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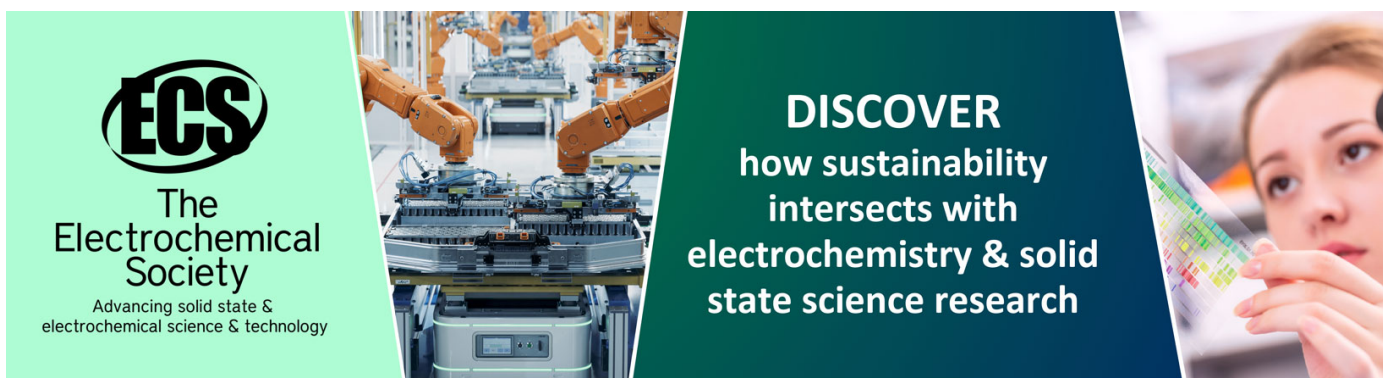
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To cite this article: R A Atlasov *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **666** 062051

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Gasification of Remote Settlements Using Technology of Artificial Gas Hydrate Production

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Abstract. Currently there are a number of problems in the Republic of Sakha (Yakutia) connected with energy supply to remote residential areas and industrial facilities. Taking into account the logistical difficulties of gasification of remote settlements existing in our region, the authors study modern gasification methods. The object of their study is artificially produced gas hydrates. In order to expand the use of hydrates for storage and transportation of natural gas it is important to take into consideration the features of gas hydrate formation process in high-pressure chambers when laboratory settings of gas hydrate synthesis are being realised. The analysis show that gas hydrates can be prospective and effective new source of energy. In addition, since the territory of Yakutia is located in the permafrost zone, there is a scientific, industrial and socio-economic expediency to study the features of gas hydrates. The following work illustrates the study of ways of natural gas artificial hydrate production, analysis of options of its use as a new energy resource in the conditions of the Far North and the process of its synthesis in Federal Research Center of the Division of Institute of Oil and Gas Problems of Siberian Branch of the Russian Academy of Science.

1. Introduction

At present there are a number of scientific works devoted to the study of gas hydrates. In [19], the presence of «micro- and nano-bubbles (MNBs)» of gas in water samples after decomposition of methane hydrate was determined by transmission electron microscope. V.E. Kirpichev has studied methods of gas hydrate deposits development [9]. Theoretical study of gas extraction from hydrate-saturated formation [12] has been revealed. The work of F. Wang is also worth mentioning, where it is said that the smaller the wetting angle, the higher the growth of hydrates on the reactor wall and the more intensive the process of hydrate formation [21].

Nowadays, gas hydrates are not produced on industrial scale [4]. This is connected with the fact that the nature of gas hydrate occurrence is not well studied and its extraction technology is not well developed [7]. However, technologies for the following resource extraction are being developed [2, 6, 14, 13, 16, 22]. We offer to consider the possibility of using gas hydrates in manufacture since it is a



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promising and relatively environmentally friendly energy resource. At the same time it will have similar efficiency indicators by its chemical characteristics as traditional natural gas (methane) [23]. Natural gas reserves in gas hydrates are much higher than the number of traditional reserves on the planet [3, 20]. The concept suggested by us for gas hydrate production using natural-low temperature of Russian northern regions and its descriptive and technological scheme of the process considers the peculiarities of obtaining synthetic natural gas hydrates in closed-type reactor chambers. Gasification of residences that are located outside the vicinity of large gas transportation networks is possible either with commissioning of new fields located in the territorial vicinity or using alternative technologies [18]. We suggest to focus on fuel needs of our region - the Republic of Sakha (Yakutia). Today, natural gas is supplied to 87 settlements in 9 districts (Vernevilyusky, Vilyusky, Gorny, Kobyaisky, Namsky, Hangalassky, Megino-Kangalassky, Mirninsky, Lensky) and Yakutsk with its suburbs [17]. In accordance with the following data it can be concluded that the territory of Yakutia is gasified only by 30%. There are also reference points in the republic that can really promote this alternative energy source.

The aim of this article is to study the current situation of gasification in the region, as well as to analyze the prospects for the use of gas hydrates as a new energy resource in the Far North.

2. Gasification of remotest settlements

Within the frames of gasification of the Far East the "Program of creation of unified system of gas production, transportation and gas supply in Eastern Siberia and the Far East taking into consideration the possible gas export to Chinese market and other countries of Asia-Pacific region (Eastern gas program). On the basis of the following program the investment project of PJSC "Gazprom" gas pipeline "Power of Siberia" was realized [1, 15]. The route of this pipeline is designed in such a way that it is possible to gasify as many settlements as possible during its exploitation. In the Republic of Sakha (Yakutia) the main gas pipeline passes through the territory of Lensky, Olekminsky, Aldan and Neryungrinsky districts.

The gas transportation system of the republic consists of four local gas transportation systems that function in a closed and technologically independent manner [10, 11]. Taking into account the closure and limited domestic gas market for the existing gas transportation systems in the republic, the volume of natural gas production increased significantly in the beginning of 2020, due to the completion of the main gas pipeline «Power of Siberia» and the beginning of natural gas export. Until then, gasification system of the republic remain isolated, and gas supplies are carried out only for housing needs and communal services. Economic impracticability due to the small number of the population and absence of large industrial consumers play additional role in rejection of gasification activities in the northern regions of the republic [5].

Consequently, gasification possibilities of the northern regions of the republic become necessary to be considered. This is why the possibilities of alternative energy, such as the use of gas hydrates, are being considered within the framework of the federal project on the development of the Arctic Cluster in the Bulun district of the Republic. The trial start-up of the boiler house operating on gas hydrate raw materials is planned in the village of Bykov. After comprehensive analytical and practical work, the project can be replicated to other areas and entities. Projects that are mostly adapted to real application are carried out in the Institute of Oil and Gas Problems of Siberian Branch of the RAS. The concept of gas hydrate production they suggest using natural-low temperature conditions of northern regions of the Russian Federation and its descriptive and technological scheme of process takes into account the peculiarities of natural gas synthetic hydrate production in closed type reactor chambers.

3. How to obtain gas hydrate in laboratory conditions

Gas hydrates can be synthesized artificially, in laboratory conditions. In the laboratory of Institute of Oil and Gas Problems of Siberian Branch of the RAS junior research assistant Portnyagin Albert Serafimovich demonstrated the process of gas hydrates obtaining artificially (figure 1).

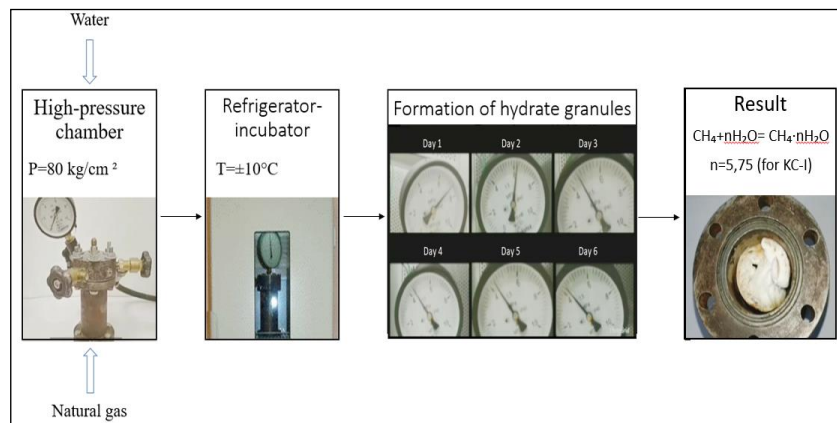


Figure 1. The process of gas hydrates obtaining artificially.

The equipment illustrated in figure 2 is called high-pressure chamber.

The manometer can show excessive pressure in the chamber. Gas is supplied via the valve and hydrates are produced of natural gas. A certain volume of water is filled into the chamber, then it is filled with gas. Usually pressure is 80 kg/cm². It is approximately 8 MPa. Later the device is placed into the refrigerator-incubator with temperature of ± 10 degrees and here it infuses for about a week or two. Meanwhile gas hydrates are formed. The process occurs in closed space because water keeps the gas, that is it turns gaseous state into solid state. The volume of gas decreases, and pressure begins to fall. It is important to monitor the changes of pressure during the process of hydrate formation and as it stops changing in a certain level the water that is in the chamber turns into hydrate. The process of hydrate formation is finished when all the water becomes hydrate.



Figure 2. The high-pressure chamber with a volume of 1 liter.

4. Results and discussion

In the result of the research we obtained gas hydrate which reminds snow or ice (figure 3). It consists of natural gas molecules encased in a solid lattice of water molecules. It has a density of 0.8 kg/l. During the experiment the gas hydrate was formed under low temperature and high pressure. They remained unchanged at an elevated pressure and temperature of up to 280 K. The total amount of carbon contained in such a unique source is greater than conventional fossil fuels such as oil and coal [8]. After all, its one volume released about 158 volumes of methane (figure 4).



Figure 3. A sample of gas hydrate in the laboratory of Yakutia.

Many hydrate features are similar to those of ice, since hydrates have an ice-like structure. The energy generated by hydrates is 16 times more than the net energy consumption needed to decompose them. The amount of carbon dioxide from the gas hydrate is generated by methane burning, and it is 38% lower than coal and almost 17% lower than oil. Due to this efficiency any release of greenhouse gases will reduce global pollution.



Figure 4. The combustion of the gas hydrate.

The experiments have shown that natural gas hydrates can be used as precursors in synthesis of gas mixtures of high level of hydrogen. The worked out method of obtaining natural gas hydrates, selected temperature mode and chamber structure make it possible to produce hydrates with high level of gas content (about 88%). They are some kind of a natural storage for methane gas and are considered to be an option to facilitate transition to alternative fuel of future.

Since both science and the industry work on search of new power sources, it is important to understand social consequences of development of resources. Social consequences: increase in the standard of living and safety, increase in employment of the population, technical and commercial skills transfer, development in the field of budget revenues in the local level of Far North. The use of gas hydrate resources will be beneficial and for economic activity of the region, population employment, will offer various privileges, as well as will decrease energy consumption, etc.

5. Conclusion

Now there is a transition from electricity generation on the basis of coal to gas generation because of huge benefits therefore in the current context gas hydrates can be used in electricity production. The level of modern research works and industrial conditions allow to reveal any difficulties on this way. The world has to search and find new mineral sources of ecologically clean energy. Natural gas hydrates are such kind of raw materials since they include a great amount methane. Even a small amount of it can fulfill the energy needs for centuries.

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Acknowledgements

The authors would like to thank Portnyagin Albert Serafimovich and Semyonov Matvey Yegorovich - research associates of the Institute of Oil and Gas Problems of Siberian Branch of the RAS, Yakutsk, Russia, for assistance in conducting research.