Well Test Interpretation

SKM4323

CONVENTIONAL INTERPRETATION METHODS

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WEEK 03

Drawdown Test

- The equation that describes pressure variations versus time and distance from the well after opening the well at a constant flow rate, q, is given by:

$$p_i - p(r,t) = -\frac{qB\mu}{4\pi\,kh}\,Ei\left(\frac{-r^2}{4Kt}\right) \qquad \textbf{(4.1)}$$

with

$$K = \frac{k}{\phi\,\mu c_t}$$

Drawdown Test.../2

- When the pressure is measured in the well where the flow rate disturbance is located, $r = r_w$.

- As soon as $r_w^2/4Kt < 10^{-2}$, which usually occurs before the wellbore storage effect is over, the Ei function can be replaced by its logarithmic approximation:

$$p_i - p_{wf}(t) = -\frac{qB\mu}{4\pi\,kh}\left(\ln\frac{Kt}{r_w^2} + 0.81\right) \qquad \textbf{(4.2)}$$

Drawdown Test.../3

- Taking pressure drops in the skin into account, this expression becomes:

$$p_i - p_{wf}(t) = -\frac{qB\mu}{4\pi kh}\left(\ln\frac{Kt}{r_w^2} + 0.81 + 2S\right)$$ **(4.3)**

Drawdown Test.../4

- It can also be written in other equivalent forms:
  - in practical US units:

$$p_i - p_{wf}(t) = -\frac{162.6\,qB\mu}{kh}\left(\log t + \log \frac{k}{\phi\mu c_t r_w^2} - 3.23 + 0.87\,S\right) \quad \textbf{(4.4)}$$

  - in practical metric units:

$$p_i - p_{wf}(t) = -\frac{21.5\,qB\mu}{kh}\left(\log t + \log \frac{k}{\phi\mu c_t r_w^2} - 3.10 + 0.87\,S\right) \quad \textbf{(4.5)}$$

  - as a dimensionless equation:

$$p_D = \frac{1}{2}(\ln t_D + 0.81 + 2S) \qquad \textbf{(4.6)}$$

Drawdown Test.../5

Interpretation

- Equation (4.2) to (4.6) show that bottomhole pressure varies logarithmically versus time.

- If the pressure measured at the bottom of the hole is plotted on a graph versus the logarithm of time, a straight line with a slope of m can be observed once the wellbore storage effect has ended:

$$m = \frac{162.6 \ qB\mu}{kh} \quad \text{(in practical US units)} \qquad \textbf{(4.4)}$$

$$m = \frac{21.5 \ qB\mu}{kh} \quad \text{(in practical metric units)} \qquad \textbf{(4.8)}$$

Drawdown Test…/6

Interpretation

- The slope, m, is used to determine the reservoir's kh:

$$kh = \frac{2.303 \; qB\mu}{4\pi \, m} \qquad \text{(in SI units)} \qquad \textbf{(4.9)}$$

$$kh = \frac{162.6 \; qB\mu}{m} \qquad \text{(in practical US units)} \qquad \textbf{(4.10)}$$

$$kh = \frac{21.5 \; qB\mu}{m} \qquad \text{(in practical metric units)} \qquad \textbf{(4.11)}$$

Drawdown Test.../7

Interpretation

- The **skin** value is usually computed using the pressure measurement at 1 hour on the **semi-log straight line**; for this point log t = 0.

-in practical US units

$$S = 1.151 \left(\frac{p_i - p_{1h}}{m} - \log \frac{k}{\phi \mu c_t r_w^2} + 3.23 \right)$$

(4.12)

-in practical metric units

$$S = 1.151 \left(\frac{p_i - p_{1h}}{m} - \log \frac{k}{\phi \mu c_t r_w^2} + 3.23 \right)$$

(4.13)
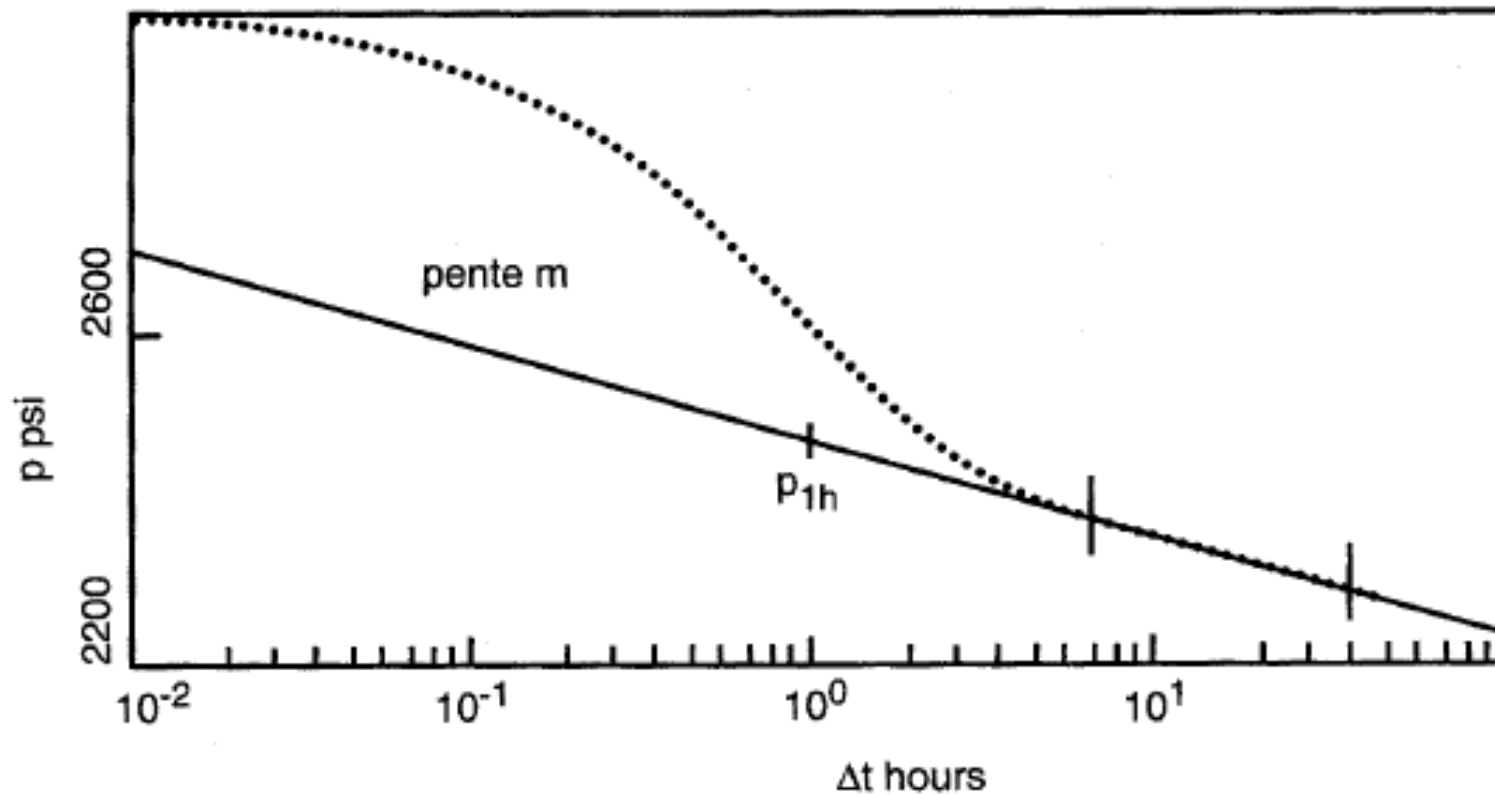
Drawdown Test.../8

Fig. 4.1

Drawdown Test…/9

Interpretation

- Care must be taken to read the pressure at 1 hour on the semi-log straight line and not by interpolating among the measurement points.

- After one hour the data may still be affected by the wellbore storage effect. In this case, they do not verify the semi-log straight line equation.

Example 1

(In-class workshop)

References

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

2. Internet.