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Development of the Impermeable Membranes Using Directional Hydraulic Fracturing

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Abstract

To solve various technological problems of mining, such as, prevention of air inflow into coal-seam degassing holes and steam entry into underground galleries when thermoshaft production of heavy oil is performed. There are developed the chemical compositions to form the membranes' impermeable and drainage elements. Also, there is provided the stand's description and laboratory studies' results which are the compositions' influence on permeability of porous medium. A method of creating membranes by hydraulic fracturing of the rocks, in which to get a transverse fracture, shear loading of the walls along the wellbore axis is used. A comparative analysis of this method with directional hydraulic fracturing on the basis of slot initiator is performed. In the article calculations of influence of the fracture pressure and fracture propagation from the wellbore and fracture radii are presented. The technological advantages of the developed method of hydraulic fracturing for the creation of impermeable membranes are represented.

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1. Introduction

In mining the impervious membranes are used to protect a mine working from water and gas inflow and to create edges of the metals leaching zone and etc. Among these purposes there is prevention from air filtering from the mine

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working into degassing boreholes. The sealing quality estimates the efficiency of the preliminary coal beds degassing. There is a problem of the air inflow into methane withdrawal point through the rock mass. A well-known solution addressing the problem is to apply insulating compound onto the mine working surface. Its uneven surface causes great specific consumption of expensive chemical reagents. However, isolation of a surface part around the degassing borehole head does not interfere with the air filtering through the disturbed rock bed around the mine working made out of its non-isolated parts.

More effective solution is impervious membranes created inside of the rock mass with the help of one or several hydraulic fracturing fractures parallel to each other and located across an uncased borehole. This paper suggests several schemes for the membranes made of drainage and impermeable elements. In order to obtain the elements a fill fluid and insulating compound have been created. The work presents results of the laboratory research on the fill fluid and insulating compound's influence on porous medium permeability.

2. Impervious membrane construction

Several types of impervious membranes have been developed. The simplest one is a double-layered membrane containing one of the created fractures across the borehole. There is a rock mass layer with the artificially lowered permeability around the fracture. The fracture is filled with viscous liquid under pressure higher than the pressure of fluid (water, methane, steam, alkali solutions) filtering of which has to be stopped. The external layer decreases the membrane's fill fluid leakage into the rock. Setting of the membrane is performed in several steps. At first, the borehole interval is isolated, and the hydraulic fracturing is performed in it [1]. The second step is to saturate the rock bed around the fracture with the insulating compound. At the third step, the fracture is filled with the viscous liquid under pressure. This type of membrane can be used to increase the quality of the long-term sealing of the coal beds' degassing boreholes.

“Water seal” type of the membrane consists of two close parallel created fractures, into one of which the water is injected. The water is drained into the second fracture. The filtering flow in the rock is directed against the air filtering from the mine working into the methane recovery zone (Fig. 1a). The fractures are made of two shot holes. The results of the mathematical modelling of two close created fractures propagation are presented in the paper. This type of membrane is low cost because the chemical reagents are not needed for its production. The membrane can be used to restore the sealing of the producing boreholes without the working being interrupted. A disadvantage of the membrane is the high requirements for the drainage fracture's permeability.

The most complicated is a “zonal” membrane. Its aim is to create the flooding zone of the increased pore pressure in the rock mass. The “flooding zone” scheme is shown in Fig. 1b. It consists of three parallel created fractures. The external fractures form impermeable borders of the flooding zone. They are filled with polymeric compound. The internal is a drainage fracture. Through the internal fracture the water or another agent under pressure higher than the formation fluid pressure is injected. The filtering of the formation fluid should be prevented. This type of the membrane is used to deal with the stream entry into a gallery in case of heavy oil thermal mining. Then, the drainage fracture is filled with thermally-resistant liquid under pressure higher than the pressure of the heat flow.

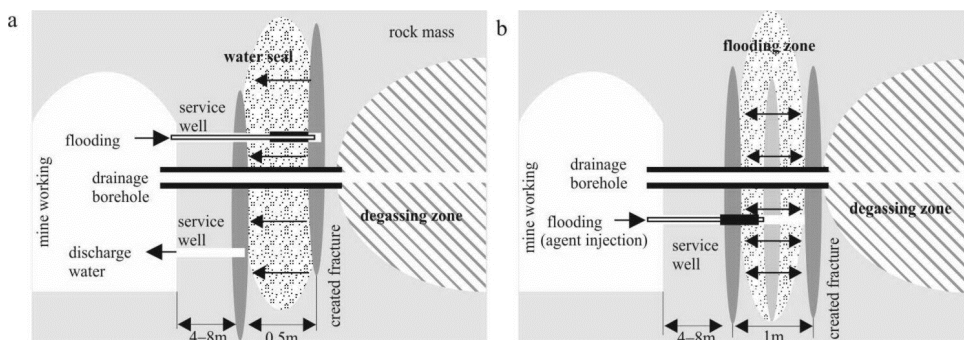


Fig. 1. Impervious membrane in rock mass: (a) «water seal» membrane; (b) «flooding zone» membrane.

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