Well Test Interpretation

SKM4323

TYPE CURVES

Azmi Mohd Arshad

Department of Petroleum Engineering

WEEK 06

Introduction

- Type curves first appeared in oil industry literature in the seventies.
- Several kinds, as listed below, are used to interpret a test in a vertical well with a infinite homogeneous reservoir:
  - Agarwal et al. type curves;
  - McKinley type curves;
  - Earlougher and Kersch type curves;
  - Gringarten et al. type curves.
- Gringarten et al. curves are the most complete and practical to use. They are also the most widely used in oil industry literature.

Gringarten Type Curves

- A type curve represents the variations in pressure versus time for a specified reservoir-well configuration.
- It is calculated using an analytic model and expressed in dimensionless variables.
- The analytic model used by Gringarten to describe a vertical well in an infinite homogeneous reservoir is discussed by F. Daviau (1986).

Gringarten Type Curves…/2

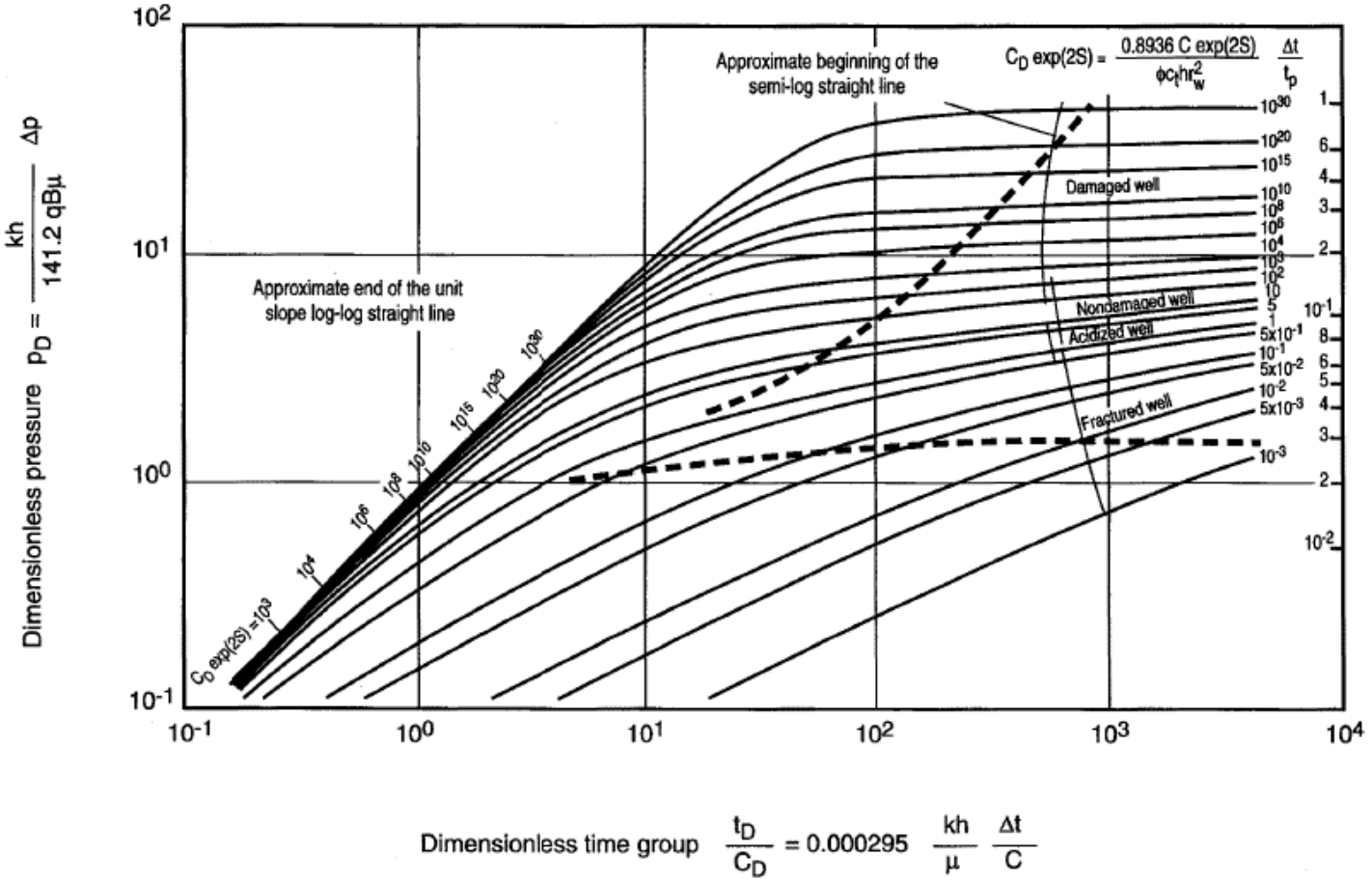


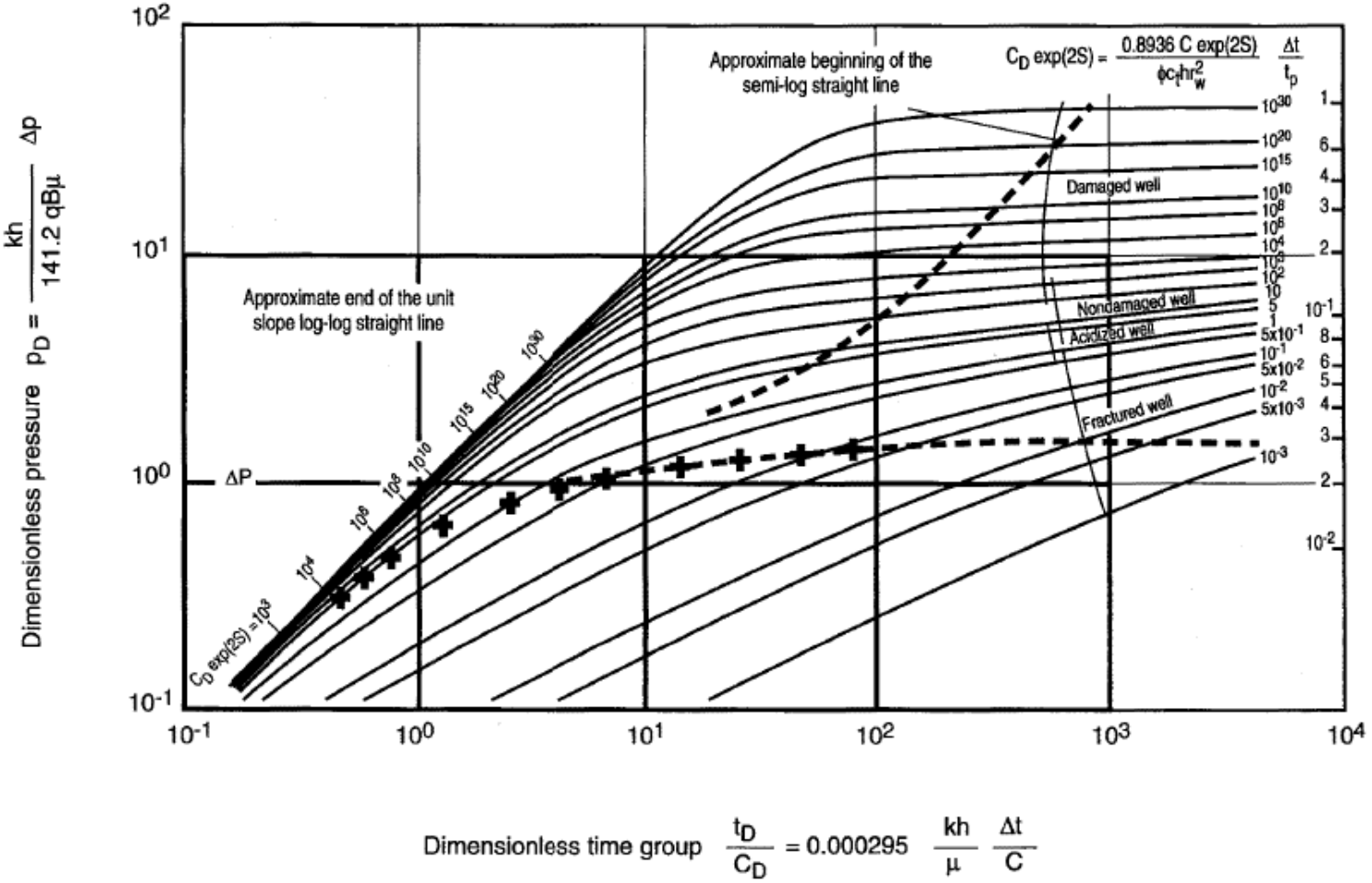
Fig. 5.1 Type curves for a well with wellbore storage and skin (infinite homogeneous reservoir)

Gringarten Type Curves.../3

Procedure

- Plot the measured pressure drop Δp versus Δt on tracing paper lying on the type curves, using the log-log scale of the type curves.
- Look for the portion of an underlying type curves matching the data best. Only translation are allowed during this step, keeping the two grids parallel.
- Note the specifications of the type curve where the measured points match; they correspond to value of $C_D \exp(2S)$.
- Pick a match point, M, whose coordinates can be read in both the type curve system of axes (p_D, t_D/C_D) as well as in the field data system (Δp, Δt). The point M can be chosen anywhere on the plot, not necessarily on the curve.

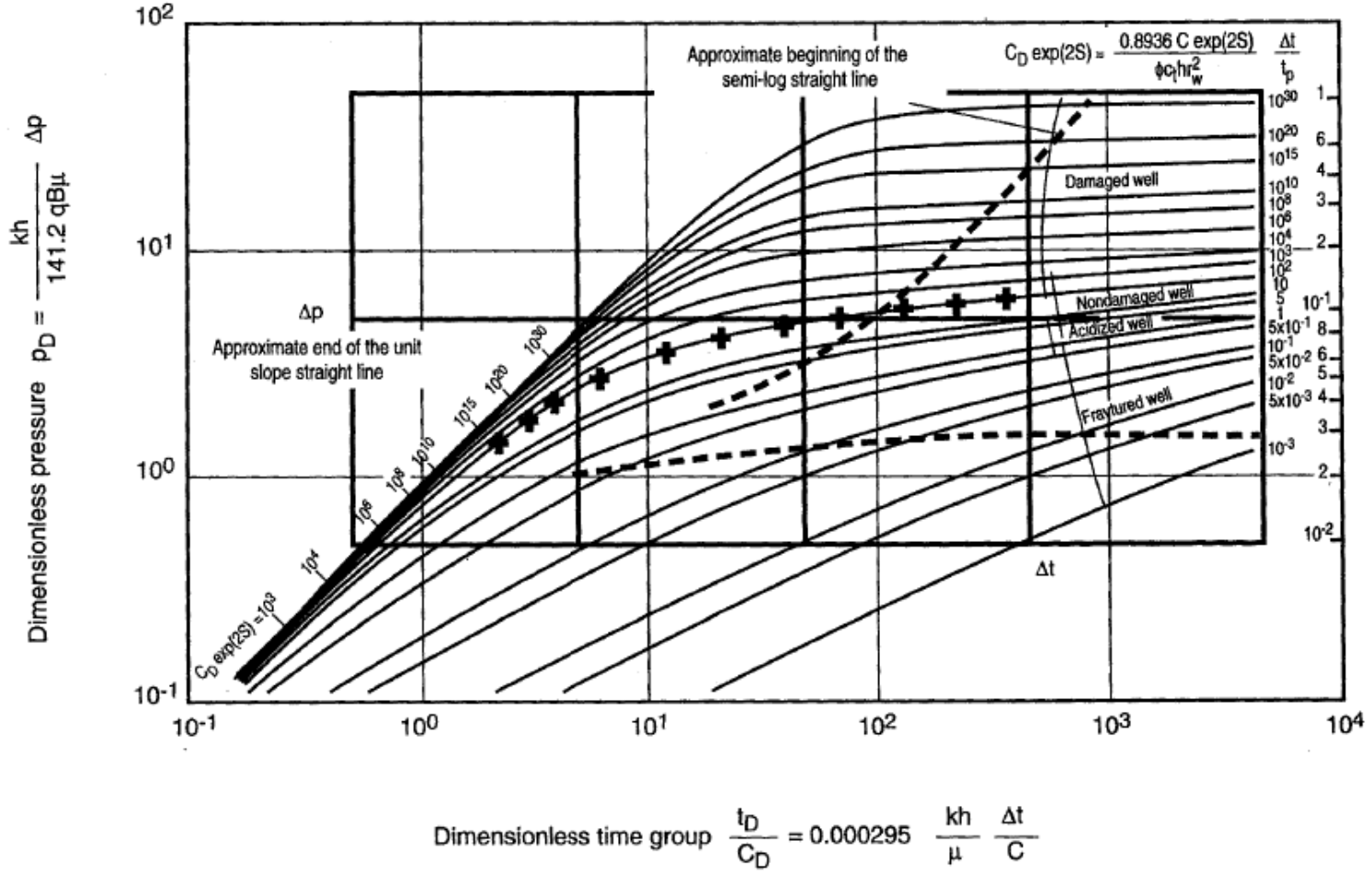
Gringarten Type Curves.../4



Dimensionless time group $\frac{t_D}{C_D} = 0.000295 \frac{kh}{\mu} \frac{\Delta t}{C}$

Fig. 5.2a

Gringarten Type Curves.../5



Dimensionless time group $\frac{t_D}{C_D} = 0.000295\ \frac{kh}{\mu}\ \frac{\Delta t}{C}$

Fig. 5.2b

Gringarten Type Curves…/6

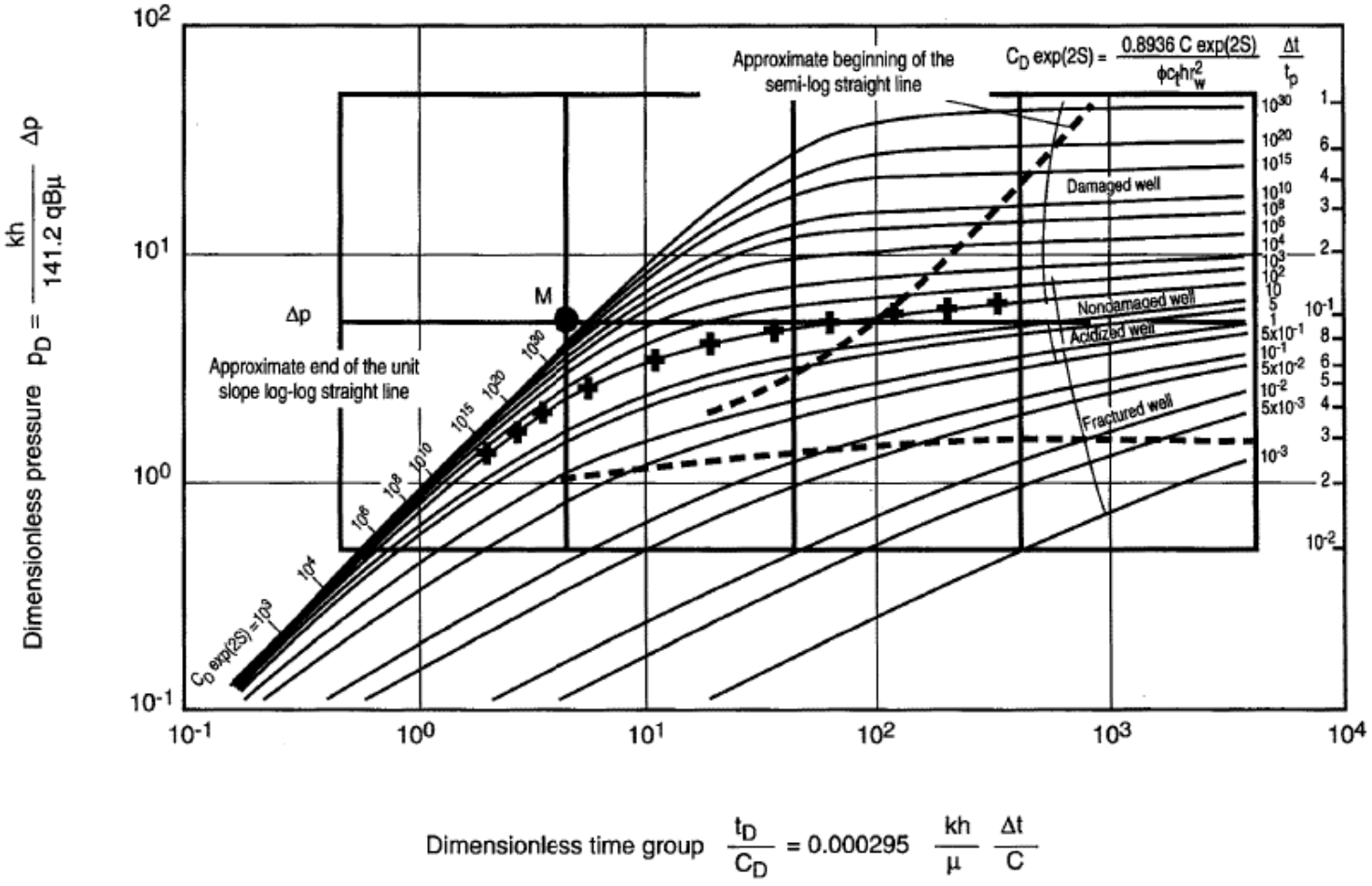


Fig. 5.2c

Gringarten Type Curves.../7

Interpretation

- The ordinate of the match point is measured:
  - in the type curve system of axes: p_D
  - in the field data system of axes: Δp.

As: $$p_D = \frac{kh}{141.2\,qB\mu}\Delta p$$ (in practical US units)

- The proportionality factor between p_D and Δp can be used to determine the reservoir's kh:

$$kh = 141.2\,qB\mu\frac{(p_D)_M}{(\Delta p)_M} \qquad \textbf{(5.4)}$$

Gringarten Type Curves.../8

Interpretation

- In the same way the abscissa of the match point, M, is measured in the type curve system of axes, t_D/C_D and in the field data system of axes: Δt..

$$t_D/C_D = \frac{0.000295\,kh}{\mu C}\Delta t \qquad \text{(in practical US units)} \qquad \textbf{(5.5)}$$

As kh is already determined

- The proportionality factor between t_D/C_D and Δt can be used to calculate C, the wellbore storage:

$$C = \frac{0.000295\,kh}{\mu}\frac{(\Delta t)_M}{(t_D/C_D)_M} \qquad \textbf{(5.6)}$$

Gringarten Type Curves.../9

Interpretation

- The type curve where the data have been matched is characterized by $C_D\exp(2S)$.

  C_D is then calculated:

$$C_D = \frac{0.89C}{h\phi c_t r_w^2} \qquad \text{(in practical US units)} \qquad \textbf{(5.7)}$$

- The value of CDexp(2S) is used to determine the skin:

$$S = \frac{1}{2}\ln\frac{(C_D\exp(2S))}{C_D} \qquad \textbf{(5.8)}$$

Gringarten Type Curves.../10

Using Type Curves During Buildup

- Type curves were established for constant flow rate production (drawdown).
- The curves can be used directly to analyze buildup if:
  - $\Delta t << t_p$ after constant flow rate;
  - $\Delta t << t_{p(n-1)}$ after a multirate history
    $t_{p(n-1)}$ duration of the last production period before shut-in.
- These conditions are the same as for using MDH method.
- If these conditions do not exist, using the types directly may lead to inaccurate results.

Gringarten Type Curves…/11

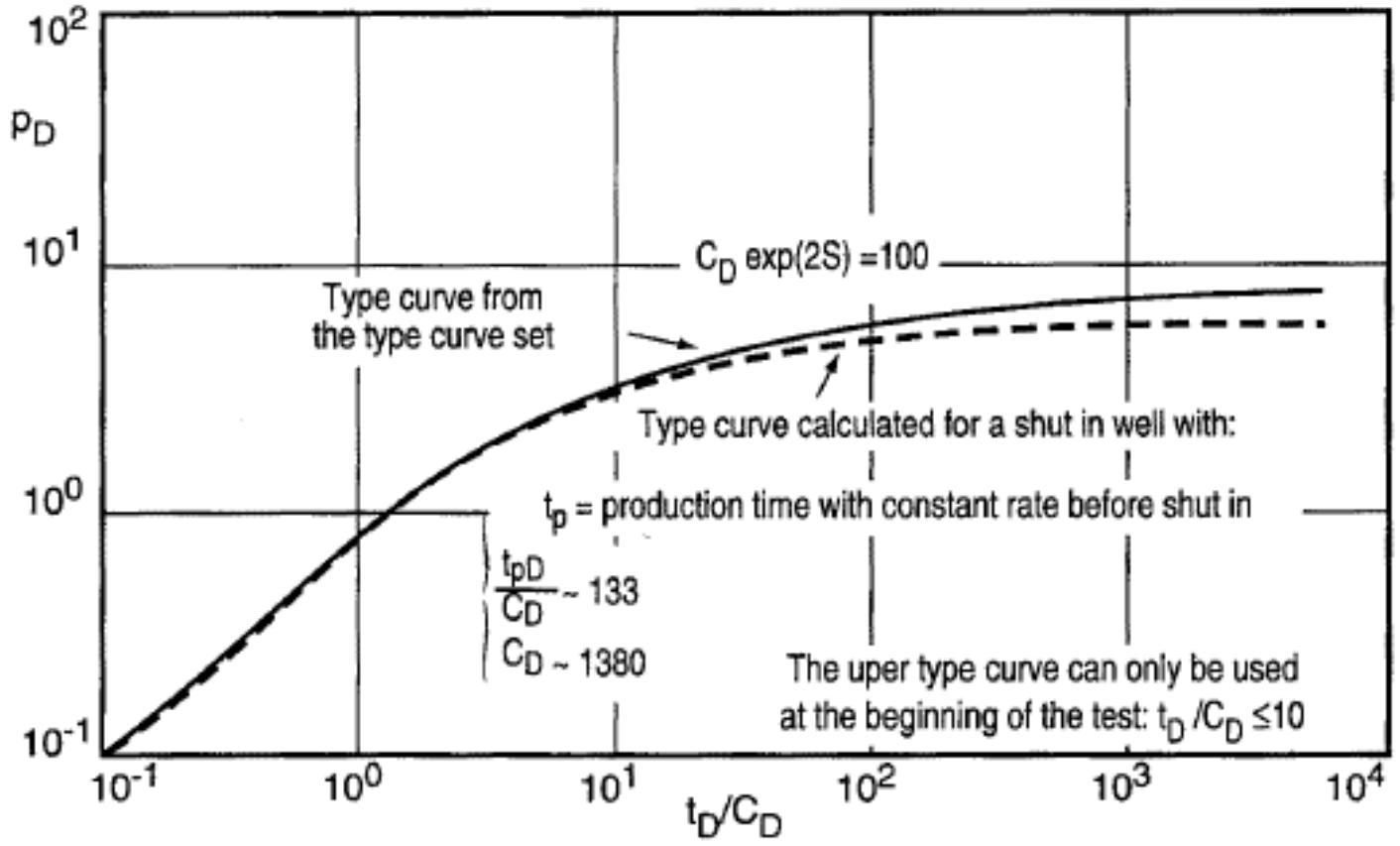


Fig. 5.3

Gringarten Type Curves.../12

Using Type Curves During Buildup

- The effect of short production time can be seen in a flattening out of the type curve, the buildup curve under the drawdown type curve.
- Attempting to force a match between the buildup data points and a drawdown curve would result in a type curve located too high on the set of curves and therefore in inaccurate results.

Gringarten Type Curves.../13

Using Type Curves During Buildup

- The most useful method of using drawdown type curves for buildup is Agarwal's method. It consists in plotting each measurement versus an equivalent time, Δt_e as defined below instead of versus Δt:

$$\Delta t_e = \frac{\Delta t}{1 + \frac{\Delta t}{t_p}} \qquad \textbf{(5.9)}$$

- The equivalent time is very close to Δt for Δt values that are small compared to production time.

Gringarten Type Curves…/14

Using Type Curves During Buildup

- The buildup measured points plotted versus Δt_e are located on a drawdown curve and the flattening effect of buildup disappears.
- F. Daviau indicates that Agarwal's method can be used for buildup provided that the semi-log straight line was reached during the previous drawdown period.

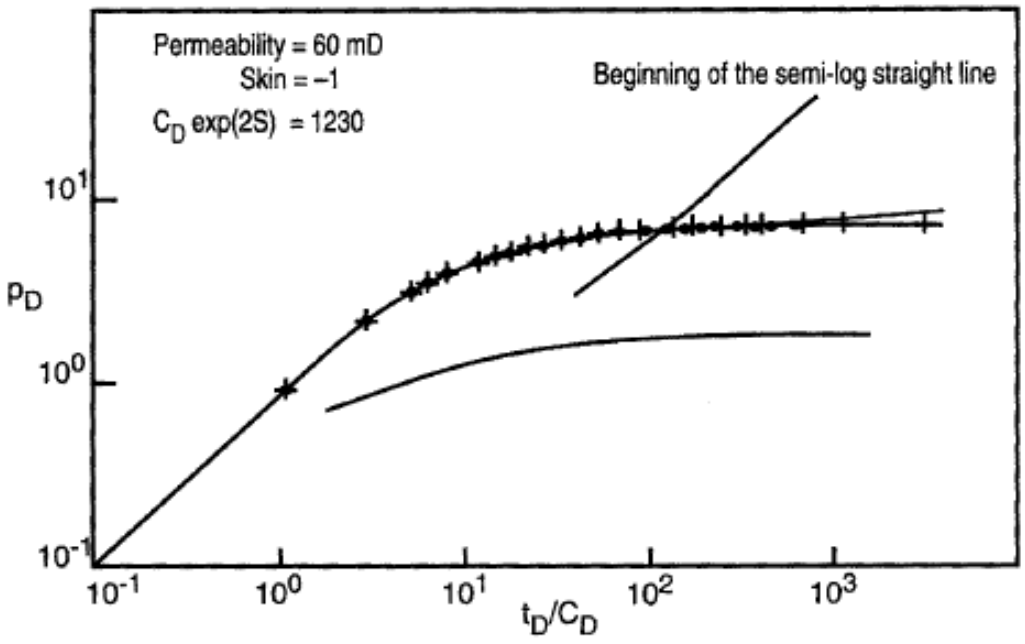


Fig. 5.4

Example 6

(In-class workshop)

- Drawdown -

Example 7

(In-class workshop)

- Buildup -

References

1. Bourdarot, Gilles : Well Testing: Interpretation Methods, Éditions Technip, 1998.
2. Internet.