analyzing the differential of pressure behavior for wells with wellbore storage and skin in homogeneous reservoirs.

INTERPRETATION BASED ON PRESSURE BEHAVIOR

In this example of techniques currently in use, the initial step is to plot pressure change, Δp , versus elapsed time, Δt , for a particular flow period, on a log-log scale. An example of a build-up test is shown in Fig. 1 (data are listed in Table 1).

This plot is diagnostic because it allows the identification of well and reservoir behavior. Once the behavior has been identified, which involves comparing actual pressure response with theoretical responses known as type curves, the correct analyses can be performed.

In well test analysis the most frequently encountered behavior is that of a well with wellbore storage and skin in a homogeneous reservoir. The corresponding set of type-curves is shown in Fig. 2.¹ The curves are also plotted on log-log scale in terms of dimensionless pressure, p_D versus dimensionless time divided by dimensionless wellbore storage, t_D/C_D . Equations for these two terms are as follows:

$$p_D = kh\Delta p/141.2qB\mu \quad (1)$$

$$t_D/C_D = 0.000295kh\Delta t/\mu C \quad (2)$$

Each curve is labelled by the dimensionless group, C_De^{2S} , which defines the shape of the curves:

$$C_De^{2S} = 0.8936C_e^{2S}/\phi c_i h r_w^2 \quad (3)$$

All the curves merge, in early time, into a unit slope straight line corresponding to pure wellbore storage flow. At later time, curves correspond to infinite acting radial flow, when the effects of wellbore storage have subsided and the flow is radial in the reservoir. Making an initial match of the data on one of these type curves allows:

- Confirmation of original diagnosis
- Identification of the two flow

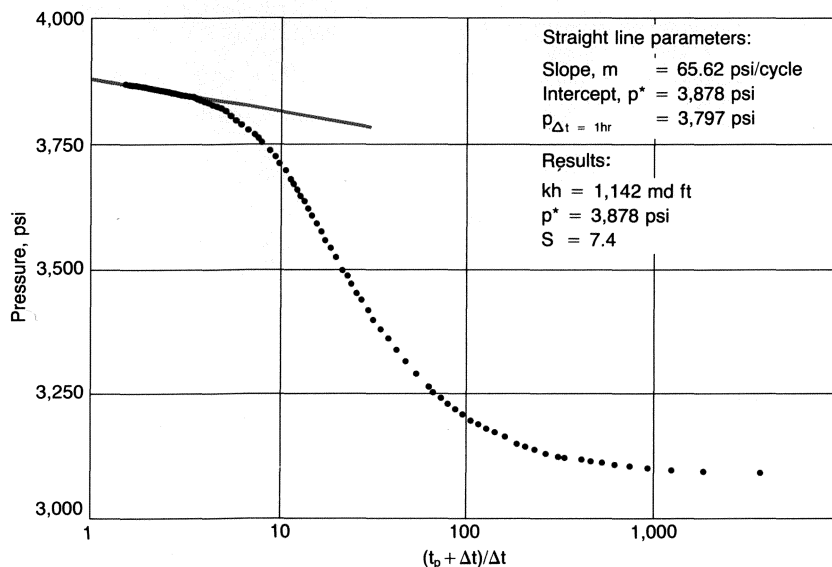


Fig. 3—After well and reservoir behavior have been identified, a typical Horner plot is used to calculate initial values for kh , and S . The kh value will be used later to obtain a refined match on the type curves.

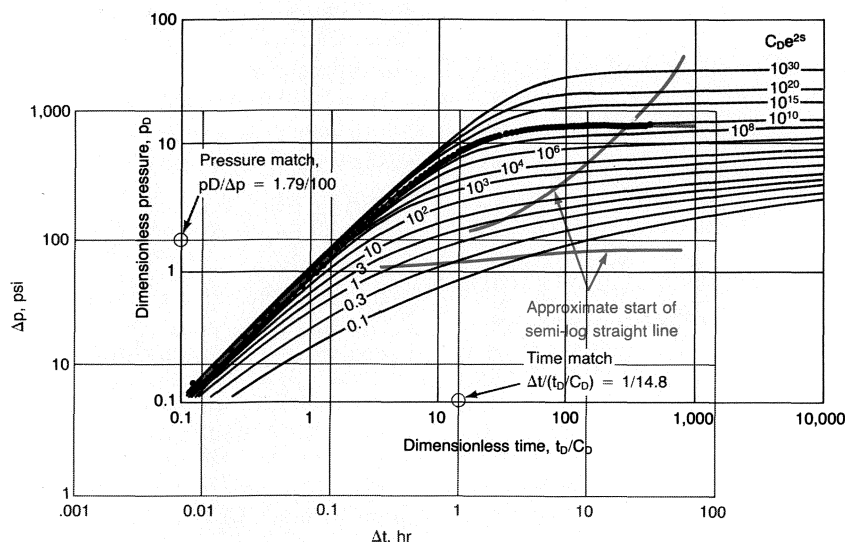


Fig. 4—The technique for obtaining the proper pressure and time match is illustrated. After the correct type curve has been selected, the permeability and skin parameters are recalculated and compared with the Horner analysis.

Editor's note:

The new set of type curves described in this article is partially derived from the derivatives of the dimensionless pressure and time functions normally used in most type curves. The explanation of how this derivative was obtained, for both establishing the type curves and handling the well test data, is beyond the scope of this article. Therefore, those readers interested in the details of the mathematics involved should contact the authors. In addition, full-size copies of the type curves are available from the authors. Write to Flopetrol: 228, Rue Einstein; 77530 Vaux-Le Penil; France or B. P. 592; 77005 Melun Cedex; France.

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regimes—wellbore storage and infinite acting radial flow

The initial match is made by sliding a plot of the test data over the type-curves, with respect to the unique straight line at early time, and then selecting the best possible match-curve. The end of wellbore storage and the start of infinite acting radial flow are then obtained from the limits marked on the type curves (Fig. 2). However, there are two problems commonly encountered in log-log type curve matching:

- For high values of $C_D e^{2S}$, type curves have very similar shapes, therefore if the data correspond to one of these curves (as in the example) it is not possible to find a unique match by a simple comparison of shapes.

- Build-up data deviate from type curves designed for the analysis of drawdown data. Deviation depends on the duration of the previous production period, t_p .

In the example, the data match all the curves above $C_D e^{2S} = 10^8$, although it seems that in all cases pure wellbore storage flow lasted less than about 5 minutes and infinite acting radial flow started after about 23 hours.

Once flow regimes have been identified, there are specialized analyses that are applicable to each. For a build-up, the Horner method is the specialized analysis applicable during the infinite acting radial flow regime. The method involves a plot of bottomhole shut-in pressure, p , versus $\log(t_p + \Delta t)/\Delta t$ as shown in Fig. 3.

On this plot, the data in infinite acting radial flow fall on a straight line. The straight line parameters given in Fig. 3 are used to evaluate the permeability thickness product, kh , and skin, S :

$$\begin{aligned} kh &= 162.6 q \mu B / m \\ &= (162.6)(174)(2.5) \\ &\quad (1.06) / 65.62 \\ &= 1,142 \text{ md ft} \end{aligned} \quad (4)$$

$$\begin{aligned} S &= 1.151 \left\{ \left[\frac{(p_{1hr} - p_{wf})}{m} \right] \right. \\ &\quad \left. - \left[\log \left(\frac{k}{\phi \mu c r_w^2} \right) \right] + 3.23 \right\} \\ &= 1.151 \left\{ \left[\frac{(3,797 - 3,086)}{65.62} \right] - \log \left[\frac{(10.68)}{(0.25)} \right] \right. \\ &\quad \left. (2.5)(4.2 \times 10^{-6})(0.29)^2 \right] \\ &\quad \left. + 3.23 \right\} \\ &= 7.3 \end{aligned} \quad (5)$$

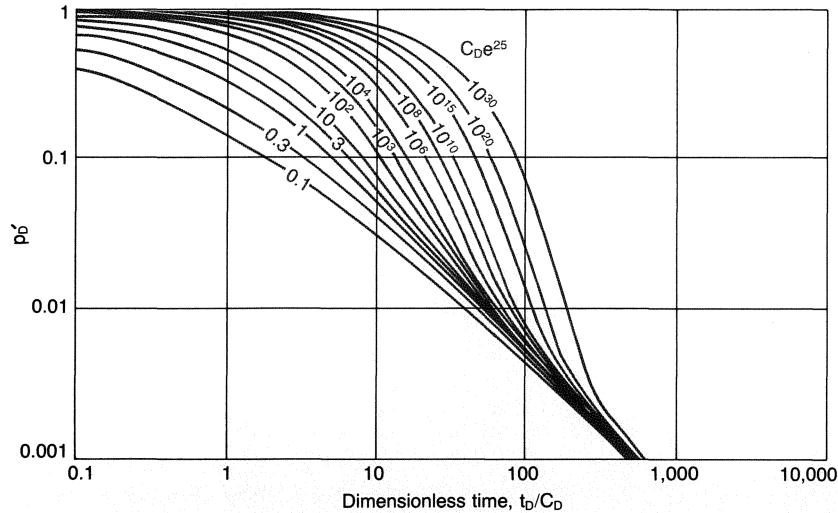


Fig. 5—A plot of the derivative of dimensionless pressure shows that at both early and late times the curves merge into straight lines.

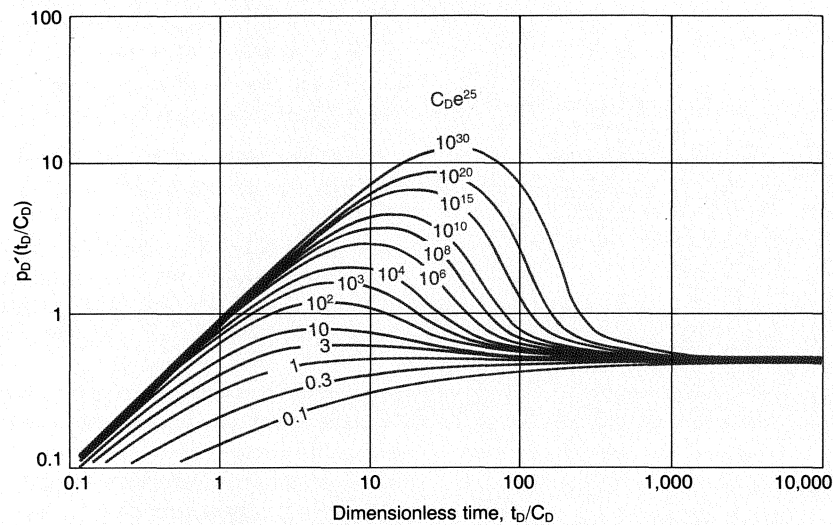


Fig. 6—By replotting the curves shown in Fig. 5, a more useful tool is obtained since the pressure and time axes are now consistent with the type curves of Fig. 2.

From the value of kh from the Horner plot the match on the pressure axis of the type curve can be fixed. This is done by inserting the kh value into Eq. 1 and solving for $p_D/\Delta p$. Eq. 1 is rewritten as follows:

$$\begin{aligned} p_D/\Delta p &= (kh)/141.2qB\mu \\ &= 1,142/(141.2)(174) \\ &= (1.06)(2.5) \\ &= 0.0175 \end{aligned}$$

If for convenience, Δp is set to equal 100, then p_D equals 1.75. Therefore, the log-log plot of Fig. 1 can be superimposed over the type curves of Fig. 2 knowing that 100 psi on the Y axis of Fig. 1 corresponds to a value of 1.75 on the Y axis of Fig. 2 (see Fig. 4). This estab-

lishes an initial vertical match, or $(p_D/\Delta p)_{match}$. The time match is then found by shifting the test data plot horizontally until the early time straight line curves are aligned. In this case, it was found that the best match was obtained when the pressure match was modified slightly to 0.0179 at a time match of 14.8 ($\Delta t = 1.0$ on Fig. 1, $t_D/C_D = 14.8$ on Fig. 2). The resulting type curve match is shown in Fig. 4. The refined curve (build-up type curve shown in blue) was generated numerically using the duration of the previous flow period, t_p .

When the refined match has been achieved, the $C_D e^{2S}$ value of the match curve, together with the

translation of the axes of the data plot with respect to the type curve axes, enable well and reservoir parameters to be calculated:

$$\begin{aligned} kh &= 141.2qB\mu(p_D/\Delta p)_{match} \\ &= 141.2(174)(1.06) \\ &= (2.5)(0.0179) \\ &= 1,165 \text{ md ft} \end{aligned}$$

$$\begin{aligned} C &= (0.000295kh/\mu)(\Delta t/(t_D/C_D)_{match}) \\ &= [(0.000295)(1.165)/2.5] \\ &= [1/14.8] \\ &= 9.3 \times 10^{-3} \text{ bbl/psi} \end{aligned}$$

$$\begin{aligned} C_D &= (0.8936 C) / (\phi c_i h r_w^2) \\ &= (0.8936)(9.3 \times 10^{-3}) / [(0.25) \\ &= (4.2 \times 10^{-6})(107)(0.29)^2] \\ &= 879 \end{aligned}$$

$$\begin{aligned} S &= 0.5 \ln (C_D e^{2S}/C_D) \\ &= 0.5 \ln (4 \times 10^9/879) \\ &= 7.7 \end{aligned}$$

Values of kh and S thus calculated are in agreement with those found from Horner analyses. In addition, the start of the Horner straight line is consistent with the start of infinite acting radial flow identified from the type curve.

In conclusion, there are two complementary aspects to the analysis of pressure behavior:

- A global aspect using type curves to identify the nature of the behavior
- A specific aspect using specialized analyses to accurately calculate well and reservoir parameters.

To attain a high degree of confidence in the results of the interpretation of pressure behavior, and to access all parameters of interest, the analysis method is iterative because agreement must be obtained between these two aspects of the analysis.

DIFFERENTIAL OF PRESSURE ANALYSIS

The two dominating regimes described on the type curve of Fig. 2 can be differentiated. During pure wellbore storage flow, when $p_D = t_D/C_D$ then:

$$d(p_D)/d(t_D/C_D) = p_D' = 1$$

During infinite acting radial flow in a homogeneous formation, $p_D = 0.5[\ln(t_D/C_D) + 0.80907 + \ln(C_D e^{2S})]$, then:

$$d(p_D)/d(t_D/C_D) = p_D' = 0.5/(t_D/C_D)$$

Therefore, both at early and at late time, all p_D' behaviors are iden-

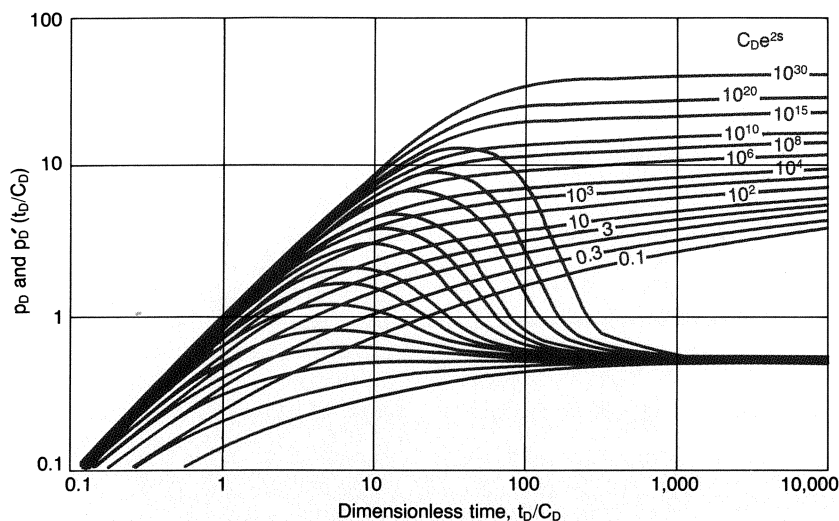


Fig. 7—The new set of type curves combines Fig. 6 with the result being that both the pressure and time matches can be obtained without going through the Horner analysis.

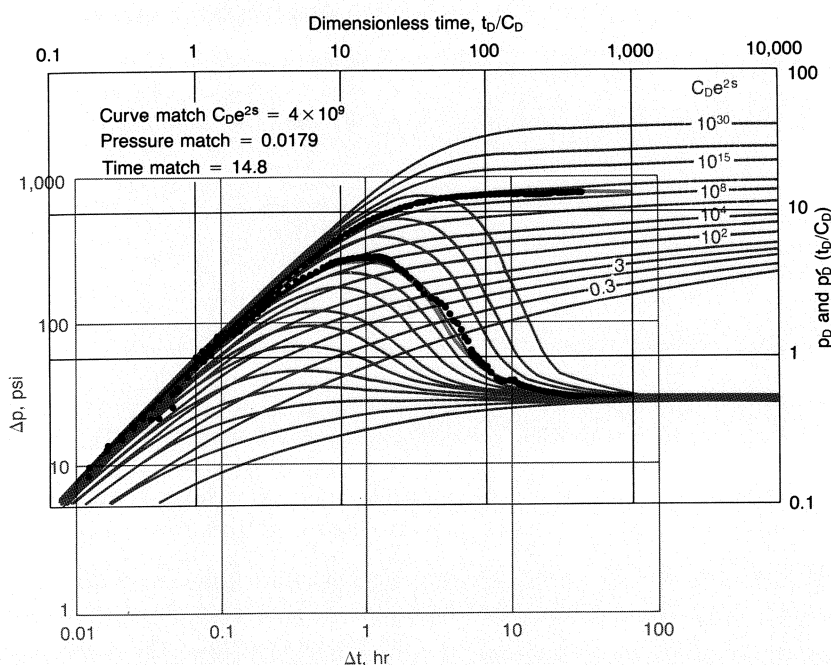


Fig. 8—Example 1, analyzed earlier using the Horner technique and type curves, is evaluated using the new type curves. Note how well the differential of pressure curve establishes the pressure match.

tical and independent of the C_{De}^{2S} group. The log-log type curve that corresponds to these relationships is shown in Fig. 5. At early time, all curves merge into a straight line corresponding to $p_D' = 1$. At late time, curves merge into a straight line of slope -1 , corresponding to $p_D' = 0.5/(t_D/C_D)$. Between these two asymptotes, at intermediate times, each C_{De}^{2S} curve produces a specific shape.

However, from a practical point of view, it was found preferable to

plot the type curves as $p_D'(t_D/C_D)$ versus t_D/C_D as in Fig. 6:

$$p_D'(t_D/C_D) = \Delta t \Delta p' kh / (141.2 q B \mu)$$

This plot is preferred because:

- The dimensionless groups of both the pressure and time axes are consistent with the type curve of Fig. 2.
- The type curves fit better onto the commonly used 3×5 grid, log-log scale.

To use this new type-curve, actual data must be plotted as $\Delta t (\Delta p')$ ver-

sus Δt . In Fig. 6, at early time, the curves follow a unit slope log-log straight line. When infinite acting radial flow is reached, at late time, the curves become horizontal at a value of $p_D'(t_D/C_D) = 0.5$.

These type curves are easier to use than the usual dimensionless pressure type curves. If both well-bore storage flow and infinite acting radial flow have occurred during the test period, then a log-log plot of the data will also exhibit the two straight lines. Therefore by matching the two straight line portions of the data on the asymptotes of the type curve, it is clear that only one match point will be possible. Between the asymptotes the type curves are distinctly different for differing values of C_{De}^{2S} . Thus, it is easy to identify the correct C_{De}^{2S} curve corresponding to the data.

In addition to this uniqueness and high definition, the method also has another very important feature—the infinite acting radial flow regime gives rise to a straight line on the log-log plot of the differential of pressure. Hence, in comparison with analysis of pressure behavior, analysis of the differential of pressure combines the advantages of type curve matching (a global consideration of the response) with the accuracy of a semi-log specialized plot. **The analysis of the differential of pressure is, therefore, performed with a single plot, eliminating the need for further plots to confirm the match.**

BUILD-UP ANALYSIS

When a pressure build-up test, following a single constant rate drawdown of duration t_p , is analyzed, build-up type curves (given by the following equation where $p_D\{t_D/C_D\}$ is the dimensionless pressure function), are used.

$$p_{D, BU}'\{t_D/C_D\} = p_D\{t_D/C_D\} + p_D\{t_p/C_D\} - p_D\{t_p/C_D + (t_D/C_D)\}$$

By differentiation, the relationship becomes:

$$p_{D, BU}'\{t_D/C_D\} = p_D'\{t_D/C_D\} - p_D'\{t_p/C_D + (t_D/C_D)\}$$

However, if infinite acting radial flow has been reached, $p_D'\{t_D/C_D\} = 0.5/(t_D/C_D)$, the build-up function then becomes:

$$p_{D, BU}'\{t_D/C_D\} = 0.5/(t_D/C_D) - 0.5/[(t_p/C_D) + (t_D/C_D)]$$

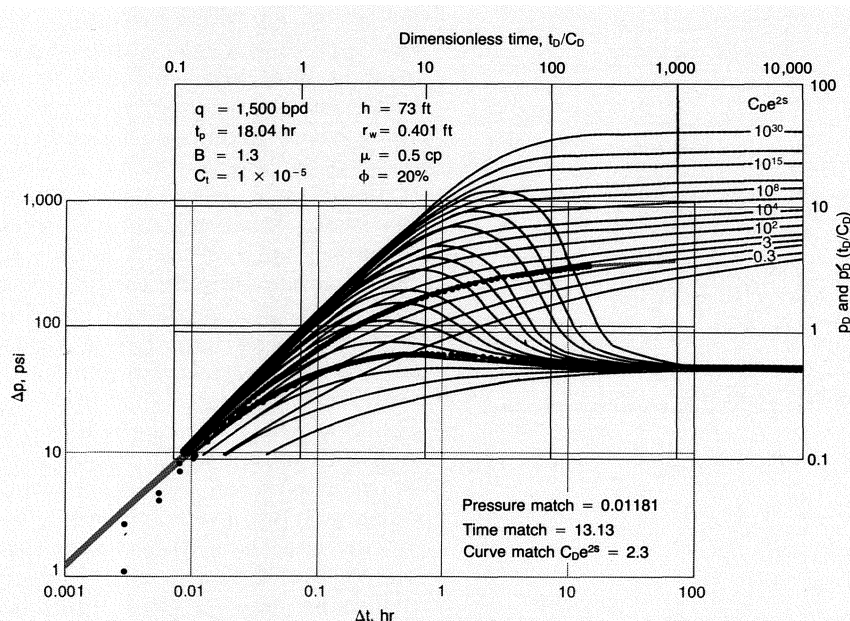


Fig. 9—In example 2, the lack of data on the unit slope straight line would have made an analysis using pressure change only, very difficult.

TABLE 2—Well test data for Example 2

Elapsed time, hr	Pressure, psi	Elapsed time, hr	Pressure, psi
0.00000	2,235.28	2.28112	2,325.85
3.11120 × 10 ⁻⁴	2,236.19	2.39312	2,328.08
3.11112	2,237.69	2.50312	2,330.25
5.91112 × 10 ⁻³	2,239.53	2.61512	2,332.34
8.71112	2,241.62	2.78112	2,335.35
1.15111	2,243.41	2.94712	2,338.22
1.43112	2,246.26	3.11512	2,340.95
1.71112	2,248.53	3.28112	2,343.48
1.97112	2,250.71	3.44712	2,346.06
2.25112	2,252.38	3.61512	2,348.39
2.53112	2,254.78	3.78112	2,350.70
2.81112	2,256.33	3.94712	2,352.93
3.09112	2,258.53	4.28112	2,357.13
3.37112	2,260.30	4.61512	2,361.03
3.65112	2,261.67	4.94712	2,364.64
3.93112	2,263.35	5.28112	2,368.09
4.21112	2,265.28	5.61512	2,371.32
4.47112	2,266.54	5.94712	2,374.34
4.75112	2,268.08	6.61512	2,379.93
5.03112	2,269.86	7.28112	2,385.02
5.31112	2,271.02	7.94712	2,389.60
5.59112 × 10 ⁻²	2,272.43	8.94712	2,395.77
5.87112	2,273.82	9.94712	2,401.13
6.15112	2,275.16	1.09471	2,405.84
6.43112	2,276.49	1.26151	2,412.87
6.71112	2,277.79	1.42811	2,419.12
6.97112	2,279.04	1.59471	2,424.58
7.25112	2,280.28	1.76151	2,429.44
7.53112	2,281.49	1.92811	2,433.63
7.81112	2,282.66	2.26152	2,440.84
8.09112	2,283.82	2.59472	2,446.78
8.37112	2,284.98	2.92812	2,451.81
8.65112	2,286.10	3.26152	2,456.20
8.93112	2,287.18	3.92812	2,463.38
9.21112	2,288.27	4.26152	2,466.46
9.47112	2,289.32	4.59472	2,469.18
1.00311	2,291.38	4.92812	2,471.68
1.05911	2,293.66	5.59472	2,476.05
1.11511	2,295.32	5.92812	2,478.00
1.17111	2,297.18	6.59472	2,481.50
1.28111	2,300.78	7.26152	2,484.54
1.33711	2,302.49	7.92812	2,487.24
1.42111	2,304.98	8.59472	2,489.62
1.47511	2,306.56	9.26152	2,491.76
1.53111 × 10 ⁻¹	2,308.11	9.92812	2,493.72
1.61511	2,310.38	1.09281	2,496.29
1.69711	2,312.57	1.19281	2,498.61
1.78111	2,314.95	1.29281	2,500.66
1.86511	2,316.71	1.39281	2,502.50
1.94712	2,318.55	1.45947	2,503.63
2.05912	2,321.07	1.52615	2,504.69
2.17112	2,323.52	1.59281	2,505.71

$$= [t_{pD}/(t_{pD} + t_D)] [0.5/(t_D/C_D)]$$

or:

$$[(t_D + t_{pD})/t_{pD}](t_D/C_D)p_D' \{t_D/C_D\} = 0.5$$

Thus, instead of plotting $\Delta p' \Delta t$ versus Δt for build-ups, $\Delta p' \Delta t$ ($t_p + \Delta t$)/ t_p is plotted versus Δt , and then data can be matched to p_D' drawdown type curves with minimal error. The method has the advantage that it maintains the straight line when infinite acting radial flow occurs, hence in build-up analysis the method combines the advantages of type curve matching with those of the Horner analysis.

EXAMPLES USING DIFFERENTIAL OF PRESSURE ANALYSIS

As soon as radial flow is reached, all differential of pressure curves are identical and, in particular, are independent of skin factor. This means that the effect of skin is only manifested in the curvature between the straight line due to wellbore storage flow and the straight line due to infinite acting radial flow. Experience has shown that data in this portion of the curve are not always well defined. For this reason, it was found useful to superimpose the two type curves of Figs. 2 and 6 on the same scale. The result, Fig. 7, allows simultaneous matching of pressure change data, Δp , and differential of pressure data, $\Delta t(\Delta p')$, since they are plotted on the same scale. The differential of pressure data then provides, without ambiguity, the pressure match and the time match, while the $C_D e^{2s}$ value is obtained by comparing the label of the match-curves for the differential of pressure data and the pressure change data.

Example 1. For the example given earlier (data are in Table 1), the analysis procedure is now as follows:

- Both Δp and $\Delta t(\Delta p')(t_p + \Delta t)/t_p$ are plotted on the same log-log graph versus Δt .
- The late-time data points of the differential of pressure curve are matched on the horizontal radial flow straight line of the p_D' type curve. The pressure match is then

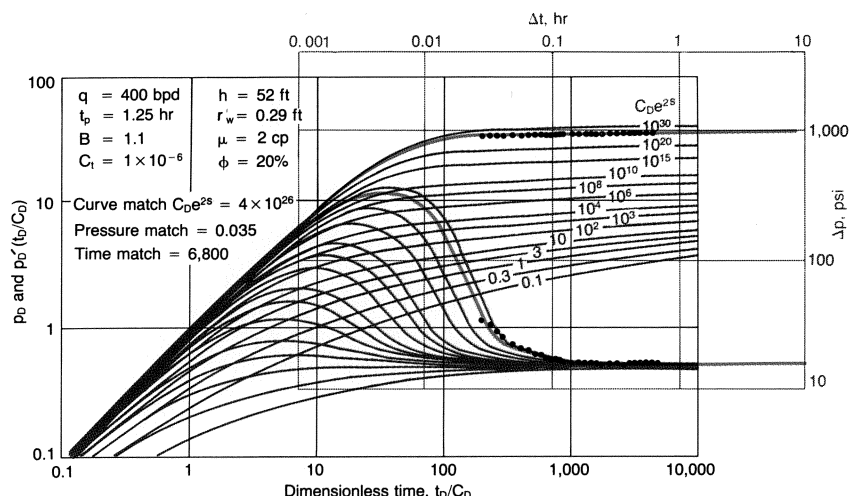


Fig. 10—In example 3, the pressure change plot would have been useless since it is flat. However, the differential of pressure plot has a distinct shape that was useful in obtaining the correct type curve match.

fixed at 0.0179. And, as before, $kh = 1,165$ md ft.

- The log-log data plot is displaced horizontally until the early time data match the unit slope wellbore storage straight line. The time match is then fixed at 14.8, and the value of C is determined to be 9.3×10^{-3} bbl/psi.

- The label of the curve matching the differential of pressure data ($C_{De^{2S}} = 4.0 \times 10^9$) is consistent with that matching the pressure change data. This is the final log-log match, resulting in Fig. 8, which could not have been obtained directly if only pressure change data were used, as was done previously. The curve match allows skin to be calculated as $S = 7.7$.

The second example is an analysis of a build-up test of an acidized well in a homogeneous reservoir (Table 2 lists the data). The two plots in Fig. 9 show that there are no data on the unit slope straight line, but from differential of pressure it can be seen that infinite acting radial flow was reached quickly. The matching procedure is the same as used in the first example, and a good fit was obtained on the curves $C_{De^{2S}} = 2.3$. Results of the analysis are:

$$\begin{aligned} kh &= 1,630 \text{ md ft} \\ C &= 7.3 \times 10^{-2} \text{ bbl/psi} \\ S &= -3.5 \end{aligned}$$

The third example is a DST pressure build-up in a homogeneous reservoir (data in Table 4). The first

pressure reading occurred well after the end of pure wellbore storage flow. The log-log plot of pressure change, Δp , versus elapsed time, Δt , is flat and, therefore, difficult to match (Fig. 10). The differential of pressure plot, however, shows some curvature before the horizontal radial flow straight line is reached. By using the double plot matching technique, a unique match is obtained on curves $C_{De^{2S}} = 4 \times 10^{26}$. This match would not have been unique if only pressure change data

TABLE 3—Well test data for Example 3

Elapsed time, hr	Pressure, psi
0.00000	2,511.00
2.91668	3,468.59
3.33333	3,473.38
3.75000	3,476.48
4.16668	3,478.88
5.00000	3,482.55
5.83333	3,485.65
6.66668	3,488.20
7.50000	3,489.33
8.33333	3,491.87
9.16668	3,493.00
1.00000	3,494.84
1.08333	3,495.40
1.16667	3,496.53
1.25000	3,497.38
1.45833	3,499.64
1.66667	3,501.48
1.87500	3,503.04
2.08333	3,504.03
2.29167	3,505.44
2.50000	3,506.86
2.91668	3,508.41
3.33333	3,510.11
3.75000	3,511.38
4.16668	3,512.52
4.58333	3,513.65
5.00000	3,514.78
5.62500	3,515.77
6.25000	3,516.91

had been considered since the time match would have been indeterminate. Results of the analysis are:

$$\begin{aligned} kh &= 4,350 \text{ md ft} \\ C &= 9.5 \times 10^{-5} \text{ bbl/psi} \\ S &= 28 \end{aligned}$$

CONCLUSION

These field examples show that the analysis method is very dependent upon the quality of differential of pressure data. It is the authors' experience that only electronic pressure gauges can provide usable $\Delta p'$ data. The analysis of the differential of pressure, which has already been introduced for interference tests,² fractured well test analysis³ and for some boundary effects⁴ seems to be particularly suited to the interpretation of the very common case of wells with wellbore storage and skin in homogeneous reservoirs. By using this new method, interpretation is not only more simple, but also more accurate as a result of the following features:

- Interpretation is performed by a single plot of pressure that combines the advantages of type curve matching with semi-log analysis.
- Due to the uniqueness of the behavior of differential of pressure at early and late times, the match point is fixed without ambiguity.
- Due to the shape sensitivity of the p_D' curves to changes of $C_{De^{2S}}$ values, the match curve is also definitively fixed. If the data are scattered, the skin factor can still be determined accurately by simultaneously matching pressure change data and differential of pressure data on the double type curve of Fig. 7.
- The method has shown to be particularly powerful for build-up analysis since a very simple, new time function can change the build-up data into the equivalent draw-down response, thereby eliminating the use of build-up type curves.

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