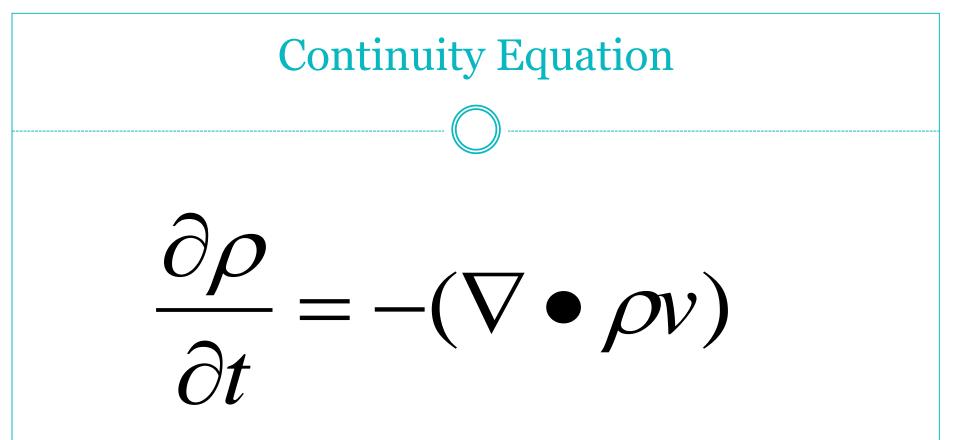
Closed-Loop WB Components

- Wellbore Thermal Modeling (Warming/Cooling)
- Liquid Drop Out (Build-ups)
- Liquid Surge (Start-up)
- Phase Behaviour EOS Calcs
 Use SRK or PR w/Peneloux
- Rate Modeling
 - Residence Time
 - Rate Surging & Decay
- Coupled Effects (Rate-Thermal-Phase)

Developing Thermal/PVT Models

- Run Static Temp/Pressure Survey
- Run Flowing Temp/Pressure Survey

 Multiple Rates
- Develop Heat Transfer Model Account for:
 Heat Capacity of Fluids/Tubulars/Annuli/Sinks
 Heat X-fer via Conduction
 Heat X-fer via Convection
 Heat X-fer via Forced Convection
- Can Tune PVT using same data...just get a good sample first



• Rate of Change in Density Caused by Changes in Mass Flux

Differential Form of Bernoulli Eqn Compressible Conditions

$$\Delta \frac{1}{2} (v)^{2} + g \Delta h + \int_{p1}^{p2} dp / \rho + Ws + \sum_{i}^{p2} \left(\frac{1}{2} v^{2} \frac{L}{R_{h}} f \right)_{i} + \sum_{i}^{p2} \left(\frac{1}{2} v^{2} e_{v} \right)_{i} = 0$$

Mechanical Energy Balance (Single Phase Gas)

• For Single-Phase Gas Flow in Pipes, the MEB reduces to:

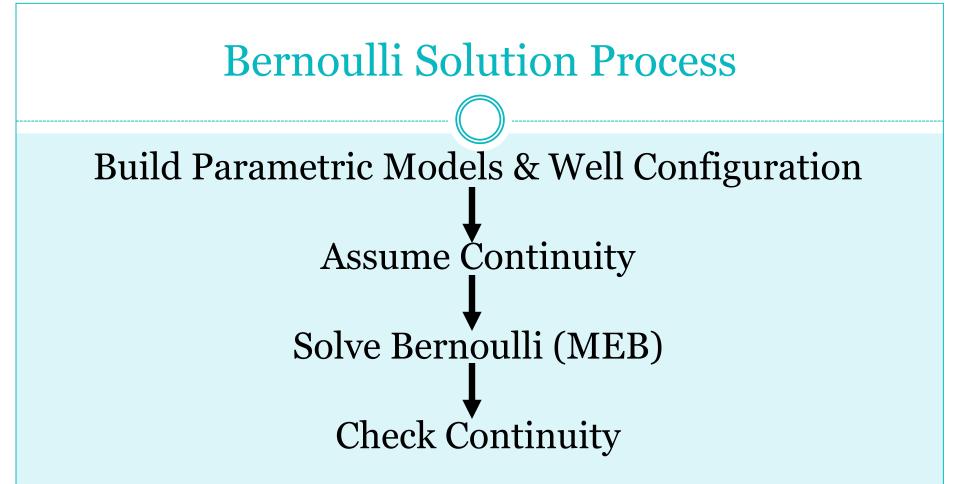
 $dp/\rho = -(g \sin \theta/g_c + 2f_f u^2/g_c D) dL$

• Basis for CS, Gray & A-C

Bernoulli for Single Phase Oil Incompressible Conditions

$$\frac{dp}{d\rho} + \frac{vdv}{g_c} + \frac{g}{g_c}dz + \frac{2f_f v^2 dL}{g_c D} + dW_s = 0$$

• Basis for Hagedorn-Brown & Beggs/Brill



Note: If Continuity Doesn't Hold, the Well is Loading–up (which is important to know)

Using a Direct Bernoulli Solution for WB

- Works for Oil, Gas or Water (Continuity)
- Gas
 - Have DP, solve for rate
 - Have Rate, solve for DP
- Oil
 - Have Rate, solve for Water cut
 - Have DP, solve for Water cut
- Much Easier to Apply Parametric Models Continuously:
 - Thermal Transients
 - Rate Transients
 - Phase Transients
 - Combined Rate, Phase & Thermal Transients