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INTERNAL AND EXTERNAL CAUSES OF CRACKS OCCURRENCE IN A COAL SEAM IN THE AREA OF VIBRATION EXPOSURE

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Abstract: *The methane extraction from the coal massif is needed due to preparatory and treatment works before starting the mining. The amount of natural methane extraction is very low and deceases with the coal seams depth. Therefore, the goal of this article is to analyze the influence of the vibration impact on low-permeable gas-bearing coal massifs by means of creating new crack systems. The vibration treatment of the coal seam consists in inducing vibration of the gas-saturated mass, which arrives at the crack formation and the flow of methane from the reservoir to the well. The wave equations with a double periodicity are presented here. They make it possible to determine displacements of microcracks on the coal block surfaces. The process of forming the crack arrays is most efficient if the excitation frequency is equal to the resonance one of the coal seam. On these conditions the growth of cracks and their number is significant and contributes to the intensification of the methane disloging from the coal seam.*

Keywords: Vibration, methane, impact, massif, microcracks.

1. Introduction

Significant increase of the gas permeability is an important issue of effective recovery of methane from the unloaded coal seams. This can be achieved by creating or opening new gas-conducting systems of cracks leading to degassing to the wells drilled from the surface.

In some cases the traditional degassing methods can become unusable regarding to the safety of effectivity of preparatory works. Therefore, the present research is focused on comprehensive methods based on setting the coal seams into vibration motion at the resonance frequency. This leads to creation of conditions for effective opening new crack systems and enables stable recovery of methane from the coal massif.

2. Analytical solution

In cases when degassing by the wells drilled from the surface can not be applied, the vibration effect is one of the possible ways of increase of the gas permeability in the coal seams.

The corresponding vibration technologies based on transmitting energy from the borehole sources to the coal are easy to use and are not expensive. They induce effective fluctuations of the fluid within the distance of 50÷100 m from the well, which results in sufficient fracturing of the coal array.

The researched vibro-seismic method was applied in the field of the «Vorkutaugol» OJSC mine. The key point was inducing the low-frequency oscillations in the frequency range corresponding to the reservoir resonance by means of cyclic impacts on the coal seam.

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The natural permeability of fossil coals widely varies, mostly between 0,1-0,001 μm, and depends on a number of factors. Nevertheless, the porosity of the same coal seam and in the same depth changes only slightly. To reduce the content of methane in a low-permeable coal bed, it is possible to change its properties by means of vibration (Pavlenko M.V. 2002).

The available data on the impact of earthquakes on the oil deposits confirmed by the laboratory research show that the positive effect of vibration on the gas recovery occurs if velocity of the medium vibration and density of the seismic power reach the values of 1 mm/s and 1-2 W/m^2, respectively. Energy of mechanical waves propagating through the coal seam goes down if they pass through heterogeneous formations.

Solution of the problem concerning the safe and effective preparation of the gas-bearing coal seam is impossible without the integration of scientific knowledge and wide experience provided by mining science.

Specific problems are related to the effective methane extraction from low-permeable coal seams. This is caused by low gas output from the coal mass due to increasing the depth of the coal seam. Unfortunately, the study of paremeters controlling the impacts has not been done yet in these cases.

The vibration treatment of the coal seam consists in irradiation of the gas-saturated mass with a vibration field (>10 W/m^2). The effects contributing to intensification of crack formation and the methane outlet from the reservoir into the well are reported in (Pavlenko 2018.).

The simpliest type of the oscillatory motion under the vibration action is harmonic oscillations satisfying the sine law (1):

$$x(t) = A \cdot \sin(\omega t + \varphi_0) \tag{1}$$

In the investigated case the wave oscillations lead to displacements of the walls of the coal block microcracks x with the oscillation amplitude A. ω is the angular excitation frequency, φ_0 id the phase shift and t is the time. Displacement of the walls of the coal block microcracks is a function of two variables – time t and the spatial coordinate of L.

Because the parts of the coal blocks are elastically linked, the oscillations propagate along axis x at the speed of v from surface B to the point K (see Fig. 1). If there is no damping in the coal block, then the displacement on this surface is: $L_{b.l.} = A\sin\omega(t - \Delta t)$, since the displacement is delayed by the time of Δt and arrives at the formula for the wave equation:

$$L_{b.l.} = A\sin\omega\left(t - \frac{l}{v}\right), \tag{2}$$

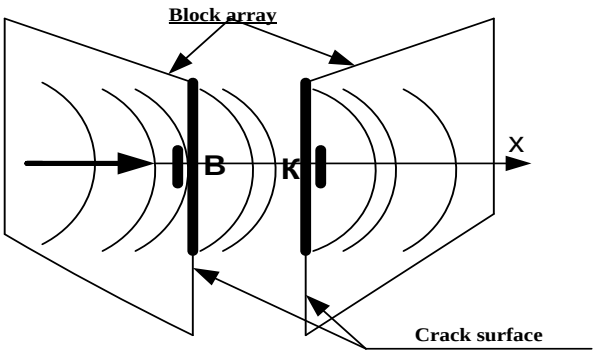

Fig. 1: Distribution scheme of the vibration waves in the microcracks of the block of coal.

Expressing ω by means of T, the period of the oscillation, $\omega = 2\pi/T$ and taking into account the formula for the wavelength is $\lambda = vT$ expression (2) can be rewritten as:

$$L_{b.l.} = A\sin 2\pi\left(\frac{t}{T} - \frac{l}{\lambda}\right), \quad (3)$$

The equations for the vibration wave (2) or (3) have a double periodicity and therefore, they allow to determine the displacement of any surface of the microfracture of the coal block with coordinate *x* at any moment of time *t*.

The vibration effect is applied to the coal seam from a well drilled from the surface and filled with liquid using a piston lowered into the well and coupled with the oscillator.

The vibration generator powered by two 10 kV electric motors works as a self-balanced exciter of directional vibrations acting through the piston on the liquid in the well. This manipulation prevents closing the newly formed cracks in the coal seam.

The power of the two electric motors forming the vibration unit fixed to the well are sufficient to provide necessary energy in the radius of 50,0 meters (Pavlenko M. V. 2002).

3. Conclusions and discussion

Forming the cracks in low-permeable gas-bearing coal massif is possible by application of mechanical vibration. This was confirmed by the carried out industrial experiments. The oscillations lead to compressing and streatching the material, which results in occurance of the new crack systems. The results of measurements show that fracturing of the coal medium is very sensitive to the vibration frequencies.

In order to intensify the release of methane from the coal it is necessary to satisfy two factors: to reach the resonance frequency and the conditions of forming of new crack systems in the coal bed.

The problem reported in this article is very complex. It solution requires finding new methods and cooperation with relevant research institutions.

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