Production Analysis

A Complete Example Analysis —
East Texas Gas Well

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PA Example: $\log(q_g)$ and $p_{wf}$ vs. Time

Production Data Analysis Plot for East Texas Gas Well
"Summary" History Plot — Rate and Pressure Functions

Legend: East Texas Gas Well
- $q_g$ Production Data
- $p_w$ Production Data (measured surface/converted bottomhole)
- $p_{ws}$ Well Test Data (measured bottomhole)
PA Example: \( \log(q_g) \) vs. Time (with rate extrapolations)

Production Data Analysis Plot for East Texas Gas Well
"Summary" History Plot — Rate and Pressure Functions

Legend: East Texas Gas Well
- \( q_g \) Production Data
- \( q_g \) Exponential Model
- \( q_g \) Hyperbolic Model
- \( q_g \) Reservoir Model

\textbf{EUR Analysis Results:} East Tx Gas Well
- \( q_i = 4000 \text{ MSCF/D} \)
- \( D_i = 0.00471 \text{ 1/D} \)
- \( b = 0.3 \) (dimensionless)
- \( G = 1.586 \text{ BSCF} \) (reservoir model)

\( q_g \) Reservoir model extrapolation made from last \( p_{wf} \)
PA Example: $q_g$ vs. $G_p$ (with rate extrapolations)

Production Data Analysis Plot for East Texas Gas Well
Rate Versus Cumulative Gas Production Plot (EUR)

Legend: East Texas Gas Well
- $q_g$ Data Function
- $q_g$ Exponential Model
- $q_g$ Hyperbolic Model
- $q_g$ "Quadratic" Model
- $q_g$ Reservoir Model (last $p_{wf}$)

EUR Analysis Results: East Tx Gas Well
- $q_i = 4000$ MSCF/D
- $D_i = 0.00471$ 1/D
- $b = 0.3$ (dimensionless)
- $G = 1.586$ BSCF (reservoir model)

Exponential Extrapolation:
\[
(EUR)^{\text{min}} = 0.85 \text{ BSCF} \\
(q_g = q_{gi} - D_i G_p)
\]

Hyperbolic Extrapolation:
\[
(EUR)^{\text{hyp}} = 1.21 \text{ BSCF} \\
q_g = q_{gi} \left[1 - (G_p (1-b) (D_i/q_{gi}))^{1/(1-b)}\right]
\]

Quadratic Extrapolation:
\[
(EUR)^{\text{max}} = 1.7 \text{ BSCF} \\
q_g = q_{gi} - D_i G_p + [D_i(2G)] G_p^2
\]

Reservoir Model Extrapolation:
\[
(EUR)^{\text{res}} = 1.45 \text{ BSCF} \\
p_{wf} = 785 \text{ psia (last pressure)}
\]
PA Example: Arps Hyperbolic Type Curves

Specialized Hyperbolic "Rate-Cumulative" Type Curve (Arps' Relations)

Normalized Gas Flowrate \( \frac{q_g}{q_{gi}} \) Versus
1 - Normalized Cumulative Gas Production \[ 1 - \left( \frac{G_p}{G} \right) \]

East Texas Gas Well

\[
q_g = q_{gi}\left[1 - \left(\frac{G_p}{G}\right)\right]^{1/(1-b)} \quad \text{(where: } G = q_{gi}/[(1-b)D_1])
\]

Hyperbolic Trend: \( q_g = q_{gi}\left[1 - \left(\frac{G_p}{G}\right)\right]^{1/(1-b)} \)
PA Example: $p_{wf}$ vs. $q_g$ Crossplot (quality check)

Calculated Bottomhole Pressure Versus Gas Flowrate
East Texas Gas Well (Tight Gas Reservoir Case)

Boundary-Dominated Flow Behavior (late time)

Transient "Spikes" Caused Periodic by Shut-Ins

Transient Flow Behavior (early time)
PA Example: Normalized Log-Log Plot (model match)

Production Data Analysis Plot for East Texas Gas Well
"Log-Log" Plot (Normalized Productivity Index)

Data for East Tx Gas Well:
Fluid Properties:
- $\gamma_g = 0.7$ (air=1)
- $T=300$ Deg. F
Formation Properties:
- $r_w=0.333$ ft
- $h=177$ ft
- $\phi=0.088$ (fraction)
- $S_w=0.131$ fraction
- $p_i = 9330$ psia

Analysis Results: East Tx Gas Well
(Bounded Circular Reservoir Case)
- $k = 0.0554$ md
- $x_f = 290$ ft
- $F_{CD} = 9.52$ (dimensionless)
- $G = 1.586$ BSCF
- $r_e = 339$ ft

Legend: Model Responses
- $p_{Dd_i}$ Model Function
- $p_{Dd_id}$ Model Function

Legend: Data Functions
- $p_{Dd_i}$ Data Function
- $p_{Dd_id}$ Data Function

Dimensionless Pressure Functions

Dimensionless Decline Material Balance Time Function, $t_{Dd}$
PA Example: "Blasingame" Log-Log Plot (model match)

Production Data Analysis Plot for East Texas Gas Well
"Blasingame" Plot

Legend: Model Responses
- $q_{DDd}$ Model Function
- $q_{DDi}$ Model Function
- $q_{DDid}$ Model Function

Analysis Results: East Tx Gas Well
(Bounded Circular Reservoir Case)
- $k = 0.0554$ md
- $x_f = 290$ ft
- $F_{CD} = 9.52$ (dimensionless)
- $G = 1.586$ BSCF
- $r_e = 339$ ft

Data for East Tx Gas Well:
Fluid Properties:
- $\gamma_g = 0.7$ (air=1)
- $T = 300$ Deg. F
Formation Properties:
- $r_w = 0.333$ ft
- $h = 177$ ft
- $\phi = 0.088$ (fraction)
- $S_w = 0.131$ fraction
- $p_i = 9330$ psia

Legend: Data Functions
- $q_{DD}$ Data Function
- $q_{DDi}$ Data Function
- $q_{DDid}$ Data Function

Dimensionless Rate Functions
$q_{DD}, q_{DDi}, q_{DDid}$

Dimensionless Decline Material Balance Time Function, $t_{DD}$
PA Example: PTA (match/comparison)

Pressure Buildup Test Analysis Plot for East Texas Gas Well
"Log-Log" Summary Analysis Plot

Data for East Tx Gas Well:
- Fluid Properties:
  - \( \gamma_g = 0.7 \) (air=1)
  - \( T = 300 \) Deg. F
- Formation Properties:
  - \( r_w = 0.333 \) ft
  - \( h = 177 \) ft
  - \( \phi = 0.088 \) (fraction)
  - \( S_w = 0.131 \) fraction
  - \( p_i = 9330 \) psia

Analysis Results: East Tx Gas Well
- \( k = 0.0545 \) md
- \( x_f = 260 \) ft
- \( F_cD = 26.1 \) (dimensionless)
- \( C_s = 0.012 \) RB/psi
- \( r_e = 340 \) ft
- \( p_i = 9330 \) psia ("imposed")

Legend: Model Responses
- \( p_{Dd} \) Model Function
- \( p_{Dd} \) Model Function (Bounded Circular Reservoir Case)

Legend: Data Functions
- \( p_{Dd} \) Production Data Function
- \( p_{Dd} \) Production Data Function
- \( p_{Dd} \) Well Test Data Function
- \( p_{Dd} \) Well Test Data Function

Dimensionless Time Function (in terms of \( x_f \), \( t_{Dxf} \))

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**PA Example: Summary Plot**

Production Data Analysis Plot for East Texas Gas Well
"Summary" History Plot — Rate and Pressure Functions

**Legend:**
- East Texas Gas Well
- $q_g$ Data Function
- $p_{wf}$ Data Function
- $q_g$ Model Response
- $p_{wf}$ Model Response

**Analysis Results:**
East Tx Gas Well
(Bounded Circular Reservoir Case)
- $k = 0.0554$ md
- $x_f = 290$ ft
- $F_{CD} = 9.52$ (dimensionless)
- $G = 1.586$ BSCF
- $r_e = 339$ ft

**Graph Details:**
- $q_g$, MCFG/Day
- $p_{wf}$, psia
- Production Time, hr
- Flowing Bottomhole Pressure, $p_{wf}$, psia
Production Analysis
A Complete Example Analysis — East Texas Gas Well
(End of Lecture)

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