PIPE AND ANNULAR PRESSURE LOSSES

Dr. Raed H. Allawi

PRESSURE LOSS

- Pipe losses P2 and P3 take place inside the drill pipe and drill collars.
- Annular losses P4 and P5 take place around the drill collar and drill pipe.
- The magnitudes of P2, P3, P4 and P5 depend on:

1. Dimension of drill pipe (or drill collars), e.g. inside and outside diameter and length.
2. Mud rheological properties, which include mud weight, plastic viscosity, and yield point.
3. Type of flow, which can be laminar, or turbulent.

EQUATIONS

- $\Delta P_{bit} = P_{stand\ pipe} - (P_1 + P_2 + P_3 + P_4 + P_5)$
- $V_n\left(\frac{ft}{min}\right) = 33.36\sqrt{\frac{\Delta P_{bit}}{\rho}}$
- $A_n(in^2) = \frac{0.32*Q}{V_n}$
- $d_n = 32\sqrt{\frac{4*A_n}{3*\pi}}$
- Q= gpm

- $HHP = \frac{Q\ P_T}{1714\ e_v e_m}$
- $B.H.C.P. = 0.052\rho D + \Delta P_{ap} + \Delta P_{ac}$
- $E.C.D. = MW + \frac{\Delta P_{ap} + \Delta P_{ac}}{0.052 \times D}$
- HHP: Hydraulic Horse Power
- BHCP: Bottom Hole Circulating Pressure
- ECD: Equivalent Circulating Density

PROCEDURE

1. Calculate surface pressure losses.

2. Decide on which model to use: **Bingham Plastic** or **Power Law**.

3. Calculate pressure loss inside the drill pipe first then inside drill collars as follows:

- Calculate the critical velocity of flow $\mathbf{V_c}$.
- Calculate actual average velocity of flow $\mathbf{V_a}$ or **V́**.
- $V_a > V_c$ Turbulent flow Use the appropriate equation to calculate pressure drop.
- $V_a < V_c$ Laminar flow Use the appropriate equation to calculate pressure drop.

4. Divide the annulus into open and cased sections.

5. Calculate annular flow around drill collars (or BHA) as follows:

- Calculate the critical velocity of flow $\mathbf{V_c}$.
- Calculate actual average velocity of flow $\mathbf{V_a}$ or $\mathbf{\acute{V}}$.
- $V_a > V_c$ Turbulent flow Use the appropriate equation to calculate pressure drop.
- $V_a < V_c$ Laminar flow Use the appropriate equation to calculate pressure drop.

6. Repeat step **FIVE** for flow around drill pipe in the open and cased hole sections.

7. Add the values from step 1 to 5, call these system losses.

8. Determine the pressure drop available for the bit = pump pressure - system losses.

9. Determine nozzle velocity, total flow area and nozzle sizes.

BINGHAM PLASTIC MODEL

A) **Pipe Flow**

- Determine average velocity and critical velocity ($\acute{V}$ and V_c):

- $\acute{V} = \frac{24.5 \times Q}{D^2}$,

- $V_C = \frac{97\ PV + 97\sqrt{PV^2 + 8.2 * \rho * D^2 * Y_P}}{\rho * D}$

- If $\acute{V} > V_c$, flow is turbulent; use $P = \frac{8.91 \times 10^{-5} \rho^{0.8} Q^{1.8} PV^{0.2} L}{D^{4.8}}$

- If $\acute{V} < V_c$, flow is laminar; use $P = \frac{L * PV * V'}{90000 D^2} + \frac{L * Y_p}{225 * D}$

BINGHAM PLASTIC MODEL

A) **Annular Flow**

- Determine average velocity and critical velocity ($\acute{V}$and V_c):

- $\acute{V} = \frac{24.5 \times Q}{Dh^2 - OD^2}$ $\quad$ $V_C = \frac{97\,PV + 97\sqrt{PV^2 + 6.2 * \rho * D_e^2 * Y_P}}{\rho * D_e}$ $\quad$ Where: $D_e = D_h - OD$

- If $\acute{V} > V_c$, flow is turbulent; use $P = \frac{8.91 \times 10^{-5} \rho^{0.8} Q^{1.8} PV^{0.2} L}{(D_h - O_D)^3 (D_h + O_D)^{1.8}}$

- If $\acute{V} < V_c$, flow is laminar; use $P = \frac{L * PV * V'}{60000\, D_e^2} + \frac{L * Y_p}{225\, D_e}$