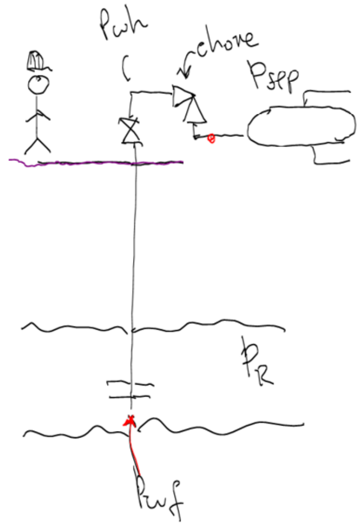
PROBLEM 1 (47 POINTS).

Consider the dry gas production system shown in the figure below:



An excel file is provided with all the information and VBA functions you need to make your calculations. Assume the model used to represent the IPR of the formation is the backpressure equation. Assume that the model used to represent the TPR is the dry gas tubing equation.

Task 1. (10 POINTS) If the well is producing a dry gas rate of 1 E5 Sm^3/d, and wellhead pressure is 80 bara, estimate the backpressure coefficient of the formation. Assume n= 1.

The Excel file provides the behavior of the term $\frac{1}{\mu_g \cdot B_g}$ versus pressure. Assess if using the back-pressure equation is appropriate or not in this case.

Explain your answer.

Task 2. (12 POINTS) Consider that the sensor of the wellhead pressure is damaged and unavailable. The only information available is pressure downstream the choke (40 bara), choke opening (9.4 mm) and rate of 1 E5 Sm^3/d. Is it still possible to estimate the backpressure coefficient of the formation? Is the choke operating in the critical or subcritical regime?

Explain your answer.

Task 3. (13 POINTS) Assume reservoir pressure has changed to 100 bara. Estimate choke adjustment (new value of choke opening) to ensure the dry gas rate remains constant. Use the values of dry gas IPR estimated in task 2. Is the choke operating in the critical or subcritical regime?

Explain your answer.

Task 4 (12 POINTS). At this new reservoir pressure, you are concerned about liquid loading. Check if there could be risk of liquid loading at well bottom, using the Turner equation:

$$v_{gc} = 5.46 \cdot \left(\frac{(\rho_L - \rho_G) \cdot \sigma_{LG}}{\rho_G^2} \right)^{1/4}$$

Assume that liquid density is 1000 kg/m3, and interfacial tension liquid-gas is 0.028 N/m. Assume the tubing inner diameter is 0.07 m.

Explain your answer.

Additional information:

Dry gas low pressure IPR equation (backpressure equation), assuming Darcy flow (n=1):

$$q_{\bar{g}} = C_R \cdot \left(p_R^2 - p_{wf}^2\right)$$

This equation is available as several VBA functions, with names "IPRqg", and "IPRpwf"

Dry gas IPR equation, assuming Darcy flow:

$$q_{\bar{g}} = C_R \cdot \int_{p_{wf}}^{p_R} \frac{1}{\mu_g \cdot B_g} dp$$

Dry gas tubing equation:

$$q_{\bar{g}} = C_T \cdot \left(\frac{p_{wf}^2}{e^S} - p_{wh}^2\right)^{0.5}$$

This equation is available as several VBA functions, with names "Tubingqg", "Tubingp1" and "Tubingp2"

Dry gas choke equation:

$$q_{\bar{g}} = \frac{p_1 \cdot T_{sc} \cdot A_2 \cdot C_d}{p_{sc}} \cdot \sqrt{2 \cdot \frac{R}{Z_1 \cdot T_1 \cdot M_w} \cdot \frac{k}{k-1} \cdot \left(y^{\frac{2}{k}} - y^{\frac{k+1}{k}}\right)}$$

With 1 referring to the inlet, and $y = p_2/p_1$. This equation is available as a VBA function with the name: "Orificerate_metric"

With the critical gas pressure ratio:

$$y_c = \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

k is the adiabatic constant. This equation is available as a VBA function with the name: "Criticalratio"

the following VBA functions are provided to estimate dry gas properties:

- ZfacStanding: gas deviation factor
- Bg: gas volume factor
- deng: gas density