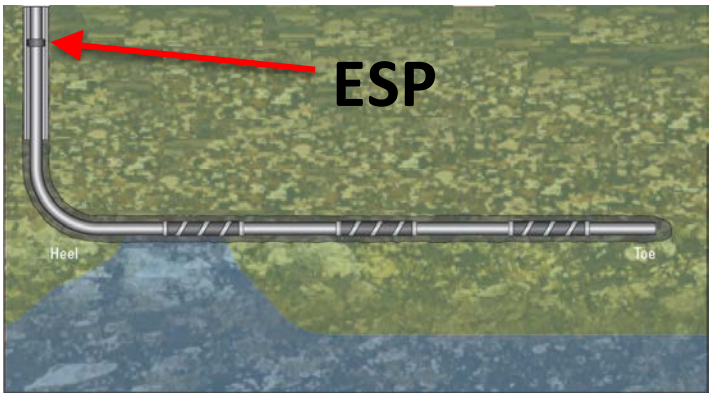
SOLVE THIS PROBLEM USING THE EXCEL FILE PROVIDED

PROBLEM 2 (20 POINTS). Estimation and verification of ESP requirements

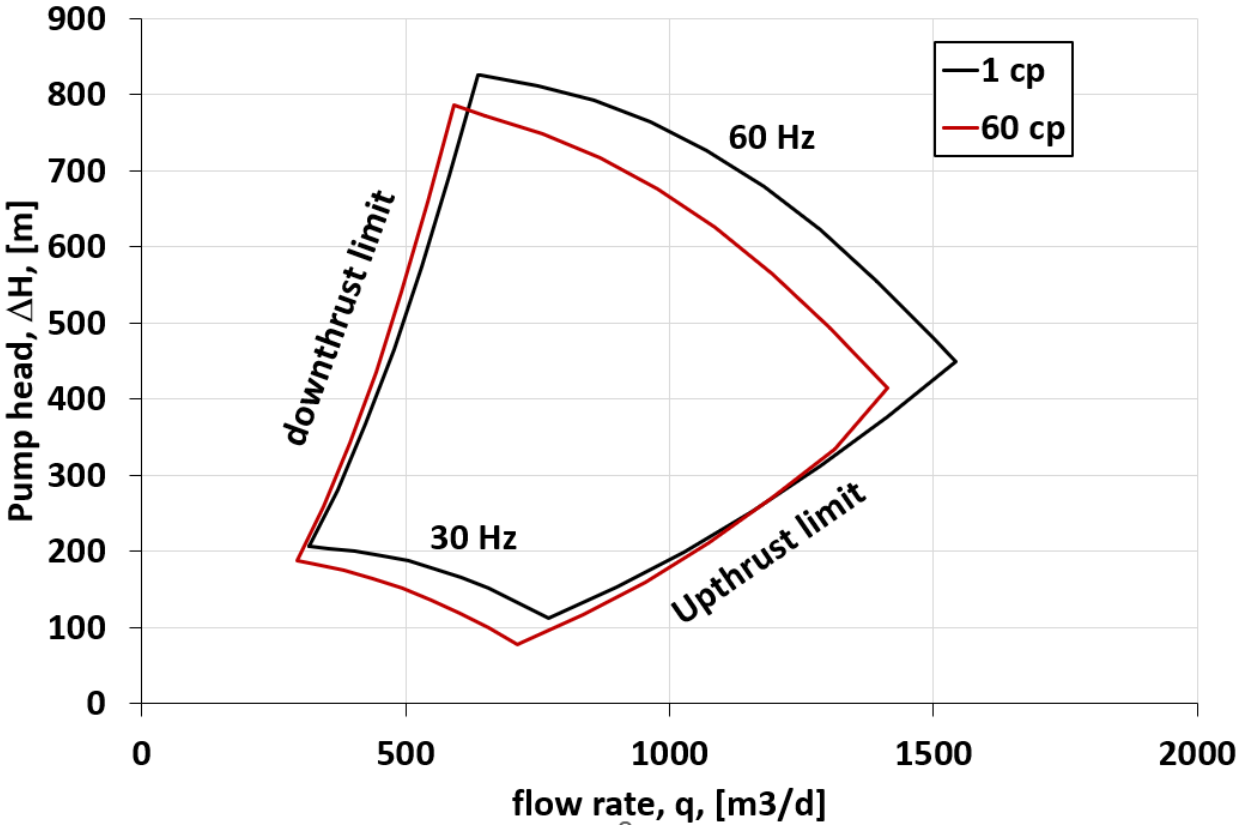
The Rio Ariari complex is a field currently under development in the region of "Los llanos" in Colombia. The reservoir has a thin layer (19 m) containing undersaturated oil and a very strong bottom aquifer. There is coning from the water layer into the well
The field will be produced with ESP-lifted horizontal wells like the one shown in the figure below.



The Wood company has proposed a unique ESP model (TE7000) with 50 stages which they claim has a wide operational envelope to handle all possible well operational conditions.
Your task is to estimate and verify the ESP requirements for a well in the Ariari Field.

TASKS:

Task 1 (5 POINTS). What is the effective viscosity (in cP) of the oil-water mixture (using the Richardson emulsion equation) when the well is producing a total liquid rate of 250 Sm^3/d with 54% water cut?
Explain how you have performed this task.
Task 2 (10 POINTS). -For the total liquid rates of 250 Sm^3/d, estimate the required pump pressure boost (DP in bar, input a positive number) and pump power (in kW) to deliver the rate if the wellhead pressure is constant and equal to 40 bara.
Explain how you have performed this task.
Task 3 (5 POINTS). -According to the ESP envelope given below, will the ESP model suggested be able to deliver the desired rate of 250 Sm^3/d?
Explain how you have performed this task.



Additional information

- Neglect the flow pressure drop from the bottom-hole to the pump suction (i.e. $p_{suc} = p_{wf}$).
- Assume that the oil compressibility and GOR can be neglected such as the rate at standard conditions is equal to the rate at local conditions p and T.
- The Water cut (WC, in fraction) is defined as

$$WC = \frac{q_{\bar{w}}}{q_{\bar{o}} + q_{\bar{w}}}$$

- The well inflow can be represented with a linear PI equation:

$$q = J \cdot \left(p_R - p_{wf} \right)$$

Where:

q……total liquid rate in Sm^3/d

J……productivity index for total liquid flow **[100 $Sm^3/d/bar$]**,

p_R…...reservoir pressure [**82.7 bara**]

p_{wf}…..bottom-hole flowing pressure [bara]

This equation is programmed in VBA functions called “IPRq” and “IPRpwf” provided in the Excel sheet. IPRq is the equation provided above. IPRpwf is when pwf is cleared out in the equation above.

- The density of the oil water mixture is calculated using the following expression:

$$\rho_m = WC \cdot \rho_w + (1 - WC) \cdot \rho_o$$

Where the water density is 1025 kg/m^3

The oil density is 897 kg/m^3

WC is input in fraction.
This equation is programmed in a VBA function called "Avprop" provided in the Excel sheet.

- The oil+water mixture exhibits an emulsion behavior where its viscosity is a function of the water volume fraction. The cutoff watercut is 60%.

Regime	Richardson emulsion viscosity
Oil continuous (WC < 60%)	$\mu_m = \mu_o \cdot e^{3.215 \cdot WC}$
Water continuous (WC > 60%)	$\mu_m = \mu_w \cdot e^{3.089 \cdot (1 - WC)}$

The viscosity of the oil is 10 cp and viscosity of the water is 1 cp (1 cp = 1 E-3 Pa s). **WC is input in fraction.**

This equation is programmed in a VBA function called "Rich_emul_visc" provided in the Excel sheet.

- The pump power [in watts, W] can be estimated with:

$$Power = \frac{q \cdot \Delta p \cdot 1E5}{\eta \cdot 24 \cdot 3600}$$

Where Δp [bara], q in [m^3/d]. Assume a constant pump efficiency (η) of 0.6.

This equation is programmed in a VBA function called "ESPpower" provided in the Excel sheet.

- The pump head [m] is

$$\Delta h = \frac{\Delta p \cdot 10^5}{\rho_m \cdot g}$$

Where Δp [bara], ρ_m [kg/m^3] and g = 9.81 [m/s^2]

- Two VBA functions are provided in the Excel sheet to calculate pressure drop in pipe for incompressible flow:
  - "pin" allows to estimate required pressure at the inlet of the pipe if outlet pressure and rate are provided.
  - "pout" allows to estimate available pressure at the pipe outlet if inlet pressure and rate are provided.