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Yuriy F. Vasyuchkov*

BASES OF INTENSIVE EXTRACTION OF COALBED METHANE AFTER HYDROFRACTURING PROCESS

The problem of methane and safety for coal mine is sharply on the agenda for gassy coal seams extraction. Existing methods of coalbed methane extraction don't satisfy practice challenges. In gassy mines these situations are met with very often. Low efficiency of conventional coalbed methane extraction methods requires to decrease of coal extraction or higher of exploitation costs.

There is the effective method of methane emission decrease in coal workings. The method has proposed by Moscow State Mining University and has had the large history (during 50 years). But there is necessity to improve the calculation mechanism of the method in connection with last data about the methane capacity forms in coals and experience data. This paper is devoted the mentioned above subject.

The static indexes of hydro fracturing of coal seams are the natural coalbed methane content x_n [m^3/t], gas pressure in a coal massif P_{gas} [MPa], geostatic pressure on the determined depth P_{gst} [MPa], pressure of hydro fracturing P_{hfr} [MPa], filtrated porosity m_{por} [%] and permeability K [m^2] of the coal seam.

For the geostatic pressure there is next equation

$$P_{gst} = 10^{-6} \rho \cdot g \cdot H \quad \text{[MPa]} \tag{1}$$

where:

- ρ – average density of the upper rocks [m^3/kg],
- H – depth of the coal seam [m].

The hydro fracturing pressure may be found as

$$P_{hfr} = (1.3 - 1.6)\, P_{gst} \quad \text{[MPa]} \tag{2}$$

* Moscow State Mining University

The dynamical parameters of hydro fracturing process are filtration volume of work liquid in coal blocks of the coal masssif V_f [m^3], fracture volume of the one V_{fr} [m^3], full or injected volume of the work liquid in the coal seam during hydrofracturing process V_{inj} [m^3], time of the work liquid injection during hydro fracturing T_{inj} [s], gas-giving back surface of the fractures after hydro fracturing process S_{gas} [m^2] and initial methane return speed of the coal seam in the created fractures after the hydro fracturing process G_0 [m^3/(m^2 ·day)].

The basic index of hydro fracturing process is flow rate or the work liquid or water q_{inj} [m^3/s]. The indexes defined through the indicated curve – empirical connection between the flow rate of the work liquid and the pressure of the process $P_{inj} = f(q_{liq})$. The condition of hydro fracturing process i.e. flow rate for which forms artificial fracture systems have to be for next equation

$$q_{inj} = (1.1 - 1.15)g_{hfr} \tag{3}$$

where q_{hfr} – flow rate of the work liquid for which the indicator curve will change the increase more then 10%.

The volume of injected the work liquid is defined as

$$V_{inj} = V + V_{fr} \quad [\text{m}^3] \tag{4}$$

$$V_{inj} = V_{fr} \cdot k_{fr} \tag{5}$$

$$v_{inj} = 2h_{coal} \cdot coefc\gamma \sum[\delta_i \cdot L_i (0.85m + 0.15)] \cdot k_{fr} \leq \pi \cdot R_{ef}^2 \cdot h_{coal} \cdot \rho_{coal} \cdot m \quad [\text{m}] \tag{6}$$

where:

k_{fr} – coefficient to be divisible with V_f,
h_{coal} – thickness of the coal seam [m],
γ – angle of fractures inclination to a roof of the coal seam [degrees],
δ_i – opening of *i*-system of the fractures [m],
ρ_{coal} – density of coal in the massif [t/m^3],
m – porosity of the coal seam in the massif, dimensionless unit.

The connection of effective radius of hydro fracturing influence from a borehole with system fractures opening may be expressed with the next equation

$$L_{\max} = \frac{n \cdot R_{ef}}{\sum_{1}^{n} k_{vl}} \quad [\text{m}] \tag{7}$$

where

$$R_{ef} = \frac{L_1 + L_2 + \ldots + L_n}{n} = \frac{L_1 \cdot k_{vl.1} + L_2 \cdot k_{vl.2} + \ldots + L_n \cdot k_{vl.n}}{n} \tag{8}$$

$k_{vl.n}$ – variation coefficient of fractures i-system length which is determined from the next correlation

$$k_{vl.1} : k_{vl.2} \ldots k_{vl.n} = L_1 : L_2 \ldots L_n \tag{9}$$

Time of injection process for hydro fraturing of the coal seam may be determined as

$$T_{inj} = \frac{\pi \cdot \mu \cdot V_f^2}{(4.56 \cdot h_{coal} \cdot \Delta p)^2 \cdot \beta_{bl} \cdot K_{bl} \left[2\sum_1^n 2L_i (0.85m + 0.15) \right]^2} \quad [\text{s}] \tag{10}$$

where:

Δp = $p_{hfr} - p_{gst}$ [Pa],
β_{bl} – coefficient of volumetrically pressing of the coal [Pa^{-1}],
K_{bl} – coefficient of the coal block permeability [m^2].

And at last, the gas-giving back surface S_{gas} [m^2] and initial return speed of the coal seam G_0 [$\text{m}^3/(\text{m}^2\cdot\text{day})$] and methane extraction through the borehole M_{bh} [m^3/year] are determined as

$$S_{gas} = 2\, h_{coal} \cdot \text{cosec}\, \gamma \sum_1^n 2L_i [m - K_{uni} (m - 1)] \tag{11}$$

$$G_0 = x_{cur} \, [0.0004 \cdot (V^c)^2 + 0.16] \tag{12}$$

$$M_{bh} = S_{gas} \sum_1^p G_{o.i} \cdot k_{dr} \cdot k_{sd} \tag{13}$$

where:

K_{uni} – coefficient of fractures system uniformity,
x_{cur} – current coalbed methane content [m^3/t],
p – number of extracting coalbed methane from the coal measure at the same time,
V^c – volatile content of the coal,
M_{bh} – total metane emission through the borehole from the coal seam,
k_{dr} – coefficient of the coal seam dewatering,
k_{sd} – coefficient of flow rate of coalbed methane decrease from the hydro fracturing borehole.

CONCLUSIONS

1. The important indexes of the hydro fracturing process are notificated in the report.
2. Maiden position is contained in introduction to calculation methodics the conception about fractures development in the coal massif during hydrofracturing process.

3. Next position is to the determination of filtrated and fracturing volume into the coal massif why the calculations will put on the strong scientific base.
4. The conception of the methane-obtaining from the hydrofracturing borehole is introduced at the first time in the methodics.
5. So, to-day there is general methodology of designing for intencification method of coalbed methane extraction process that allows to widly use the active methods of the one.