EXPLOITATION OF NATURAL GAS HYDRATES AS AN ENERGY SOURCE: PROSPECTS AND PROBLEMS

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Abstract. Natural gas is the cleanest burning fossil fuel and has been identified as a strong candidate for an energy source compared to oil and coal. Natural gas hydrate is an energy source for methane, which has twice the carbon content of all fossil fuels and is evenly distributed throughout the world. Several field tests have been conducted on energy production from hydrate resources, and their results have established the possibility of energy production from hydrate resources. In this article, we review various studies on the resource potential of natural gas hydrate, including laboratory studies and several recent field tests.

Keywords: hydrate, carbon, hexagonal structure and adsorption

Annotatsiya. Tabiiy gaz eng toza yonadigan qazilma yoqilg'idir va neft va ko'mirga nisbatan energiya manbai uchun kuchli nomzod sifatida aniqlangan. Tabiiy gaz gidrati metan uchun energiya manbai bo'lib, u barcha qazib olinadigan yoqilg'idan ikki baravar ko'p uglerodga ega va butun dunyo bo'ylab teng taqsimlanadi. Gidrat resurslaridan energiya ishlab chiqarish bo'yicha bir nechta dala sinovlari o'tkazildi va ularning natijalari gidrat resurslaridan energiya ishlab chiqarish imkoniyatini yaratdi. Ushbu maqolada biz tabiiy gaz gidratining resurs salohiyati bo'yicha turli tadqiqotlarni, shu jumladan laboratoriya tadqiqotlari va yaqinda o'tkazilgan bir qancha dala sinovlarini ko'rib chiqamiz.

Kalit so'zlar: gidrat, uglerod, olti burchakli tuzilish va adsorbsiya

Аннотация. Природный газ является наиболее экологически чистым ископаемым топливом и считается наиболее перспективным кандидатом в качестве источника энергии по сравнению с нефтью и углем. Гидрат природного газа является источником энергии для получения метана, содержание углерода в котором в два раза превышает содержание углерода во всех видах ископаемого топлива и который равномерно распределен по всему миру. Было проведено несколько полевых испытаний по производству энергии из гидратных ресурсов, и их результаты показали возможность производства энергии из гидратных ресурсов. В этой статье мы рассматриваем различные исследования ресурсного потенциала гидрата природного газа, включая лабораторные исследования и несколько недавних полевых испытаний.

Ключевые слова: гидрат, углерод, гексагональная структура и адсорбция.

Introduction

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Global energy demand is expected to increase significantly in the coming decades as human society grows. The 2013 International Energy Outlook by the US DOE projected that global energy consumption will increase by 56% from 524 quadrillion BTU in 2010 to 820 quadrillion BTU in 2040 [1]. The main contributors to this increase in demand are developing countries outside the OECD, led by China and India, where demand is projected to grow by 112% between 2010 and 2040 [1].

While more energy is expected to be available from renewable and nuclear sources over time, the amount produced may fall short of meeting the large increases in energy demand. Despite the growth of other renewable sources, more than 76% of energy will come from carbon-based sources (gas, oil, and coal) in 2040 [2]. Of these three carbon-based energy sources, natural gas is expected to grow at the fastest rate (1.7% per year) compared to other fossil fuels (0.9% per year for liquid fuels and 1.3% for coal) [1,3].

2. Gas hydrates

The chemical structure and stability of natural gas hydrates are relatively well studied. Gas hydrates form under a specific set of high-pressure and low-temperature conditions, outside of which the gas and water species usually remain in separate phases. Three main structures of gas hydrates have been identified: cubic structure I (sl), cubic structure II (sII), and hexagonal structure (sH) [4]. In each structure, the water molecules arrange themselves in different ways, creating voids of different diameters for the gas molecules to occupy (ranging from 7.82 Å in the sII 512 lattice to 11.58 Å in the sH 51268 lattice [4]. The size, pressure, and temperature conditions, and the chemical nature of the gas molecules determine which hydrate structure they form [4].

3. Recovery methods

Most conventional and other unconventional natural gas is trapped underground due to geological features such as an impermeable “cap” that seals the conventional NG reservoir and ultra-low permeability reservoir conditions for unconventional NG. Gas recovery methods from these resources aim to create a conduit for these gases to flow through the geological formation. For example, hydraulic fracturing, which extracts methane from unconventional shale formations, works by creating artificial fractures in the reservoir rock surrounding the well, thereby providing chambers for the adsorbed natural gas to flow to the surface.

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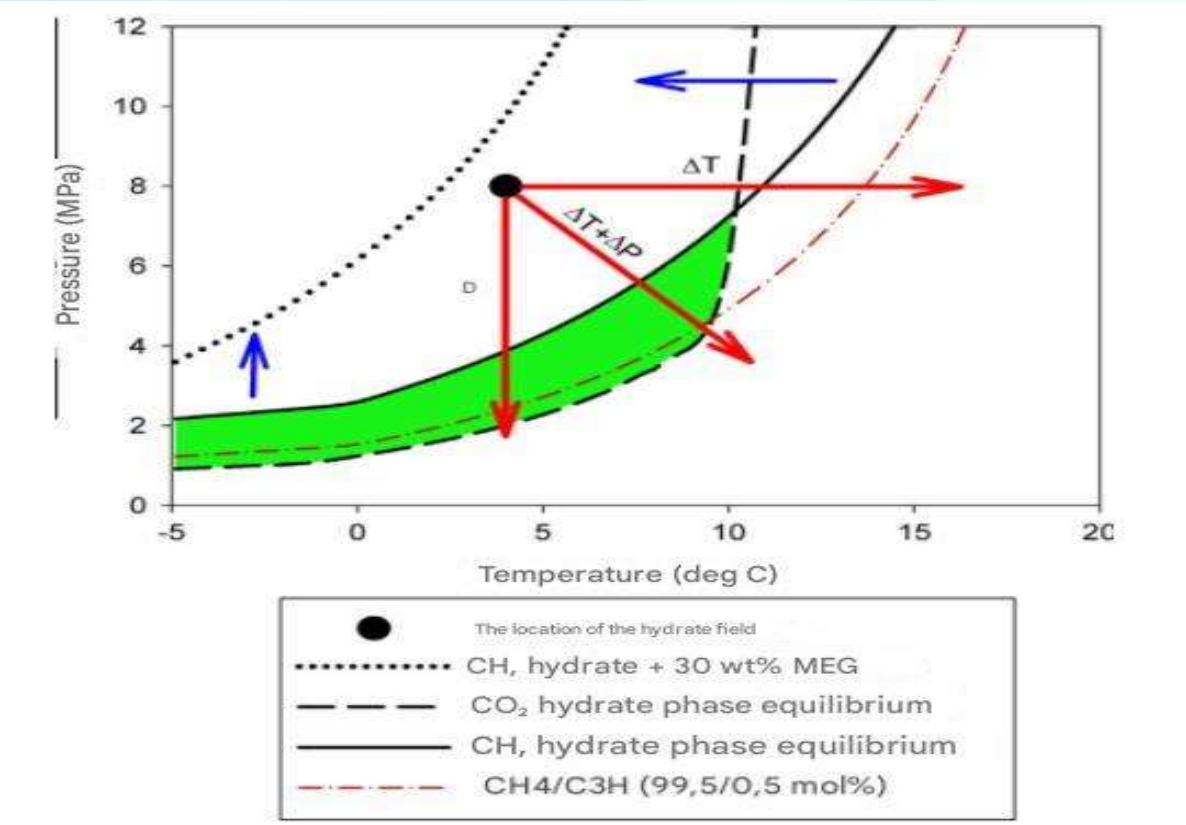


Figure 1. Schematic diagram of commonly recommended natural gas recovery methods. (Red: Thermal stimulation, depressurization, and combination; blue: inhibitor injection; and green zone: CH_4-CO_2 exchange).

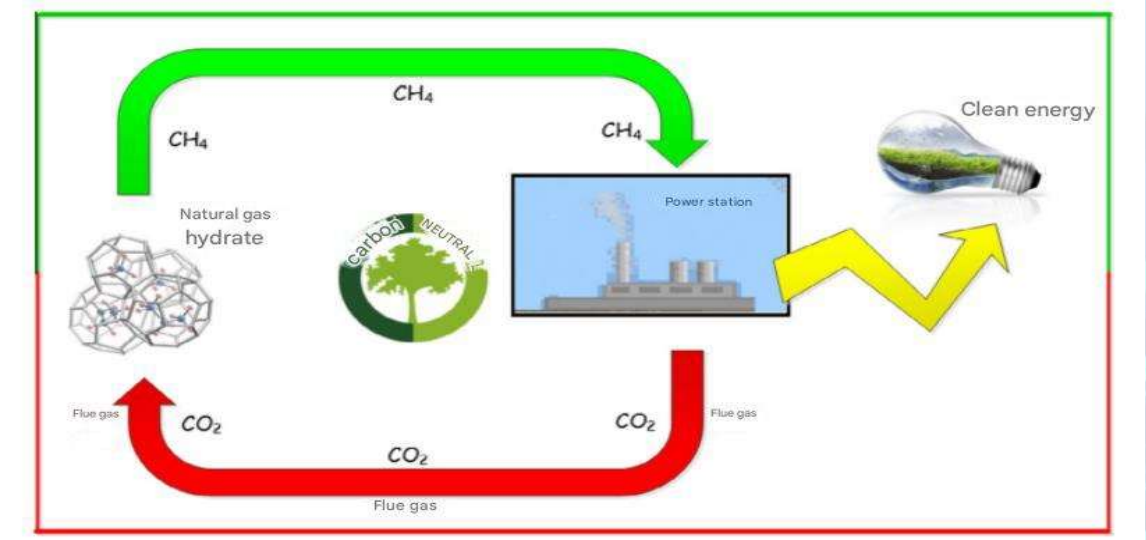


Figure 2. A sustainable approach to CO_2 capture and methane production from natural gas hydrates.

Gas hydrates, on the other hand, are fundamentally different from other unconventional natural gas sources. Gas molecules in a hydrate reservoir are trapped in the cages formed by water molecules by van der Waals forces at the molecular level. Therefore, in addition to creating conduits for gas flow, methods for extracting methane from gas hydrates involve in situ dissociation of natural gas

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hydrates. The three most proposed and studied techniques for methane hydrate separation are thermal stimulation, pressure reduction, and inhibitor injection, as shown in Figure 1. Thermal stimulation and pressure reduction methods change the local P-T conditions so that methane hydrate is not stable in water and is degassed; while chemical inhibitor injection involves the introduction of chemicals that can change the phase boundary of the hydrate system.

Conclusion

This article reviews the current state of the art in hydrate exploitation, the progress of relevant research worldwide, and suggests possible directions for NGH-related research. In addition to extracting methane from large hydrate resources, this review also examines the enormous potential for sequestering CO2 as hydrates in porous sediments at existing natural gas hydrate sites as a safe way to reduce CO2. Further field testing, as well as a sustained production rate of approximately 20,000–30,000 m^3/day, is needed to move the technology forward on the path to commercialization of gas production from natural gas hydrates. There are no technological barriers to the extraction or production of methane from hydrates, and clear technological breakthroughs will depend on effective sand and water management during production, as well as appropriate mitigation of environmental risks.

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