PRACTICE 3

1. Determine the coefficient of oil extraction which is achieved due to elastic forces in the circular shape deposit with the radius 35 km, while the reduction of average reservoir pressure by 4 MPa. Thickness of production layer 16 m, open porosity 0,15, oil saturation 0,72, compressibility factors of oil, water and rock correspondently $1,5\cdot10^{-9}$ Pa^{-1}, $4,38\cdot10^{-10}$ Pa^{-1}, and $2\cdot10^{-10}$ Pa^{-1}, radius of oil-drainage boundary 9,2 km.

$$\eta = \frac{V_{oil.ext}}{V_{dep}} = 0{,}156$$

$$V_{dep} = \pi \cdot R_{oil}^2 \cdot h \cdot m \cdot s_{oil} = 4{,}59 \cdot 10^8 m^3$$

$$V_{oil.ext} = V_1 + V_2 = \pi \cdot R_{res}^2 \cdot h \cdot \beta_1^* \cdot \Delta P + \pi \cdot R_{oil}^2 \cdot h \cdot \beta_2^* \cdot \Delta P = \pi \cdot h \cdot \Delta P \times$$

$$\times \left(R_{res}^2 \cdot \beta_1^* + R_{oil}^2 \cdot \beta_2^*\right) = 7{,}177 \cdot 10^7 m^3$$

$$\beta_1^* = m \cdot \beta_w + \beta_r = 2{,}657 \cdot 10^{-10} Pa^{-1}$$

$$\beta_2^* = \left[\beta_w \cdot (1 - s_{oil}) + \beta_{oil} \cdot s_{oil}\right] \cdot m + \beta_r = 3{,}738 \cdot 10^{-10} Pa^{-1}$$

2. Determine elastic reserves of oil inside the separated oil-bearing area of 400000 m^2, thickness of production layer 16 m, if the average reservoir pressure dropped by 5 MPa. Known values: reservoir porosity 15%, saturation factor of reservoir bound water 19%, compressibility factors of oil, water and rock correspondently $2,04\cdot10^{-9}$ Pa^{-1}, $4,59\cdot10^{-10}$ Pa^{-1} and $1,02\cdot10^{-10}$ Pa^{-1}.

F=400000 m^2

h=16 m

ΔP=5 MPa

m=15%

s_w=19%

$\beta_{oil}=2,04\cdot10^{-9}$ Pa^{-1}

$\beta_w=4,59\cdot10^{-10}$ Pa^{-1}

$\beta_r=1,02\cdot10^{-10}$ Pa^{-1}

ΔV-?

compressibility factors of liquid

$$\beta_l = \beta_{oil} \cdot (1 - s_w) + \beta_w \cdot s_w = 2{,}04 \cdot 10^{-9} \cdot (1 - 0{,}19) + 4{,}59 \cdot 10^{-10} \cdot 0{,}19 = 1{,}74 \cdot 10^{-9} Pa^{-1}$$

compressibility factors of reservoir

$$\beta^* = m \cdot \beta_l + \beta_r = 0{,}15 \cdot 1{,}74 \cdot 10^{-9} + 1{,}02 \cdot 10^{-10} = 3{,}63 \cdot 10^{-10} Pa^{-1}$$

Volume of reservoir

$$V_{res} = F \cdot h = 400000 \cdot 16 = 64 \cdot 10^5 m^3$$

elastic reserves of oil

$$V_{oil} = V_{res} \cdot \beta^* \cdot \Delta p = 64 \cdot 10^5 \cdot 3{,}63 \cdot 10^{-10} \cdot 5 \cdot 10^6 = 11616 m^3$$

3. Oil well has a production rate 70 t/day. What will be the bottomhole pressure and pressure at the distance 120 m in 5 days? Known values: initial reservoir pressure 22 MPa, well radius 0,1 m, permeability 0,07 μm^2, thickness 16 m, porosity 18%, dynamic viscosity of oil 1,2 mPa·s; volume

factor and density of degassed oil are 1,1 and 900 kg/m^3, compressibility factors of oil and rock correspondently 2,2·10^{-9} Pa^{-1} and 1,02·10^{-10} Pa^{-1}.

Q_m=70 t/day
r=120 m
t=5 days
P_{res}=22 MPa
r_w=0.1 m
k=0,07 μm^2
h=16 m
m=18%
μ_{oil}=1,2 mPa·s
b=1.1
ρ_{oil}=900 kg/m^3
β_{oil}=2,2·10^{-9} Pa^{-1}
β_r=1,02·10^{-10} Pa^{-1}

$$Q_{oil.vol} = \frac{Q_m \cdot b \cdot 1000}{\rho_{oil} \cdot 86400} = \frac{70 \cdot 1{,}1 \cdot 1000}{900 \cdot 86400} = 9{,}9 \cdot 10^{-4}\,\frac{m^3}{s}$$

Piezoconductivity factor

$$\kappa = \frac{k}{\mu\beta^*} = \frac{k}{\mu(\beta_{oil} \cdot m + \beta_r)} = \frac{0.07 \cdot 10^{-12}}{1{,}2 \cdot 10^{-3} (2{,}2 \cdot 10^{-9} \cdot 0{,}16 + 1{,}02 \cdot 10^{-10})} = 0{,}117\frac{m^2}{s}$$

Bottomhole pressure

$$P_{bh} = P_{res} - \frac{Q_{oil.vol}\mu}{4\pi kh}\ln\left(\frac{2{,}25\kappa t}{r_w^2}\right) = 22 \cdot 10^6 - \frac{9{,}9 \cdot 10^{-4} \cdot 1{,}2 \cdot 10^{-3}}{4 \cdot 3{,}14 \cdot 0{,}07 \cdot 10^{-12} \cdot 16} \cdot \ln\left(\frac{2{,}25 \cdot 0{,}117 \cdot 5 \cdot 86400}{0{,}1^2}\right) = 21{,}865 MPa$$

Pressure at the distance 120 m

$$P_r = P_{res} - \frac{Q_{oil.vol}\mu}{4\pi kh}\ln\left(\frac{2{,}25\kappa t}{r^2}\right) = 22 \cdot 10^6 - \frac{9{,}9 \cdot 10^{-4} \cdot 1{,}2 \cdot 10^{-3}}{4 \cdot 3{,}14 \cdot 0{,}07 \cdot 10^{-12} \cdot 16} \cdot \ln\left(\frac{2{,}25 \cdot 0{,}117 \cdot 5 \cdot 86400}{120^2}\right) = 21{,}933 MPa$$

4. What is the pressure at the distance 300 m from the well after 100 day of development at elastic water drive? Flow rate of the well is 50 t/day. Reservoir pressure 23 MPa, piezoconductivity factor 1,2 m^2/s, formation conductivity 10^{-9} m^3/Pa·s, oil density 830 kg/m^3.

$$Q_{oil.vol} = \frac{Q_m \cdot 1000}{\rho_{oil} \cdot 86400} = 6{,}97 \cdot 10^{-4}\,\frac{m^3}{s}$$

$$\varepsilon = \frac{kh}{\mu}$$

$$P_r = P_{res} - \frac{Q_{oil.vol}\mu}{4\pi kh}\ln\left(\frac{2{,}25\kappa t}{r^2}\right) = P_{res} - \frac{Q_{oil.vol}}{4\pi\varepsilon}\ln\left(\frac{2{,}25\kappa t}{r^2}\right) = 22{,}37 MPa$$