1.Calculate the bottomhole pressure of injection well for pumping water to annular space for data: the internal diameter of production string is 136 mm; the outside diameter of tubing 73 mm, water density 1000 kg/m^3, the coefficient of dynamic viscosity of water 1.05 mPa·s; wellhead pressure 13 MPa, depth tubing is 2800 m, flowrate of water is 190 m^3/day.

Din=136 mm
d_{out}=73 mm
ρ_w=1000 kg/m^3
μ_w=1.05 mPas
P_{wh}=13 MPa
H=2800 m
Q=190 m^3/day

P_{bhinj}=?

$$\mathrm{P_{bhinj}} = P_{wh} + \rho_w \cdot g \cdot H - \Delta P$$

$$\Delta P = \lambda \frac{L}{D_{in} - d_{out}} \cdot \frac{\upsilon^2}{2} \cdot \rho_w$$

$$\upsilon = \frac{4 \cdot Q}{\pi \cdot (D_{in}{}^2 - d_{out}{}^2)} = \frac{4 \cdot 190}{86400 \cdot 3.14 \cdot (0.136^2 - 0.073^2)} = 0.2 \text{ m/s}$$

$$\mathrm{Re} = \frac{\upsilon \cdot (D_{in} - d_{out})}{\nu_w} = \frac{0.2 \cdot (0.136 - 0.073)}{1.05 \cdot 10^{-6}} = 12000$$

$$\nu_w = \frac{\mu_w}{\rho_w} = \frac{1.05 \cdot 10^{-3}}{1000} = 1.05 \cdot 10^{-6} \text{ m}^2/\text{s}$$

$$\lambda = \frac{0.3164}{\mathrm{Re}^{0.25}} = \frac{0.3164}{12000^{0.25}} = 0.03$$

$$\Delta P = 0.03 \frac{2800}{0.136 - 0.073} \cdot \frac{0.2^2}{2} \cdot 1000 = 26666.7 Pa$$

$$\mathrm{P_{bhinj}} = 13 \cdot 10^6 + 1000 \cdot 9.81 \cdot 2800 - 26666.7 = 40.444 \text{ MPa}$$

2.Determine the total volume of injection water for the following data:
fluid flowrate is 43 m^3/day
the pressure in the injection line is 17 MPa
average formation pressure in the aquifer zone 15 MPa
the coefficient of dynamic viscosity of water 1,1 mPa·s;
the length of injection line 600 m
layer thickness is 13 m
the coefficient of permeability 1.9 mD,
the piezoconductivity factor is 3.2 m^2/sec,
the time is 37 days.
Data

Q_{sel}=43 m^3/day
P_{line}=17 MPa
P_f=15 MPa
μ_w=1,1 mPa·s
B=600 m
h=13 m
k=1.9 mD=1.9 $\cdot 10^{-15} m^2$
χ=3.2 m^2/sec
t=37 days
Q_{inj}-?

$$Q_{inj} = Q_{sel} \pm Q_{loss}$$

1) If $P_{line} > P_f$, then the water pumped flows into the aquifer area. In this case $Q_{inj}= Q_{sel} + Q_{los}$. It is necessary to take into account the elastic properties of the reservoir and fluid out the line injection.

2) If $P_{line} < P_f$, then $Q_{inj}= Q_{sel} - Q_{los}$. This case is rarely used in practice.

3) When $P_{line} = P_f$ no loss of water and $Q_{los} = 0$. This case is used most often. In this case, the impact of external area completely isolated and reservoir works due to the energy of water injection. In this case, water is injected into injection wells completely used to displacement oil.

$$Q_{loss} = \frac{k \cdot B \cdot h}{\mu_w} \cdot \frac{P_{line} - P_f}{\sqrt{3 \cdot \chi \cdot t}}$$

$$Q_{loss} = \frac{1.9 \cdot 10^{-15} \cdot 600 \cdot 13}{1.1 \cdot 10^{-3}} \cdot \frac{(17-15) \cdot 10^6}{\sqrt{3 \cdot 3.2 \cdot 37 \cdot 86400}} = 4.86 \cdot 10^{-6} \text{ m}^3/\text{s}$$

$$Q_{inj} = \frac{43}{86400} + 4.86 \cdot 10^{-6} = 5.025 \cdot 10^{-4} \text{ m}^3/\text{s}$$