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Practice session N4

Lessen topic: Determination of initial gas reserves in gas field

$$Q_{gas\,res.} = \frac{\alpha_{init} \cdot \Omega_{init} \cdot P_{init} \cdot T_{st}}{Z_{init} \cdot P_{at} \cdot T_{res}}$$

$$\Omega_{init} = F \cdot h \cdot m_0$$

$$Q_{gas\,res.} = \frac{\Omega^{*} \cdot P_{init}}{Z_{init}}$$

$Q_{gas\,res.}$ - initial gas reserves;

α_{init} - initial gas saturation coefficient;

Ω_{init} – gas-saturated porous volume;

P_{init} - initial reservoir pressure;

Z_{init} - gas compressibility factor at the initial reservoir condition;

T_{res} - reservoir temperature;

Ω^{*} - reduced gas-saturated pore volume.

Task N1. Determine initial gas reserves in gas field with reservoir radius 900m, initial gas saturation 0.81, effective porosity of 0.16, reservoir thickness 22m, initial reservoir pressure 40 MPa, reservoir temperature 70 ^{0}C, and gas gravity 0.85.

Data:
R=900 m
α_{init}=0.81
m_o=0.16
h=22 m
$P_{init.}$=40 MPa
$T_{res.}$=70+273=343K
$\bar{\rho}_g$ =0.85

$$Q_{gas\,res.} = \frac{\alpha_{init} \cdot \Omega_{init} \cdot P_{init} \cdot T_{st}}{Z_{init} \cdot P_{at} \cdot T_{res}}$$

$$\Omega_{init} = F \cdot h \cdot m_0 = 3.14 \cdot 900^2 \cdot 22 \cdot 0.16 = 8.953 \cdot 10^6 \text{ m}^3$$

Pseudocritical pressure:

$$p_{cr} = 4{,}892 - 0{,}4048 \cdot \bar{\rho}_g = 4{,}892 - 0{,}4048 \cdot 0{,}85 = 4{,}548 \text{ MPa},$$

Pseudocritical temperature:

$$T_{cr} = 94{,}717 + 170{,}8 \cdot \bar{\rho}_g = 94{,}717 + 170{,}8 \cdot 0{,}85 = 239{,}897 \text{ K}.$$

Pseudoreduced pressure and temperature :

$$p_{red} = \frac{p_{init}}{p_{cr}} = \frac{40}{4{,}548} = 8{,}795,$$

$$T_{red} = \frac{T_{init}}{T_{cr}} = \frac{343}{239{,}897} = 1{,}43,$$

Gas compressibility factor:

$$z_{init} = (0{,}4\lg(T_{red}) + 0{,}73)^{p_{red}} + 0{,}1 \cdot p_{red} =$$
$$= (0{,}4\lg(1{,}43) + 0{,}73)^{8{,}795} + 0{,}1 \cdot 8{,}795 = 1{,}008.$$

Initial gas reserves:

$$Q_{gas.res.} = \frac{0{,}81 \cdot 8{,}953 \cdot 10^6 40 \cdot 293}{1{,}008 \cdot 0{,}1013 \cdot 343} = 2{,}4 \cdot 10^9 \text{ m}^3$$

Task N2. Determine initial gas reserves in gas field with gas productive area $4.1 \cdot 10^7 m^2$, effective porosity of 0.15, reservoir thickness 12m, initial gas saturation 0.8, initial reservoir pressure 34 MPa, reservoir temperature 75 ^0C, and gas gravity 0.6.

Data:
$F = 4.1 \cdot 10^7 m^2$
$m_o = 0.15$
$h = 12$ m
$\alpha_{init} = 0.8$
$P_{init.} = 34$ MPa
$T_{res.} = 75 + 273 = 348K$
$\bar{\rho}_g = 0.6$

Pseudocritical pressure:

$$p_{cr} = 4{,}892 - 0{,}4048 \cdot \bar{\rho}_g = 4{,}892 - 0{,}4048 \cdot 0{,}6 = 4{,}649 \text{ MPa},$$

Pseudocritical temperature:

$$T_{cr} = 94{,}717 + 170{,}8 \cdot \bar{\rho}_g = 94{,}717 + 170{,}8 \cdot 0{,}6 = 197{,}197 \text{ K}.$$

Pseudoreduced pressure and temperature :

$$p_{red} = \frac{p_{init}}{p_{cr}} = \frac{34}{4{,}649} = 7{,}3,$$

$$T_{red} = \frac{T_{init}}{T_{cr}} = \frac{348}{197{,}197} = 1{,}76,$$

Gas compressibility factor:

$$z_{init} = (0{,}4 \lg(T_{red}) + 0{,}73)^{p_{red}} + 0{,}1 \cdot p_{red} =$$
$$= (0{,}4 \lg(1{,}76) + 0{,}73)^{7{,}3} + 0{,}1 \cdot 7{,}3 = 0{,}982.$$

$$Q_{gas\ res.} = \frac{\alpha_{init} \cdot \Omega_{init} \cdot P_{init} \cdot T_{st}}{Z_{init} \cdot P_{at} \cdot T_{res}}$$

$$Q_{gas.res.} = \frac{0{,}8 \cdot 4{,}1 \cdot 10^7 \cdot 12 \cdot 0.15 \cdot 34 \cdot 293}{0{,}99 \cdot 0{,}1013 \cdot 348} = 2{,}1 \cdot 10^{10} \text{ m}^3$$

Task N3. Determine initial gas reserves in gas field with initial reservoir pressure 9.2 MPa, reservoir temperature 34 ^{0}C, and gas gravity 0.57. The average reservoir pressure and total gas production at the end of each year are given in table. 1

Year of field development	Total gas production , Q(t), 10^6 m^3	Reservoir pressure at the end of the year $\tilde{p}_{res}$, MPa
1	0	9,2
2	18	8,87
3	52	8,24
4	75	7,92
5	100	7,48
6	135	6,98
7	156	6,71
8	174	6,38
9	191	6,2
10	227	5,66
11	254	5,13
12	277	4,9

$$p_{cr} = 4{,}892 - 0{,}4048 \cdot \bar{\rho}_g = 4{,}892 - 0{,}4048 \cdot 0{,}57 = 4{,}661 \text{ MPa},$$

$$T_{cr} = 94{,}717 + 170{,}8 \cdot \bar{\rho}_g = 94{,}717 + 170{,}8 \cdot 0{,}57 = 192{,}073 \text{ K}.$$

$$p_{red} = \frac{p_{res}}{p_{cr}} = \frac{9{,}2}{4{,}661} = 1{,}974,$$

$$T_{red} = \frac{T_{res}}{T_{cr}} = \frac{307}{192{,}073} = 1{,}598.$$

$$z_{init} = (0{,}4\lg(T_{red}) + 0{,}73)^{p_{red}} + 0{,}1 \cdot p_{red} =$$
$$= \left(0{,}4 \cdot \lg 1{,}598 + 0{,}73\right)^{1{,}974} + 0{,}1 \cdot 1{,}974 = 0{,}859.$$

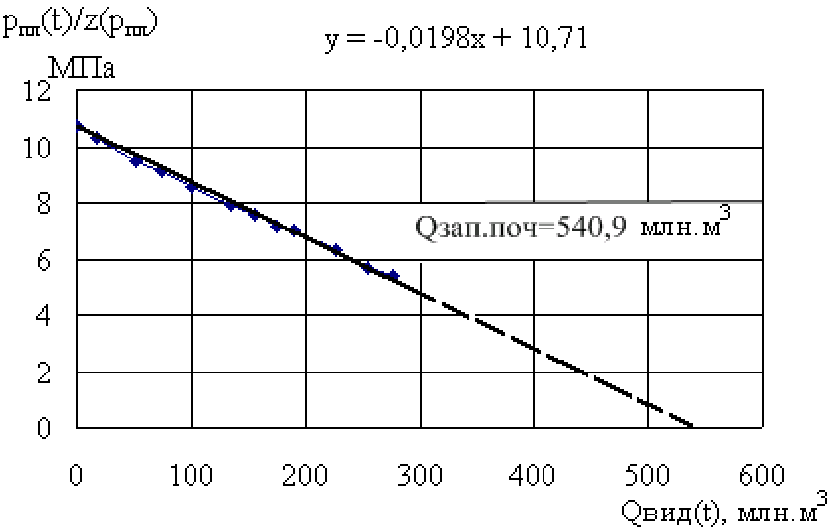
Reduced reservoir pressure:

$$\frac{p_{res}}{z\left(p_{res}\right)} = \frac{9{,}2}{0{,}859} = 10{,}71012$$ MPa.

Table. 2

Year of field development	Total gas production , Q(t), 10^6 m^3	Reservoir pressure at the end of the year $\tilde{p}_{res}$, MPa	Gas compressibility factor, $z(\tilde{p}_{res})$	Reduced reservoir pressure, $\frac{\tilde{p}_{res}(t)}{z\left(\tilde{p}_{res}\right)}$, MPa
1	0	9,2	0,859	10,710
2	18	8,87	0,962	10,297
3	52	8,24	0,968	9,493
4	75	7,92	0,871	9,092
5	100	7,48	0,876	8,542
6	135	6,98	0,881	7,922
7	156	6,71	0,884	7,589
8	174	6,38	0,888	7,183
9	191	6,2	0,890	6,983
10	227	5,66	0,897	6,307
11	254	4,9	0,908	5,6707
12	277	5,05	0,906	5,397

We represent the graphical dependence based on the results of calculations: $\frac{\tilde{p}_{res}(t)}{z(\tilde{p}_{res})} = f(Q_{prod}(t))$



Calculate the initial and residual gas rezerves in the field:

$Q_{init} = 540.9 \cdot 10^6 m^3$

$Q_{resid} = 540.9 \cdot 10^6 - 277 \cdot 10^6 = 263.9 \cdot 10^6 m^3$