PROBLEM 2. (40 POINTS)

A pressure survey has been performed in a producing oil well (production rate of 1394 Sm3/d, GOR = 155.1 and water cut of 30%), and pressure and temperature at several depths have been recorded. The values are provided in the Excel file attached. Assume that the water density is constant and equal to 1000 kg/m³, the water viscosity is constant and equal to 0.6 cP, and the liquid-gas interfacial tension is constant and equal to 0.01 N/m. Assume there is no slip between the oil and water.

Task 1 (25 POINTS). Calculate the following parameters along the well:

- Non-slip gas volume fraction
- Gas void fraction
- Liquid and gas real velocities
- The gas-liquid slip ratio
- The hydrostatic pressure gradient

Task 2 (5 POINTS). Is it important to consider the effect of r_s in your calculations? Can it be neglected?

Task 3. (10 POINTS) Consider that gas lift is applied to the bottom of the well (rate of 300 000 Sm³/d), and the temperature and pressure is 93 C and 160 bar bara. The oil rate is 1450 Sm3/d. Can the table provided be used to estimate black oil properties for these conditions? If they can, estimate local rates of oil and gas.

Useful information:

• ε is the gas void fraction, equal to:

$$\varepsilon = \frac{A_g}{A_l + A_g}$$

A VBA function named "e_simpson" is provided to calculate the void fraction using the gas density, liquid density, and non-slip gas volume fraction (λ_g).

• The following matrix to convert from standard conditions to local conditions

$$\begin{bmatrix} q_g \\ q_o \\ q_w \end{bmatrix} = \begin{bmatrix} \frac{B_g}{1 - R_s \cdot r_s} & \frac{-R_s \cdot B_g}{1 - R_s \cdot r_s} & 0 \\ \frac{-B_o \cdot r_s}{1 - R_s \cdot r_s} & \frac{B_o}{1 - R_s \cdot r_s} & 0 \\ 0 & 0 & B_w \end{bmatrix}_{(p,T)} \cdot \begin{bmatrix} q_{\bar{g}} \\ q_{\bar{w}} \end{bmatrix}$$

There are two VBA functions available in the Excel sheet: "qg_local", to calculate local gas rates from SC oil and gas rates and black oil properties and "qo_local", to calculate local oil rates from SC oil and gas rates and black oil properties

• A VBA function called "TwoDimInterpol" is provided to find BO properties at any p-T by interpolating on the table provided on the sheet "BO_tables"