PRACTICE 2

1. Two wells work in a layer. Flow rate of the first well is 19 tons/day, flow rate of the second well of 22 tons/day. Determine the change in pressure in 65 days after their work for the data: the coefficient of dynamic viscosity 2.7 mPa·s, layer thickness 19 m, the permeability coefficient 0.07 mkm^2, the piezoconductivity factor 0.42 m^2/s, density of oil 860 kg/m^3, the volume formation factor - 1.3. The distance from the first and second wells to the point at which pressure is determined by changing the 810 m and 620 m respectively.

Q_1=19 tons/day

Q_2=22 tons/day

t=65 days

μ=2.7 mPa·s

h=19 m

k=0.07 mkm^2

χ=0.42 m^2/s

ρ=860 kg/m^3

b=1.3

r_1=810 m

r_2=620 m

ΔP -?

$$P(r,t) = P_f - \left(\frac{Q_1 \cdot \mu}{4 \cdot \pi \cdot k \cdot h} \cdot \ln \frac{2{,}25 \cdot \chi \cdot t}{r_1^2} + \frac{Q_2 \cdot \mu}{4 \cdot \pi \cdot k \cdot h} \cdot \ln \frac{2{,}25 \cdot \chi \cdot t}{r_2^2} \right)$$

$$\Delta P = \frac{Q_1 \cdot \mu}{4 \cdot \pi \cdot k \cdot h} \cdot \ln \frac{2{,}25 \cdot \chi \cdot t}{r_1^2} + \frac{Q_2 \cdot \mu}{4 \cdot \pi \cdot k \cdot h} \cdot \ln \frac{2{,}25 \cdot \chi \cdot t}{r_2^2}$$

$$\Delta P = \frac{19 \cdot 1000 \cdot 1.3 \cdot 2.7 \cdot 10^{-3}}{86400 \cdot 860 \cdot 4 \cdot \pi \cdot 0.07 \cdot 10^{-12} \cdot 19} \cdot \ln \frac{2{,}25 \cdot 0.42 \cdot 65 \cdot 86400}{810^2} +$$

$$+ \frac{22 \cdot 1000 \cdot 1.3 \cdot 2.7 \cdot 10^{-3}}{86400 \cdot 860 \cdot 4 \cdot \pi \cdot 0.07 \cdot 10^{-12} \cdot 19} \cdot \ln \frac{2{,}25 \cdot 0.42 \cdot 65 \cdot 86400}{620^2} =$$

2. In operation let the oil well with a constant flow rate. What is the pressure bottomhole and at a distance for some time such data

well flow rate 25 t/d

initial reservoir pressure 30 MPa

well radius of 0.12 m;

permeability coefficient 0.012 mkm^2

layer thickness 19 m

porosity of 22%;

coefficient of dynamic viscosity of oil 1.13 mPa·s
volume factor 1.07
relative density 0.81
time varies 35 days
compressibility factor of oil 2.2 $\cdot 10^{-9}$ Pa^{-1}
compressibility factor of rocks 2.7 $\cdot 10^{-10}$ Pa^{-1}
distance from the wells 200 m

Q=25 t/d
P_f=30 MPa
r_w=0.12 m
k=0.012 mkm^2
h=19 m
m=0.22
μ=1.13 mPa·s
b=1.07
$\bar{\rho}$=0.81
t=35 days
$ß_{oil}$=2.2 $\cdot 10^{-10}$ Pa^{-1}
$ß_r$=2.7 $\cdot 10^{-10}$ Pa^{-1}
r=200 m
P_{bh}-? P(t,r)-?

$$P(t,r) = P_f - \frac{Q_f \cdot \mu}{4 \cdot \pi \cdot k \cdot h} \cdot \ln \frac{2.25 \cdot \chi \cdot t}{r^2}$$

$$P_{bh} = P_f - \frac{Q_f \cdot \mu}{4 \cdot \pi \cdot k \cdot h} \cdot \ln \frac{2.25 \cdot \chi \cdot t}{r_w^{\ 2}}$$

$$Q_f = \frac{Q \cdot 1000 \cdot b}{\rho \cdot 86400} = \frac{25 \cdot 1000 \cdot 1.07}{0.81 \cdot 1000 \cdot 86400} = 3.822 \cdot 10^{-4}\ \text{m}^3/\text{s}$$

$$\bar{\rho} = \frac{\rho_{oil}}{\rho_w} \quad \rho_{oil} = \bar{\rho} \cdot 1000$$

$$\chi = \frac{k}{\mu \cdot \beta^*} = \frac{0.012 \cdot 10^{-12}}{1.13 \cdot 10^{-3} \cdot 3.184 \cdot 10^{-10}} = 0.033$$

$$\beta^* = m \cdot \beta_{oil} + \beta_r = 0.22 \cdot 2.2 \cdot 10^{-10} + 2.7 \cdot 10^{-10} = 3.184 \cdot 10^{-10} \quad \text{Pa}^{-1}$$

$$P(t,r) = 30 \cdot 10^6 - \frac{3.8822 \cdot 10^{-4} \cdot 1.13 \cdot 10^{-3}}{4 \cdot \pi \cdot 0.012 \cdot 10^{-12} \cdot 19} \cdot \ln \frac{2.25 \cdot 0.033 \cdot 35 \cdot 86400}{200^2} = 29.74 \cdot 10^6\ \text{Pa}$$

$$P_{bh} = 30 \cdot 10^6 - \frac{3.8822 \cdot 10^{-4} \cdot 1.13 \cdot 10^{-3}}{4 \cdot \pi \cdot 0.012 \cdot 10^{-12} \cdot 19} \cdot \ln \frac{2.25 \cdot 0.033 \cdot 35 \cdot 86400}{0.12^2} = 27.498 \cdot 10^6\ \text{Pa}$$

3. 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 $2{,}04 \cdot 10^{-9}$ Pa^{-1}, $4{,}59 \cdot 10^{-10}$ Pa^{-1} and $1{,}02 \cdot 10^{-10}$ Pa^{-1}.

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

$$V_{res} = F \cdot h = 400000 \cdot 16 = 64 \cdot 10^5 m^2$$

elastic reserves of oil

$$V_{oil} = V_{res} \cdot \beta^* \cdot \Delta p = 64 \cdot 10^5 \cdot 3{,}63 \cdot 10^{-10} \cdot 5 \cdot 10^6 = 11616\, m^2$$

4. 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 mcm^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}.

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

Piezoconductivity factor

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

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

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

5. 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.

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

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

$$P_r = P_{res} - \frac{Q_{oil.vol}\mu}{4\pi kh} \ln\left(\frac{2{,}25\kappa t}{r^2}\right) = P_{res} - \frac{Q_{oil.vol}}{4\pi\varepsilon} \ln\left(\frac{2{,}25\kappa t}{r^2}\right) = 22{,}69 MPa$$