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VIBRATORY STIMULATION OF FLUID FLOWS IN POROUSMEDIUM OF COAL SEAM

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Abstract: *The present article describes the results of research related to vibration wave impact on the coal array and the coal seam in particular, which is used to increase the methane recovery in the seam. The known methods of vibrating wave impact on coal array do not always successfully ensure the necessary methane recovery. For experimental research, the effects obtained in laboratory conditions through vibratory simulations of fluid flows in porous medium of coal seam are also considered. A highly recommended method of well treatment is the method of low-frequency effects on the coal seam through wells drilled from the surface. A vibration facility developed with direct participation of the author of this article allows a near-well zone to work in several hydrodynamic regimes without changing the wellhead. Complex research of vibrating wave impact based on a wide range of seam thickness, methane content, pressure and temperature is also needed to account for the impact on the dynamic features of the array. This research allows us to select optimal working parameters of technological facilities using the vibrating wave impact and thereby reduce energy costs and increase the duration of their effectiveness.*

Keywords: ***Vibrating wave impact, fluid flow, porous medium, coal seam, coal array, well treatment, seam face zone, near-the-well zone.***

1. Introduction

Vibrating wave effects on coal array have recently become a promising subject for research of porous medium of the coal seam. One of the most effective methods of vibrating wave – the impact on coal seam - is used to increase the methane recovery from the seam. This article reviews the relevant studies on changes in hydrodynamics in the coal seam associated with the changing nature of fluid absorption. The studies describe experimental research of vibrating wave effects under the conditions of saturation of the coal seam with fluid. The known methods of vibrating wave effects on coal array do not always successfully ensure the necessary methane recovery. For experimental research, the effects obtained in laboratory conditions are also considered; even the obtained in vitro data that allow in natural conditions to reproduce quite accurately the effects of sufficiently high accuracy.

One of the main ways of increasing the efficiency of methane recovery is to improve the technology of integrated effects when preparing the exploitation of coal deposits.

2. Methods and materials

A choice of method to impact the coal seam is mainly carried out empirically, since the experimental studies are always associated with high costs; therefore it is not always possible to choose effective hydrodynamic modes of processing (Nozhkin N.V., 1971).

Among many methods of well treatment, a highly recommended method is the method of low-frequency effects on the coal seam through wells drilled from the surface (Nicholaevski V.1989).

A vibration facility developed with direct participation of the author of this article allows a seam face well zone to work in several hydrodynamic regimes without changing the wellhead. Subjects of gas recovery intensification in the minefield were represented by low-permeability coals. Their porosity was 3-5%, the type of coal was crack - porous, and deposit depth of 600 - 650 m. Duration of vibrating wave impact on the well averaged from 0.1 to 0.5 hours. As a result of the above intensification by the

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method of vibrating wave impact (VVI) in a coal array, absorption has increased by 4-5 times. Technology of vibrating wave impact solves the tasks of how to increase permeability of seams and enhance the recovery of methane and is considered as a set of measures of how to employ the vibrating wave impact of the wells drilled from the surface on the coal seam. A low coefficient of gas recovery and reduced methane recovery from coal seams is a consequence of various physical processes taking place in both the seam face zone and in the seam zones remote from the well. The effectiveness of any impact will depend on how these physical processes generated by this impact are able to neutralize those processes that are responsible for reduction of gas recovery.

If, in the process of hydro-division of the seam due to sliming and blockage of near-the-well zone of the seam, permeability of seam face zone has decreased, degassing of the seam should be started after the measures have been taken to restore its permeability.

The technology of vibrating wave impact is based on a comprehensive approach to how to solve the problems of increasing gas recovery, as well as to how to treat the seam face zone of the well with the aim to increase the gas recovery from the seam including the analysis and calculation of those processes on the basis of which the facility is designed and manufactured, and the impact parameters are selected.

3. Results

Hydraulic fracturing of the seam is widely used to increase the permeability of the seam zone. This, however, does not always yield positive results. In particular, the results of hydraulic fracturing of the seam are often unpredictable; out of a series of operations carried out, at least 5-10% are terminated prematurely due to breakthrough of seam water to nearby mining drifts. In addition, an improper choice as for fluid filters, can, by contrast, lead to blockage of seam face zones.

Technology of vibrating wave impact (VVI) has established itself exclusively in the positive terms. Its application at the stage of development enables us to start the well operation through the change of collecting properties of the coal seam. It is noteworthy that during the vibrating wave impact the well fluid starts to be absorbed by the seam within a few hours after the impact. This effect is achieved by the initiation of periodic elastic vibrations in both the seam face zone and the whole coal seam (Fig. 1).

Long-term results of research give reasons to consider the effects of elastic vibrations on the filtration processes in saturated porous media as an established fact (Pavlenko M.V., 2001).

Following the impact on the well, the fracture of zone with low seam permeability was often observed due to formation of high crack areas. The treated seams exerted the changes in the area of crack formation spread over more than 70-120 meters.

This phenomenon can be explained by the fact that these effects were due to the resonance phenomena in the productive seams (Kurlenya M.V., Serdyukov S.V., 1999).

The impact excites fluid oscillations in the coal seam saturated with fluid; these oscillations are accompanied by significant alternating loads contributing to the increase in the seam permeability and subsequently to the enhanced recovery of methane due to the following main effects:

- Increase in volumes of seam filtration in the existing pore radius and the pressure gradient due to the "piston effect", which leads to the increase in the number of cracks.
- Increase or restoration of seam permeability and its face zone is achieved due to cleaning the porous and perforated flues of slack coal, as well as the increase in effective cross-section of cracks, involving in the process of filtering the remote zones of coal seam after its hydraulic fracturing.
- Involvement in the process of filtering of the fixed volume of fluid injected within the previous hydro-division of the seam, as well as under the current radius of the developed cracks and the pressure gradient, which leads to the increase of the coefficient of gas recovery.
- Weakening of the link between the fluid and the cracks surface s in the coal increases the phase permeability of methane, which contributes to the increase in methane recovery.
- Manifestation of seismic effect contributes to the displacement of stationary fluid layers fixed at the surface; therefore their involvement in the filtering process increases the permeability of the coal seam and of the coefficient of gas recovery from the coal.

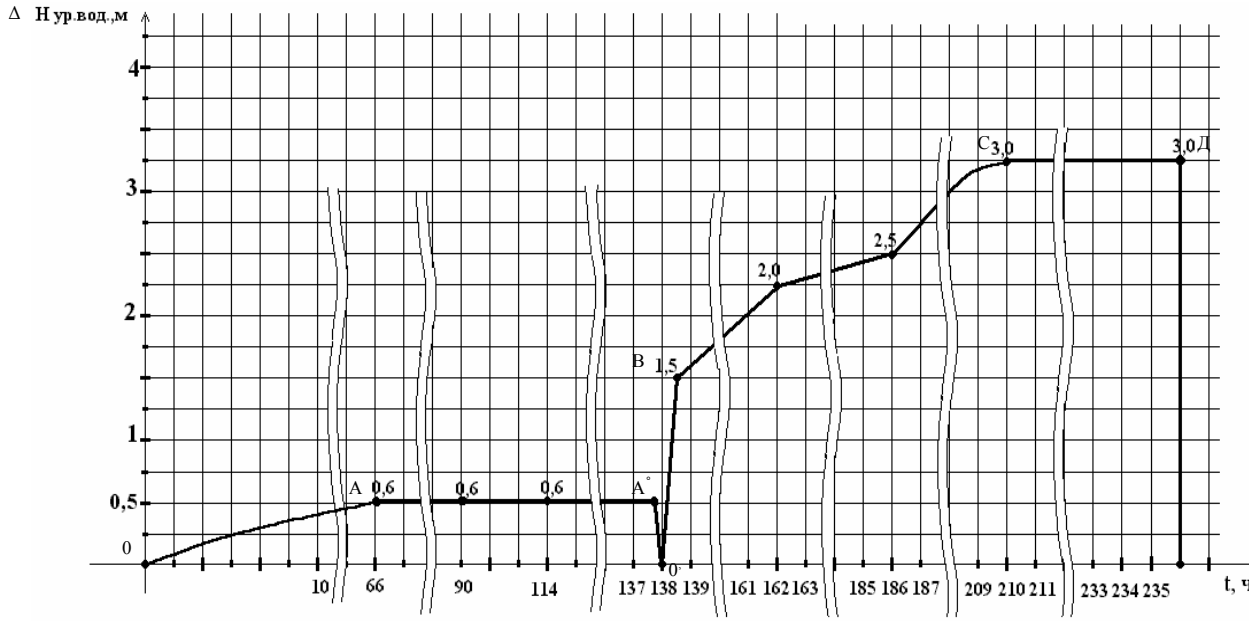

Fig. 1: Hydrodynamics of seam during the period of vibration impact after hydro-division through the well number 4447 on the coal seam of "Komsomolskaya" Vorkutaugol.

ΔH-lowering of water level in the well relative to its filling, m;

OA-lowering of level under hydrostatic column;

AO'-water topping to the well;

O'B-period of vibration impact;

BC- lowering of level due to imposition of oscillations;

DM-level stabilization.

A controllable source of elastic waves in the well used to impact the coal seam must, on the one hand, have a sufficient power to start the stagnant water moving. This can be offered by vibrating wave impact. The application of wave vibration impact, necessary for the initiation of considerable formation and growth of cracks in the coal array, facilitates the formation of steady flow of methane from the coal fractured structure, regardless of coal permeability and hydrostatic pressure of the surrounding array.

The process of wave formation in the array from the source of oscillations is accompanied by an elastic impact of the frequency of 30-40 Hz and the amplitude of 3-5 mm, and the pressure of more than 10 - 40 MPa.

Wave vibration impact exhibits alternating loads on the seam face zone of the seam and the seam as a whole. As a result of multiple cycles “compression – expansion”, alternating hydraulic pressure waves propagate along the seam skeleton and through its porous medium, and improve the capacity and filtration properties of rocks in the near-well zone. Pressure pulses reveal the natural cracks and contribute to the formation of new cracks.

An important factor is that the coal seam itself has its own resonant frequency and this should be considered through the wave impacts.

On the other hand, a rigorous theory based on broad frequency ranges of vibrating wave impact avoids an overcomplexity of mathematic modeling of the process which is characterized by the following parameters: pressure of methane in the seam, temperature of rocks, methane absorption, limiting volume of coal array.

4. Conclusions

Complex research of vibrating wave impact based on a wide range of seam thickness, methane content, pressure and temperature is also needed to account for the impact on the dynamic features of the array. This research allows us to select optimal working parameters of technological facilities using the vibrating wave impact and thereby to reduce energy costs and increase the duration of their effectiveness (Pavlenko M.V., 2001).

The solution of the tasks mentioned in connection with the spread of vibrating wave impact technology is becoming increasingly important for the study of porous-crack coals and requires an integrated approach based on modern research methods and new theoretical approaches to describe them.

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