Lecture № 8

Calculation of parameters of hydraulic fracturing (in oil well)

In oil well hydraulic fracturing has been conducted.

Parameters of hydraulic fracturing: we have to determine the volumetric concentration of sand in the liquid and sand mixture; **density of sand-carrying liquid; viscosity of** sand-carrying **liquid; the volume of displacing liquid; the volume of** sand-carrying **liquid;**
the time of pumping the fracturing liquid ;
the effect expected as a result of carrying out hydraulic fracturing ;
well productivity after **carrying out** hydraulic fracturing and increase of well productivity after **carrying out** hydraulic fracturing.

Calculation of parameters of hydraulic fracturing (in oil well)

1. Calculation of parameters of liquid and sand mixture

1.1 Volumetric concentration of sand in the liquid

$$b_s := \frac{C_s}{C_s + \rho_s}$$

C_s is mass concentration of sand in the sand-carrying liquid, $\frac{kg}{m^3}$

ρ_s is sand density, $\frac{kg}{m^3}$

1.2 Density of sand-carrying liquid, kg/m^3.

$$\rho_{s.c.l.} := b_s \cdot \rho_s + \left(1 - b_s\right) \cdot \rho_{fr.l.}$$

$\rho_{fr.l.}$ is density of the fracturing liquid, $\frac{kg}{m^3}$

1.3 Dynamic viscosity of sand-carrying liquid, Pa·s

$$\mu_{s.c.l.} := \mu_{fr.l.} \cdot e^{3.18 \cdot b_s}$$

$\mu_{fr.l.}$ is viscosity of the fracturing liquid, Pa·s

2. Calculation of the volumes (amounts) of necessary materials and reagents.

2.1 Volume of displacing liquid taking into account surface communications (surface pipelines), m^3.

$$V_{d.l.} := 1.3 \cdot \left(\frac{\pi}{4}\right) \cdot \left[\left(d_{i.t.}\right)^2\right] \cdot H$$

$d_{i.t.}$ is inner diameter of tubing, m .

H is the depth of the well to the middle of productive formation, m .

2.2. Volume of the sand-carrying liquid, m^3

$$V_{s.c.l.} := \frac{M_s}{C_s}$$

M_s is the mass of sand which is necessary for carrying out the hydraulic fracturing , kg

2.3. Volume of the fracturing liquid, m^3

Take $V_{fr.l.} = 10 \quad m^3$

3. Calculation of the time of pumping the fracturing liquid

The time of pumping the fracturing liquid could be determined by the formula:

$$t_{fr.l.} := \frac{V_{fr.l.}}{Q}$$

Q is liquid injection rate, m^3/s

4. Estimation of the effeciency of hydraulic fracturing

4.1. The radius of horizontal crack, m

$$R_{h.c.} := 0.0173 \cdot \left(Q \cdot \sqrt{\frac{\mu_{fr.l.} \cdot t_{fr.l.}}{k_f}} \right)^{0.5}$$

k_f is coefficient of permeability of formation, m^2

4.2 Expected effect of hydraulic fracturing by means of Maksimovich's formula:

$$E := \left(\frac{\ln\left(\frac{R_{e.r.b.}}{r_w} \right)}{\ln\left(\frac{R_{e.r.b.}}{R_{h.c.}} \right)} \right)$$

$R_{e.r.b.}$ is the radius of external reservoir boundary, m

r_w is well radius, m

$R_{h.c.}$ is the radius of horizontal crack, m

4.3 Well productivity after carrying out hydraulic fracturing:

$$Q_{o.w.2} := Q_{o.w.1} \cdot E$$

$Q_{o.w.1}$ is well productivity before the hydraulic fracturing, m^3/d

4.4. The increase of well productivity after carrying out hydraulic fracturing

$$\Delta Q_{o.w.} := Q_{o.w.2} - Q_{o.w.1} \quad , m^3/d$$