PET 575. Spring 2018.

Q 1.4

Hydraulic model is used to:
- describe the pressure dynamics
- help detect drilling incidents
- help choose setpoint of flow rate and choke pressure

Q 2A.1.

$$D_{eff} = \frac{4n}{3n+1} D = \frac{4 \times 0.8}{3 \times 0.8 + 1} \times 0.02 = \underline{0.0188}$$

$$V = \frac{Q}{A} = \underline{3.18} \; m/s$$

$$\mu_a = K \left(\frac{8V}{D_{eff}} \right)^{n-1} = 0.46 \left(\frac{8 \times 3.18}{0.0188} \right)^{0.8-1} = \underline{0.1088}$$

$$Re_g = \frac{v D_{eff} \rho}{\mu_a} = \frac{3.18 \times 0.0188 \times 1000}{0.1088} = \underline{549.5}$$

Q 2A.2.

Since $Re_g < 2300$

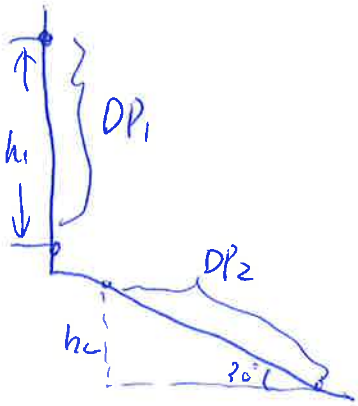
$$\Rightarrow f = \frac{64}{Re_g} = \frac{64}{549.5} = \underline{0.118}$$

Q 2A.3

$$\Delta P = \frac{\rho f l v^2}{2D}$$

$$= \frac{1000 \times 0.118 \times 4 \times 3.18^2}{2 \times 0.02} = \underline{1.1933 \times 10^5} \; Pa$$

Q2B.



$$\begin{cases} DP_1 = \rho g h_1 - \Delta P_f & — ① \\ DP_2 = \rho g h_2 - \Delta P_f & — ② \end{cases}$$

① − ②

$$DP_1 - DP_2 = \rho g (h_1 - h_2)$$

$$\rho = \frac{DP_1 - DP_2}{g(h_1 - h_2)} = \frac{22700 - 3100}{9.8 \times 2} = \underline{\underline{1000}} \ (kg/m^3)$$

From ② and $\rho = 1000\ kg/m^3$, we have

$$\Delta P_f = \rho g h_2 - DP_2 = 1000 \times g \times 2 - 3100 = 19600 - 3100 = \underline{\underline{16500}}\ Pa$$

$$f = \frac{\Delta P_f \times 2 \times D}{\rho \cdot l \times V^2} = \frac{16500 \times 2 \times 0.02}{1000 \times 4 \times (2.86)^2} = \underline{\underline{0.0202}}$$

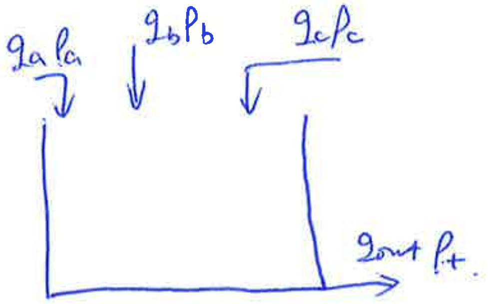
where $V = \frac{q}{A} = \underline{\underline{2.86}}\ m/s$

$$Re_{lam} = \frac{64}{f} = 3168 > 2300$$ therefore it is turbulent.

$$Re_{turb} = \frac{6.9}{10^{\left(\frac{1}{-1.8\sqrt{f}}\right)}} = \underline{55940} > 2300.$$

$$\mu = \frac{V \times D \times \rho}{Re_{turb}} = \frac{2.86 \times 0.02 \times 1000}{55940} = \underline{\underline{1.02 \times 10^{-3}}}\ Pa \cdot s$$

Q 3



Q 3.1.

$$\dot{m} = m_{in} - m_{out}$$

$$\dot{\rho}_t V = \rho_{in} q_{in} - \rho_{out} q_{out}$$

$$\Rightarrow \dot{\rho}_t = \frac{1}{V}\left[\rho_a q_a + \rho_b q_b + \rho_c q_c - \rho_t q_{out}\right]$$

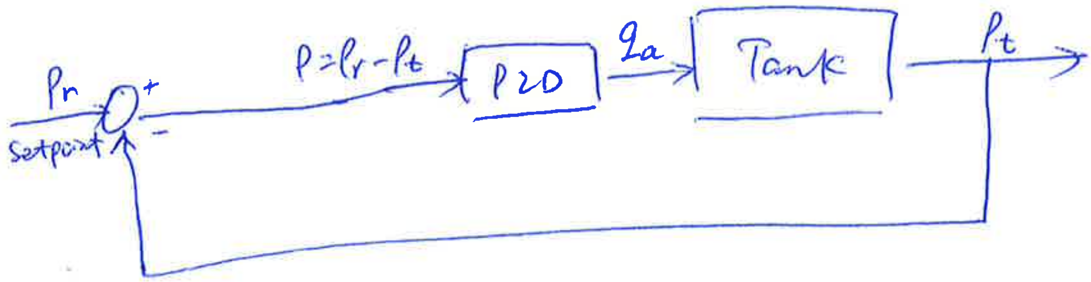
Q 3.2 since the level is stable. ($\dot{V} = 0$) $\Rightarrow q_{in} = q_{out}$

$$q_a + q_b + q_c = q_{out}$$

since $q_{out} = 2000$, $q_c = 1000$ $\Rightarrow q_a + q_b = q_{out} - q_c$

$\Rightarrow q_a + q_b = 1000$ l/min.

Q 3.4



Q4.1

x_i	y_i
1	30
2	32
3	31
4	33
5	34

$$\begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} n & \Sigma x_i \\ \Sigma x_i & \Sigma x_i^2 \end{pmatrix}^{-1} \begin{pmatrix} \Sigma y_i \\ \Sigma x_i y_i \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} 5 & 15 \\ 15 & 55 \end{pmatrix}^{-1} \begin{pmatrix} 160 \\ 489 \end{pmatrix}$$

$$\begin{pmatrix} a \\ b \end{pmatrix} = \begin{pmatrix} 29.3 \\ 0.9 \end{pmatrix}$$

$$\Rightarrow RoP = 29.3 + 0.9t.$$

Since $0.9 > 0$. RoP is increasing with the time.

Q 4.2.

Median filter := [3, 3, 3, 3, 3, 3, 3. 3]

Mean fileer = [14.4 , 14.4 , 14.2 , 14.2 , 6.2 , 6 , 6 , 5.8]

Median fileer is better.

Q 6.2a $w_n = \sqrt{\frac{k}{m}} = 1$.

Q6.2b. $w_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{1}{2}}$.

Q6.3. $w_n = \sqrt{\frac{k}{m}} = 1$. $\zeta = \frac{c}{2mw_n} = \frac{3}{2\times1\times1} = 1.5 > 1$

it is overdamped system.

Q6.4. $H(s) = \frac{1}{s^2+0.4s+4}$

PET 575 Exam – Question candidates

Managed Pressure Drilling (MPD)

a) What are the main differences with back-pressure MPD compared to conventional drilling?

Answer: Back-pressure MPD uses a rotating control head and a controllable surface choke to apply back pressure during circulation. Sometimes an additional mud pump is used to circulate drilling fluid through the MPD choke when the topdrive is disconnected and main pump is deactivated.

A well is drilled with back-pressure MPD. During drilling the temperature increases in the larger part of the well.

b) How does this increase in temperature affect the bottom hole pressure?

Answer: Increase in temperature reduces the mud density. Therefore, the hydrostatic pressure (and friction pressure) decrease, and bottom hole pressure decrease.

c) What adjustments can be done with the MPD choke opening to uphold a constant bottom hole pressure during the increase in temperature?

Answer: The MPD choke opening can be closed some to add more pressure drop over the choke, and thereby back-pressure.

d) In back-pressure MPD operations ECD in the upper part of the well is very large. Why is this?

Answer: ECD is defined as the pressure in the well at a certain depth divided by the gravity constant and the vertical depth. As the depth becomes smaller when moving upwards in the well, and back-pressure becomes dominating before the hydrostatic pressure, the denominator of the fraction approaches zero and ECD increases towards infinity

Well Control

a) In one of the well control methods the heavier drilling fluid (kill mud) is pumped, while at the same time, the kick is circulated out of the annulus. What is the name of this well control method?

Answer: Wait and weight method.

b) What measurement at the rig is used to control bottom hole pressure during circulation when using this method?

Answer: Pump pressure.

c) What is the name of an alternative well control method?

Answer: Driller’s method.

Cuttings transport

a) What are the main drilling parameters that affect the cuttings transport?

Answer: Flow rate and rpm, (and drilling fluid density and rheology)

b) Above what inclination can a cuttings bed be formed?

Answer: 30-35 degrees. (Some say 30 and some 35)

c) What are two forms of cuttings transport which are desirable for drilling?

Answer: In suspension and in moving beds.