Influence of Near Wellbore Tortuosity Upon Pump-in/Flowback Test Interpretation

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Define near wellbore tortuosity

Traditional pump-in/flowback test interpretation and challenges

Interpretation based on inflow rate

Incremental flowback test

Illustrating examples

Conclusions and discussion
WHAT IS NEAR WELLBORE FRACTURE TORTUOSITY?

- Near Wellbore Fracture Tortuosity is the mechanical flow restriction between the wellbore and a dominant induced hydraulic fracture.
- It is characterized by the restricted fracture aperture and frictional pressure drop.

\[ \Delta p_{nwf} = f(Q, p) \]

The fracture is being closed through controlled flowback.

The closure pressure is associated with the minimum in-situ stress.
Compressibility test

It is assumed that the bottom hole pressure is equal or slightly lower than the fracture pressure.

The interpretation assumes steady-state flow conditions.

**Wellbore + Fracture:**

\[
- \frac{dp}{dt} = S_{total} \left( Q_{fb} + Q_{\text{leak-off}} \right)
\]

\[
\frac{1}{S_{total}} = \frac{1}{S_{w}} + \frac{1}{S_{\text{frac}}}
\]

S: Stiffness, pressure/volume

Q: volume flow rate
MAKING SENSE OF FLOWBACK DATA

- What is the stiffness after closure?
- What if it is less than $S_w$?
- Is there a pressure rebound?

Only wellbore:

$$-\frac{dp}{dt} = S_w(Q_{fb} - Q_{inflow})$$

$$Q_{inflow} = Q_{fb} \left(1 + \frac{1}{S_w} \frac{dp}{dV_{fb}}\right)$$
EXAMPLE 1: NO APPARENT CLOSURE

No characteristic closure event!

Surface Pressures versus Flow Back Volume

Fourth reopening cycle

No closure interpreted

\[ y = -0.019x + 2.080 \]
\[ R^2 = 0.9998 \]

\[ Q_{inflow} = Q_{flowback} \left( 1 - \frac{S_{fb}}{S_w} \right) \]

\[ Q_{flowback} = 4.4 \, l/\,min \]
\[ Q_{inflow} = 4.0 \, l/\,min \]
EXAMPLE 2: PRESSURE REBOUND

First Reopening Stage

Surface Pressure versus Flow Back Volume

Step Rate Test

Pressure rebound is no indication for closure pressure!

\[ Q_{flowback} = 4.0 \text{ l/m} \]
\[ Q_{inflow} = 2.2 \text{ l/m} \]
INCREMENTAL FLOWBACK

- An idea – overcome transient response.
- Pressure must stabilize!
FAILED_INCREMENTAL FLOWBACK TEST

- Very tight connection
- Impractical to do

![Graph showing pressure and injection rate over time with a note on near wellbore friction.](image)
CONCLUSIONS AND DISCUSSION

- The wellbore stiffness is a very important parameter that allows us to QC flowback data.
- The low flowback stiffness and pressure rebound indicate near wellbore restriction and presence of the transient flow.
- The conventional interpretation is challenged. The regime of small and constant inflow rate does not need to start with far-field min stress.
- Incremental flowback test might mitigate the problem with the NWT.
- Why the inflow rate is constant while the pressure is decreasing?
- How to interpret the constant rate flowback data?