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Formation of gas hydrates while mine methane extracting and possible methods of the problem solving

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ABSTRACT: The paper supposes that in some cases formation of gas hydrates can become one of the most important problems while mine methane extracting. On the assumption of studying methods aimed at hydrate control there are identified ways of their adaptation while solving the problem during mine methane extraction. Results of studying conditions under which hydrating takes place will become strategic means against hydrates during accompanying mine methane extraction.

1 INTRODUCTIONS

Progressively increasing consumption of mineral energy reserves makes Ukrainian scientists and manufacturer solve the problem of integrated development of alternative energy bearers. Mine methane is one of the most promising directions for our country.

Despite the direction promising for Ukraine mine methane extraction is performed by some separate mining enterprises. Available degasification technique cannot give ability to have adequately qualitative gas. Lack of efficient ways of poor mine methane utilization as well as complex approach to its production result in emissions. It depends on the fact that underground coal mining technique can not stipulate simultaneous mine methane recovery.

Complex approach to the problem which helps to integrate coal mining process and methane extraction process will improve profitability of coal mines and labour safety. Besides it will guarantee power independence of our country.

2 PROBLEM DEFINITION

Results of analysis of mine methane commercial extraction in Donbas's bring into light a number of the most expectable problems which did not take place under degasification.

Expert evaluation of data on mines of Krasnoarmeysk mining district shows that gas hydrates formation is one of substantive problems while mine methane extracting. The problem is not new for enterprises engaged in commercial exploitation of natural gas. The problem is solved with varying success.

3 ANALYSIS OF THE PROBLEM STATE

Probabilities of gas hydrate formation while commercial extracting mine methane is quite possible. Many components of mine methane (methane, ethane, propane, isobutene, carbon dioxide, and azote) (Table 1) have similar physicochemical properties of hydrating. All the components form hydrates, so called gas hydrates - solid crystalline substances (looking like compressed snow), which exist under high pressure if temperature is positive.

Table 1. Mean Chemical Composition of Mine Methane

Element	Content, %(mol)	Element	Content, %(mol)
CH_4	87,2	C_5H_{12}	0,3
C_2H_6	7,6	N_2	0,4
C_3H_8	3,1	CO_2	0,1
н-C_4H_{10}	0,8		
*із*о-C_4H_{10}	0,5		

Gas hydrates are formed by means of introduction of crystalline structures into openings. The crystalline structures consist of molecules $\mathbf{H_2O}$ and gas molecules (M). General formula of gas hydrates is $\mathbf{M \cdot nH_2O}$ where value n varies from 5, 75 to 17 depending on gas composition and conditions of gas hydrate formation.

Results of different operation schedules of mine methane extraction, degasification and mine and geological conditions of Krasnoarmeysk coal mining district taking into account practice of "Krasnoarmeyskaya-Zapadnaya #1", "Dobropolskaya", "Krasnolimanskaya", "Belozerskaya", and "Almaznaya" help to determine a number of operational districts as well as a range of physical conditions for hydrate formation.

Thus, under mud-pulse action to increase effect of degasification operating fluid (most of all light water) with 1 to 8 MPa pressure and 0, 01 to 0,1s intervals is delivered into coal seam. As a result joint systems are formed through which gas gets into the hole. Then formational pressure of after-damp is sometimes 8 to 10 MPa. Under such pressure availability of water or aquatic solutions of gas makes it possible to form hydrates in the hole even if temperature is positive (Figure 1). Similar physical conditions are available on application of hydraulic fracturing. In some cases high pressure of gas dependent on mining and dynamic processes as well as watercut of a hole may result in hydrate formation. The process is possible even if external effect is not available.

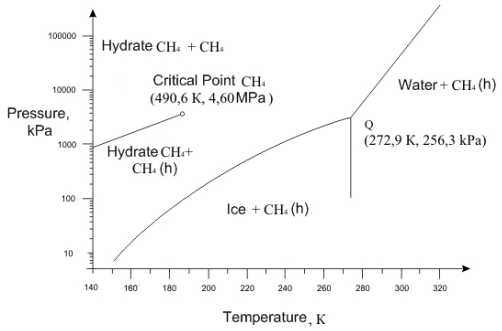

Figure 1. Conditions of Methane Hydrating

4 RESULTS

Analyses of conditions of gas hydrate formation and decomposition (Figures 1-3) help to suggest that is some cases releasing gas creates high pressure в systems of seepage blabs. If water is available it results in hydrate formation. It factors into plugging microcavities and fractures. Eventually either gas production decline or ultimate extinction of gas release is possible.

As for the systems of recovery the technogenic hydrates may be formed in a face zone and in a hole, in tails and in-field gathering lines, within systems of commercial gas treatment as well as in main gas transmission systems.

Negative development of gas hydrates within the system of mine methane extraction can become apparent become apparent in different ways. “Ice plugs” within inby gas lines, holes, gas mains etc. may considerably slow down throughput capacity of gas transmission network, and gas discharge from holes. In some cases it can completely isolate holes. Such a change of physical parameters of gas transmission network slows down efficiency and mine safety sensibly. In some cases it may result in emergency.

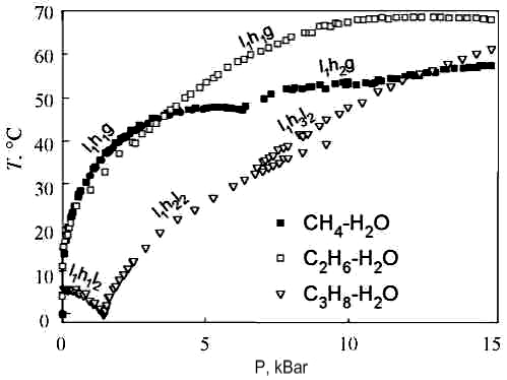

Figure 2. Curves of Hydrate Decomposition within “Water-Methane, Ethane, Propane” Systems

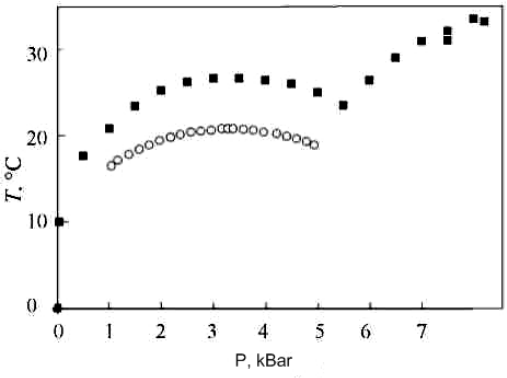

Figure 3. Curves of KC-I Hydrate Decomposition within Carbon Dioxide - Water System (■ & o are Data from Different Sources)

5 METHODS OF THE PROBLEM SOLVING

Majority of components of natural gas extraction system is in operation schedules of mine methane extraction.

Substructure of transporting pipeline in which gas is transported owing to drawdown by vacuum pump is an exception. Underpressure excludes gas hydrate formation even temperature is low. The transportation method can be considered as one of the possible solutions of hydrate formation problem while mine methane extracting.

Such methods are used against hydrates in the process of commercial extraction of natural gas:

- Inhibitor method
- Thermal method
- Method with application of surface-active materials (SAM) etc.

On the basis of methods aimed at hydrate elimination there are determined ways of their adaptation while the problem solving in the process of mine methane extraction. Dewatering, raise of transported gas temperature, transportation pressure reduction, addition of inhibitors and SAM within the most probable areas of gas hydrate formation are among them.

Thermal method is one the first methods. The method principle is to raise gas temperature over hydrating limit within defined pressure. But more and more often higher level of power consumption and nonuniformity of positive effect make giving up on it. Nevertheless the method may be quite working while underground extracting mine methane when outdoor temperature variations are completely predictable and it is possible to use energy of process loss (heat rejection from live electrical equipment, underground air, rock massif etc.).

There are cases when it is technically impossible to apply thermal method (if ice plug is formed within the hole's mouth). Then it is expedient to apply inhibitor methods or method against hydrating with the use of SAM.

Inhibitor method is in the use of solutions of non-electrolytes, lower aliphatic alcohols and glycols which induce sharp increase of induction period of gas hydrate formation (mainly, they are low-molecular water-dilutable polymeric compositions).

SAM ensures multiphase transport of hydrocarbonic systems in mode of hydrating without hydrate detention within production pipelines.

6 CONCLUSIONS

Formation of operation schedules taking into account ability of hydrating will be upcoming trend while extraction methane under the conditions of Donetsk coal basin. Primary methods to solve the problems of gas hydrate formation within live operating schedules will be the elements performing the simplest unwatering at the output of gas from holes, more complex dewatering facilities within gas transmission pipeline, adding inhibitors and SAM within areas of probable hydrating.

Results of studying conditions under which hydrating takes place will become strategic means against hydrates during accompanying mine methane extraction. They will be used while developing operating schedules. Adoption of technology which helps to improve qualitative composition of mined methane will become one of the most progressive energy-conservative methods to avoid hydrating during transportation and further gas processing.

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