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THE SORPTION OF HYDROCARBONS IN THE CONDITIONS OF COAL MOISTENING

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Abstract: *Here it has been presented a method of efficiency improvement of preliminary coal massive moistening. This method is that thermal chemical treatment of coal massive used to decrease dust formation at the process of coal extraction, coal seam degasification as well as to reduce coal hardness. It has been carried out a chromatographic analysis of both dry coal samples (seam E_5, coal rank F, Kuzbass) and coal from the same after thermal treatment, using chemical agents. Optimal concentration of penetrating agent has been estimated. The developed method is recommended at coal mines having highly gas-containing seams, which are dangerous because of coal dust explosions.*

Keywords: ***Methane, sorption, desorption, coal moistening, chromatographic analysis.***

1. Introduction

In the problem of dust control in coal mines hydro-dust removal occupies a leading position, forming the basis of anti-dust complex. In this set of actions moistening of a massive plays an important role. It prevents the ingress of dust into the air by reducing the dust-raising capacity of coal. Pre-moistening of coal seams was first used in coal mines in 1980 as a means to prevent dust explosion. Later this method was replaced by rock dusting, and only in the mid 1930-s it was again used in Ruhr (Germany), and then in other basins all over the world. In Russia, the first experiments on the moistening of layers were carried out 1935.

The choice of measures for dust supression is determined on the basis of mining and geological conditions, depending on the specific dust emission during the destruction of a rock massive. According to the Rules of Safety in coal mines in order to reduce dust emission while conducting clearing and preparation works, preliminary moistening should be carried out in a coal massive if the specific dust emission is more than 50 g/t.

2. Methods

Studying the experience of pre-moistening of coal revealed that the main reasons for the low efficiency of the method is the low wettability of the coal surface, as well as uneven distribution of injected moisture in the seam. One of the ways to improve its efficiency is thermal treatment of a coal massive, using chemical agents (TVHO) (Kudryashov, 1991; Skopintseva, 2006). It increases the moisture content and evenness of coal massive moistening; physical and chemical effects reduce dust formation when extracting coal; coal hardness decreases as well as coal degasation. This is achieved by capillary absorption of liquid into narrow cracks and pores in the movement of moisture in the direction of temperature gradient and concentration gradient of a penetrating agent.

In the process of pre-moistening of coal seams a balance in a coal-methane system is upset. Under the pressure of liquid, free gas is forced out of large cracks and pores into smaller ones, where gas is in absorbed and free state. When coal is moistened with surface active substances, absorbed gas can be forced out.

The results of moistening of gas-saturated coal with water has been studied for more than 70 years. A lot of scientists have studied the behavior of gas-saturated coals when their moisture content has been

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changed. The results of these experiments differ from each other both in quality and quantity. So far there hasn't been developed a unified theory of moistening of gas-saturated coal.

Some scientists have recorded a decrease of gas emission out of wet coal, admitting that methane is blocked by water in pores and crevices, others have seen increasing gassing after coal moistening, assuming that moisture assists in the desorption of methane.

The analysis of vast and contradictory experimental data has shown that moistening of gas-saturated coal cannot be simply taken as a single elementary action – methane replacing and its blocking. As a result of generalization of numerous experimental data and research works carried out by Vasyuchkov (1986), it has been stated a provision about a three staged process of interactions in the system methane-carbon while treating it with water. The first stage – water filtering through macropores and crevices, filling them with water and free methane displacement; the second stage – capillary soaking, poros moistening and reducing of gas emission from coal; the third – water molecules diffusion coal and methane desorption.

In the real conditions the process of liquid sorption on the free gas-saturated coal and the absence of methane desorption based on the principle of substitution, is the most probable.

Under the sorption of dropping liquid, adhesion heat and heat of sorption are released. This heat helps the desorption of methane by increasing the temperature in the coal-gas system. This conclusion has been confirmed by research works carried out in Moscow State Mining University. It was found that within 1-2 days the increase of coal temperature after moistening is 1.8 °C, while after hydrochloric solution up to 3 °C (Kirin, 1983).

Thus, from the standpoint of thermodynamics, water helps the desorption of methane, but it cannot be a powerful means of gas extracting from the sorption volume, as it desorbes methane, mainly on the thermal basis. Introducing additives of surface-active substances into the working fluid, one can increase the rate of soaking, and therefore may reduce the time of seam degassing by increasing the rate of gas displacement from the sorption volume of coal.

To study the interactions in the "coal-liquid-gas" system we have carried out a chromatographic analysis of dry coal samples from the seam E5 (rank F, the coal seam Kolchuginsky series of Permian age, Kuzbass) and samples of the same coal seam after thermal treatment, using chemical agents.

For the experiments coal samples weighing l0 g seam E5 with fraction size from 0.5 to 1.0 mm. have been chosen. The samples were moistened with solution of surfactants "Neolas" in the following concentrations (%): 0, 0.15; 0.5; 0.75 1.0. There were prepared 10 samples: five of them were moistened with a solution at 25 ° C, the other five - solution at 60 °C. The time of moistening was 24 hours. After that these coal samples were investigated by M-3700 chromatograph with a flame ionization detector. Liquid penetrating agent "Neolas" is an aqueous solution of a balanced mixture of anionic and nonionic surfactants as well as mineral supplements. "Neolas" is a colorless and odorless liquid. The mass fraction for this surfactant is 20 ± 1% of active parts.

Fig. 1 shows the diagrams of the desorption of hydrocarbon gases (methane, ethane, propane), depending on the concentration of penetrating agent "Neolas" at 25 °C. The diagrams have the form of a parabola with a pronounced optimum concentration of moistening solution, equal to 0.5%, at which the residual gas content for all three investigated gases is minimal, compared with pure water and the concentration of penetrating agent 1 %. Consequently, for pure water and 1 % concentration of penetrating agent, blocking of methane by working fluid was observed. As a result, residual gas content of coal has risen relative to the untreated coal. From the figure it also follows that of the presented adsorbed gases, content of propane is the largest (more than 3 times higher than that of methane and ethane).

Fig. 2 shows the diagrams of the desorption of the same hydrocarbon gases (methane, ethane, propane) depending on the same concentration of the solution "Neolas", but at a different temperature of 60 °C. From the diagram a clear dependence between the residual gas content of coal and the concentration of penetrating agent can't be seen, i.e, at all studied concentrations of a penetrating agent, the residual gas content remained almost the same, except pure water. In this case, for methane and propane the value of the residual gas content decreased from 1.5 to 3 times. We can say that clean water degasses the best.

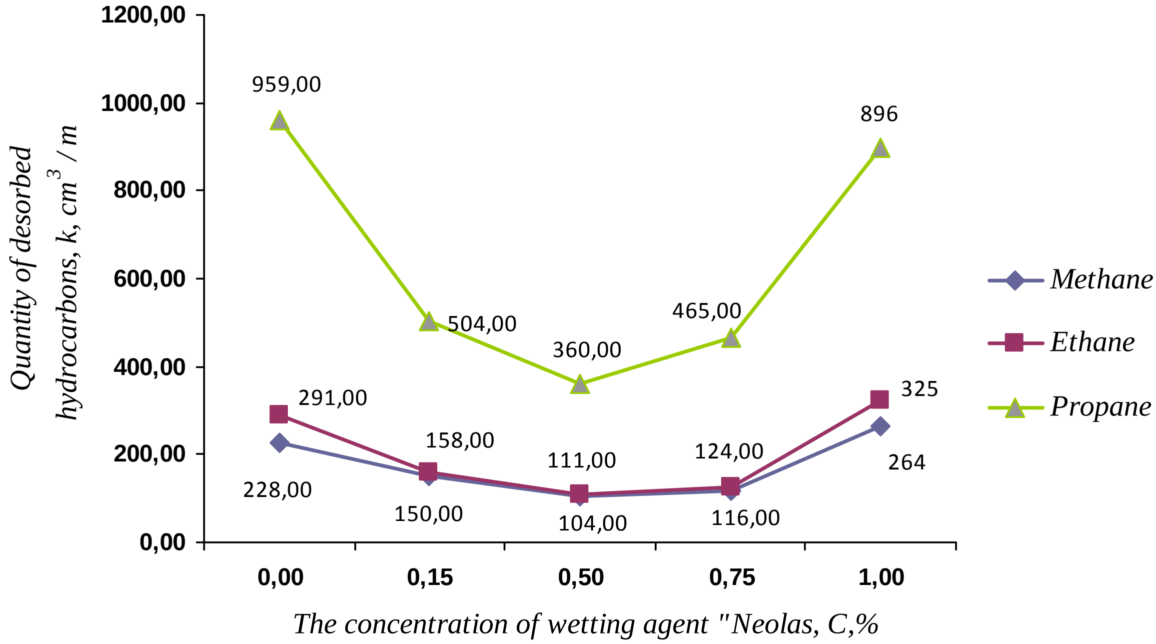

Fig. 1: The dependence of the desorption of hydrocarbons from coal, the concentration of wetting agent at a temperature of 25 °C.

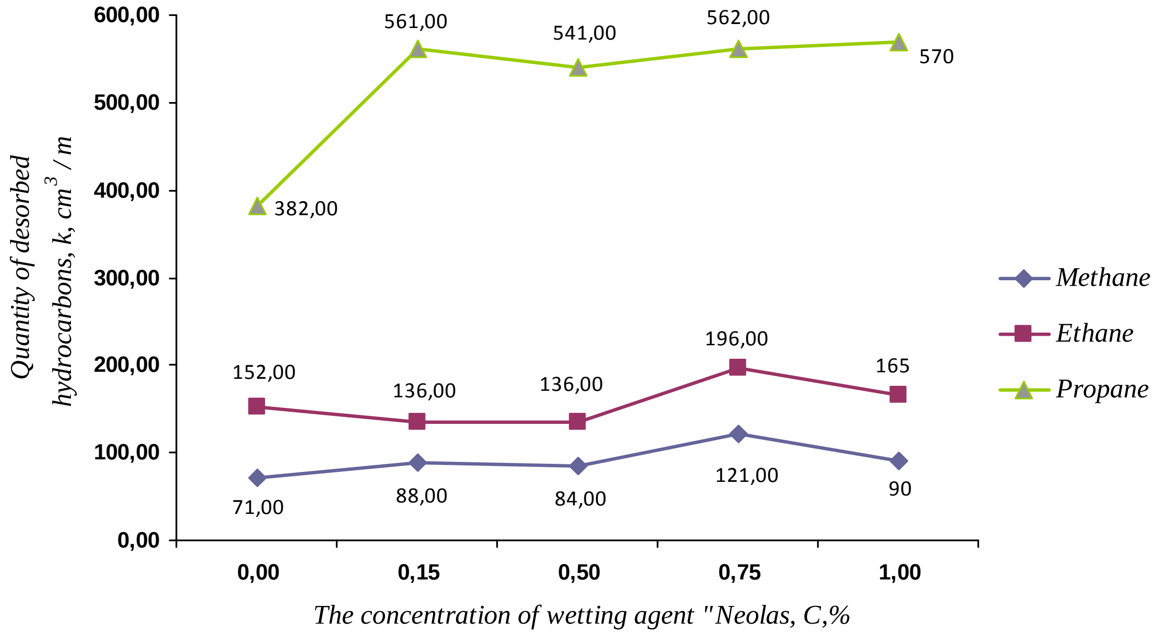

Fig. 2: The dependence of the desorption of hydrocarbons from coal, the concentration of wetting agent at a temperature of 60 °C.

3. Conclusions

One of the ways to improve the effectiveness of pre-moistening of a coal massive is its thermal treatment using chemical agents (TVHO), which aims to increase the humidity of the coal massive and the moistening more even. Chromatographic analysis of dry coal samples (seam E5) and coal samples of the same seam, treated with thermal method shows that the lowest residual gas content of coal has been determined at the concentration of penetrating agent 0.5% at 25 °C. At a temperature of 60 °C wetting clean water degasses the best.

The developed method of thermal treatment of a coal massive using chemical agents can be recommended at coal mines having highly gas-containing seams, which are dangerous because of coal dust explosions. The concentration of penetrating agent of 0.3-0.5% is optimal, in terms of reducing dust-raising capacity of coal and seam degassing .

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